FORESTRY RESEARCH PROGRESS IN 1970

McIntire-Stennis Cooperative Forestry Research Program

COOPERATIVE STATE RESEARCH SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Preface

As in recent years approximately one-fifth of the active McIntire-Stennis projects were selected to be featured in the 1970 Annual Report of Forestry Research. Each year the Current Research Information System (CRIS), from which these reports are obtained, becomes more valuable, partly as a mechanism for obtaining the reports presented herein, but also as a very valuable planning tool. This use of CRIS is discussed in the INTRODUCTION. A further attempt to use both the concepts of Research Problem Areas (RPA) and the Oxford System of Decimal Classification in Forestry was made in this report.

The printing costs of this report were borne by the Association of State College and University Forestry Research Organizations. Additional copies may be obtained by addressing a request to: Division of Information, Office of Management Services, U.S. Department of Agriculture, Washington, D.C. 20250

Cover Photo: The rejuvenation of a Michigan black walnut grove with intensive cultural care. Complete chemical weed control, fertilization, and side branch pruning are the treatments. A substantial reduction in harvest rotation time is the goal. For further information see the report of Michigan State University project 984, page 41.

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McIntire-Stennis Cooperative Forestry Research Program

Introduction

During the 7th year of the McIntire-Stennis program, 1970, 61 cooperating universities carried on forestry research from Hawaii to Maine. There were 503 projects active at the end of the year involving 525 scientists and 401 graduate students.

Program evaluation and planning are normal activities in research organizations for without these processes the result is an undirected collection of projects. The Association of State Colleges and University Forestry Research Organization (ASCUFRO), realizing the need for coordination of research at the institutional, state, and national level has been quite active in encouraging the development of well conceived, problem-oriented plans. Characteristically, an institutional plan is the product of staff action. Problems of the state in the forest resource area are analyzed and a set of projects is outlined to provide the desired solutions.

At this point in the planning process a multitude of considerations are necessary including the research going on in neighboring states and within the same state by other agencies. In other words, some organization may be working on answers to this same or similar question, thus changing the priority for the work on the problem being solved. At this point, the Current Research Information System (CRIS) is useful. Simply by requesting from CRIS a printout of the current research at other state and federal agencies in the forest resources field it is easy to obtain a wealth of information.

Compiled by Drs. Boyd W. Post, Aubrey E. Wylie, Cooperative State Research Service, USDA, Washington, D.C. 20250.

The retrieval process may be applied from several points of view. For example, the numerical commodity codes described in the CRIS Manual uses the four digits 0600 for Trees, Forests, and Forest Products, a primary classification. There are 22 secondary, or subclassifications, useful in retrieving more specific portions of the 0600 group, such as 0612 for Douglas-fir, or 0622 for fine hardwoods. Research Problem Area (RPA) codes are generally the most meaningful of the classifications. As in previous McIntire-Stennis Reports, RPA descriptions are included in this report to provide a better understanding of CRIS designations, some of which were modified during 1970. Due to the prime importance of the RPA's the new CRIS Manual is designed around this series. In fact, this is another indication of the importance attached to problem solving by state and federal research administrators who jointly developed the program.

In requesting a printout from CRIS there are a few suggestions worthy of consideration which will make the retrieval easier for the CRIS personnel to accomplish something that is agreeable with your needs and their capabilities. First of all it is essential that you define three separate types of information which you would like to receive. The first type is subject-matter. If possible this should be described in both general terms and then as specifically as possible. The second type of information which is essential, is designation

of the fields to be printed from the CRIS forms. In order to understand this it is necessary to look at the CRIS forms and see that there are numerical designations given to various information fields, or blocks, on the form. For example, the fields in which the special commodity or sub commodity codes that we mentioned earlier for Douglas-fir 0612 and for fine hardwoods 0622 would be located in fields 62 and 63 of Form AD-417. If one wished to receive the titles of research projects these are located in field 7 of Form AD-416. The performing organization is in field 8 and the investigator is in field 12. By examining the forms it is possible then to determine the type of information which is desirable in your planning situation. Once you determine what fields are to be requested then the third thing that is needed is a sequence of sorting. To establish a sorting sequence it would be best to request state and then university within the state, in case there is more than one cooperating university, and perhaps department after that. There are a number of ways of sorting any one of which may be useful for a specific purpose. A narrative summary of the use intended for the printout is perhaps the most informative type of information that you can provide to the CRIS personnel. They can interpret from previous experience some procedures which will perhaps serve better than those that come to mind for the investigator. For example, it would be very advisable to simply indicate that a program evaluation is being planned and that information is needed on research going on in other federal agencies and other state agencies which deal with the same subject-matter area being evaluated.

It is the intent of the Cooperative State Research Service and ASCUFRO that we develop improved administrative and management techniques for planning and coordinating research among the states and between the states and research agencies of the Department of Agriculture. The Current Research Information System offers much toward accomplishment of this worthy objective. If through your experience with this information system you find that certain features are useful we would appreciate knowing of those. If you have suggestions as to how we could provide better service we would appreciate knowing about that also since your cooperative effort is needed in order to maximize the results from this research program.

Chapter 1

FACTORS OF THE ENVIRONMENT, BIOLOGY

Foresters need to know enough about the environment to utilize it to provide goods and services for the present needs of mankind, and at the same time to correct previous mistakes, while providing resources for future generations. All factors of the environment are related directly or indirectly to the forest, resulting in an extremely complex forest environment relationship.

There is a great need for a better knowledge of the relationships between environment and a growth of forests. The heading of this chapter indicates a dual or interrelated subject-matter dealing with environment and biology. Following are reports describing some of the current research intended to acquire that essential knowledge relating forest environment and forest growth.

APPRAISAL OF SOIL RESOURCES

Research Problem Area 101

Agricultural agencies make appraisals of the nation's soil resources through soil classification and mapping the classified soil types. Research in support of soil mapping is concerned with identifying the parameters to be measured including the correlation of soil map information with the use to be made of the data (*e.g.*, crop production, housing developments, zoning), and the development of effective and economic ways of reporting the results.

In recent years the use of these findings has extended far beyond that made by farmers and ranchers. For example, sanitarians and home builders are using the information for judging the capacity of soils to absorb septic tank effluent; architects and developers use the information for site evaluation and foundation design; urban planners and other public officials use soil surveys for both general and operational planning of land use in rapidly expanding areas. Soil surveys can also be used to show soil characteristics such as susceptability to frost heave or slippage, depth to water table, depth to rock or other impermeable barriers, bearing strength, flood hazard, and soil erosion potential which affect suitability of a site for specific uses.

UNIVERSITY OF WASHINGTON, 17
Pedological investigation of forest soils.
F. C. UGOLINI

Analysis of the humic acid/fulvic acid ratios of the surface soils across a prairie-forest transect showed a gradual decrease in these ratios. Forested soils continuously were found to have the lowest humic acid/fulvic acid ratios, soils which had been under prairie vegetation and subsequently reforested had intermediate values.

X-ray diffraction of clay fractions of soils formed under prairie and forest vegetation show similar mineralogy. In both soils the clay fractions of the C horizons are dominated by chlorite, vermiculite, and

kaolinite, with small amounts of mica. Moving upward through both soil profiles the mica disappears and the amount of chlorite is reduced, apparently altered to vermiculite by the more intense weathering near the soil surface.

Cation exchange capacity before and after removal of free iron oxides show that a significant increase in CEC occurs after free oxide removal. This is indicative of a pH-dependent CEC in these soils. The greatest increase in CEC occurred in the B horizons of both soils in spite of the fact that the A horizons had greater percentages of free iron oxides.

Differential thermal analysis techniques are being used to characterize the organic fractions of these soils. Significant differences between the DTA patterns of the soils formed under prairie and forest vegetation have been observed. These differences are being evaluated by the selective removal of various components of soil organic matter and the effect of the removal of the DTA patterns.

ADDITIONAL PROJECTS

UNIVERSITY OF ALASKA, 270–0545
Relationships among vegetation, ground ice, and disturbances on north-facing slopes in the Fairbanks area. **B. J. NEILAND**

CONNECTICUT, NEW HAVEN, 411
Phosphorus in lake sediments. **C. R. FRINK**

UNIVERSITY OF HAWAII, 140
Soils in introduced and indigenous forests.
L. D. SWINDALE

PUBLICATIONS

FRINK, C. R.
Sediment phosphorus in lakes of varying fertility. Agron. Abst. p. 95, 1970.

SOIL, PLANT, WATER, NUTRIENT RELATIONSHIPS

Research Problem Area 102

This problem area is concerned with the chemical and physical nature of interrelationships among soils, plants, water, and nutrients. The objective is to maintain or restore the inherent production capability of soils.

NEW YORK-CORNELL UNIVERSITY, 901
Effects of ectotropic mycorrhizae on tree growth.
E. L. STONE, W. A. SINCLAIR, and P. E. LUCAS

Preliminary studies of soil respiration in mycorrhizal and non-mycorrhizal cultures were terminated by illness and departure of the graduate student involved.

A sterile greenhouse chamber with electrostatically-filtered air was constructed. Six series of experiments are now in progress in this chamber or closed containers: Two of mycorrhizal syntheses involving six fungal species; two of inoculation methods paralleling field trials being conducted by Sinclair; and two comparing response to mycorrhizal versus litter-decomposing Basidiomycetes.

This project is to be revised and updated.

WEST VIRGINIA UNIVERSITY, 6
Microclimate modifications affecting reforestation of surface mined lands. **R. LEE**

Research has demonstrated the feasibility of reducing unnaturally high temperatures on barren spoil surfaces through applications of reflective coatings. Some of the commercially available soil coatings are non-toxic and highly reflective, but they are relatively expensive. An aqueous composition of hydrated lime and white cement (whitewash) is both economically attractive and adequate in providing a reflective surface.

Radiometer measurements have indicated that, on the average, a common light-colored spoil reflects about 25 percent of solar radiation. Under similar conditions a black spoil reflected less than 5 percent. When these spoils were coated with whitewash (2 gallons per 100 square feet), they reflected about 40 and 35 percent of solar radiation respectively.

The reflectivity increases caused by whitewashing were directly correlated with surface temperature decreases. A common light-colored spoil developed surface temperatures exceeding 40°C (104°F) in summer, and maximum surface temperatures on a black spoil 60°C (140°F). When these spoils were whitewashed, maximum surface temperatures decreased by as much as 6°C (11°F) on the light spoil, and by 14°C (25°F) on the black spoil.

Since lethal temperatures for tree seedlings are in the range from 50 to 55°C (122 to 131°F), use of reflective coatings apparently will aid in the survival and growth of tree seedlings on barren spoils.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 636
Nitrogen and carbon balances in forest and range ecosystems in Arizona. **J. O. KLEMMEDSON**

UNIVERSITY OF ARKANSAS, 610
Use alternatives on forest lands of Ozark Upland Region of North Arkansas. **H. A. HOLT**

UNIVERSITY OF FLORIDA, 1250
Water control for production of southern pines.
C. M. KAUFMAN

UNIVERSITY OF KENTUCKY, 199
Edaphologically important physical and chemical properties of major forest soils. **R. L. BLEVINS**

LOUISIANA STATE UNIVERSITY, 1276
Rooting depth of mature southern pine trees as limited by soil characteristics. **N. E. LINNARTZ**

UNIVERSITY OF MAINE, 5008
Fertilization of spruce–fir sites in Maine.
C. E. SCHOMAKER, R. A. STRUCHTEMEYER and E. L. GIDDINGS

PENNSYLVANIA STATE UNIVERSITY, 1745
Revegetation of highly adverse sites created by coal mining. **R. J. HUTNIK, F. Y. BORDEN and W. W. WARD**

UNIVERSITY OF WASHINGTON, 12
Fire on a forest soil. **D. W. COLE**

PUBLICATIONS

STOIN, H. R.
Controlling brush with goats. Arkansas Farm Research 19(4):12, 1970.

EROSION CONTROL AND WATERSHED MANAGEMENT

Research Problem Area 107

Nearly 12,000 agricultural and forested watersheds in the country are in the size category commonly encompassed in developments under the Watershed Protection and Flood Prevention Act, the Small Reclamation Projects Act, and similar programs. These watersheds include the cropland of the U.S. as well as the range and forest lands. Many of these watersheds need one or more of the following flood prevention systems: sediment control, wind and water erosion control, and improved management for water yield and quality.

Erosion control is needed to protect the productive capacity of the land. Sediment control is needed to prevent unwanted deposition of eroded material in reservoirs, harbors, stream channels, streets and highways, or on floodplain lands. Sediment in streams damages recreational values and must be removed from domestic and industrial water supplies.

COLORADO STATE UNIVERSITY, 312
Impact of land use on water quality. **J. R. MEIMAN**

During the period from July 1964 to July 1970 intensive studies were made on the physical and bacterial characteristics of streams in a 105 square mile mountain watershed in the Colorado Front Range. These studies included natural streams virtually uninfluenced by man as well as the impact on such streams resulting from recreation, wildfire, road reconstruction, and combined grazing and irrigation on a mountain meadow. Parameters measured and their total ranges during the period of study were: temperature, 0 to 24°C; pH, 6.3 to 8.7; turbidity, 0 to 475 Hellige units; suspended sediment, 0 to 724 mg/l; dissolved solids, 0 to 205 mg/l; total bacteria, <10,000 to 20,000,000; coliforms, 0 to 20,000 colonies/100 ml; fecal coliforms, 0 to 5,000 colonies/100 ml; and fecal streptococcus, 0 to 2,000 colonies/100 ml. The high bacteria counts were associated with a single storm event, normally the range was from 0 to 300 colonies/100 ml for the coliforms and 0 to 75 colonies/100 ml for the fecal coliforms and fecal streptococcus. In addition to identifying certain interrelations of these parameters, specific recommendations were developed for sampling the relatively pure headwaters of mountain watersheds. Under the conditions of study only the grazing-irrigation on a mountain meadow and the wildfire had a significant effect on water quality. The effect of grazing-irrigation was reflected only in the bacterial indicators and that of wildfire only on stream temperature. Diurnal and seasonal fluctuations of bacteria during the studies suggested that solar

radiation exerted a strong influence under the conditions studied on bacterial concentrations. Extinction of solar radiation within a representative stream followed the radiation decay law, $I = I_{oe}$-bx where b = -.31988+.092352[1]+ .28591x and x = wavelength within the limits of .36 to .70μ.

UNIVERSITY OF NEVADA, 675

Water retention and movement in snowpacks on the east slopes of the Sierra Nevada.

C. M. SKAU, J. H. HUMPHREY and R. O. MEEUWIG

Aluminum tubes for snow density gage use are in place at nine locations in the Carson Range. Three of the tube sites at Tahoe Meadows (8,700 ft.) will be used in simulating a rain-on-snow event at the end of January. Electrical conductivity sensors placed on the surface after every major snowfall will detect the percolation speed of the simulated rainfall in the snowpack. A pit study after 24 hours will check the density and water content determined by the Troxler density gage.

Most of the meteorological variables (precipitation, temperature, wind, etc.) are being collected by cooperative projects. The snowpack density and water retention will be related to the initial snowfall density and environmental conditions at the surface and interior of the snowpack.

This promises to be an interesting winter since snow depths (over 9 ft. on Slide Mtn.) have already far exceeded historic maximums as of mid-December. The high elevation snowpack at this time has the potential for completely absorbing the precipitation from the type of warm rain storms which have led to severe flooding in the Sierra Nevada in past years.

UTAH STATE UNIVERSITY, 780

Root distribution and soil moisture depletion in three clones of Gambel oak. **J. D. SCHULTZ**

Measurements of root biomass in the upper five feet of soil profile have been obtained in one clone of Gambel oak in central Utah. Analyses of the biomass data with respect to soil moisture measurements obtained on the same plots are incomplete. Even so, it is apparent that concentrations of roots nearest to neutron-scattering soil moisture probe access holes have a pronounced effect upon neutron meter readings. The organic matter of the roots and the moisture contained within them affects the neutron flux in the vicinity of the detector tube and consequently yields a reading of soil moisture greater than probably exists in reality. Subsequent data analyses should show, at least in part, how much of the "excess" moisture reading is due to organic matter. Saturated soil conditions in the spring, after winter snowmelt has recharged the soil mantle, yield neutron meter readings in excess of what the analysis of physical soil properties reveals is the maximum capacity of the soil to hold water. This excess may well be due to organic root material. Referring to Table 1, the abnormally high neutron meter readings obtained between four and five feet below the soil surface may well be due to excessive root concentrations found at those depths.

Results of this investigation have potentially great import because literally thousands of neutron-scattering soil moisture access tubes are in place and

Table 1.

Root biomass in five feet of soil profile of a 110-year-old clone of Gambel oak

Soil Depth	*Root Biomass* Root Diameter < 0.125 inch	Root Diameter > 0.125 inch	All Roots
(inch)	(grams per cubic foot of soil volume)		
0–6	46.02	121.78	167.80
6–12	42.09	75.03	117.12
12–18	14.55	46.54	61.09
18–24	15.15	74.67	89.82
24–30	36.31	42.57	78.88
30–36	41.48	18.68	60.16
36–42	6.69	33.05	39.74
42–48	3.83	35.76	39.59
48–54	35.86	23.94	59.80
54–60	23.66	89.38	113.04

millions of meter readings have been obtained in many parts of the world. Soil water balance studies involving such data may have not been correctly interpreted in the past, and future studies may need to take the effects of root concentrations into account.

UTAH STATE UNIVERSITY, 641

Manipulation of trembling aspen and Gambel oak for increased water yields. **J. D. SCHULTZ**

This project has provided supporting evidence for the widely held belief that alterations in water use patterns can be achieved by manipulating woody vegetation. As many as five inches more water remained in the soil profile (root zone) at the end of three growing seasons following cutting and poisoning treatments applied in clones of quaking aspen and Gambel oak in central Utah, as compared to non-tested plots. This water represents soil moisture storage that does not need to be filled during the winter period of soil moisture recharge. Hence, potential increases in water yield were shown to exist. Clearcutting of clonal species without destruction of resprouting stems resulted in initial water savings, but these became less as each year passed. Dense stands of sprouts appear capable of using as much soil moisture as uncut control stands of trees. Where sprouts were destroyed, the water savings persisted. Approximately identical results were obtained with both oak and aspen.

UNIVERSITY OF WASHINGTON, 20

Quantity measurement of snow-melt water as related to runoff. **D. D. WOOLDRIDGE and S. P. GESSEL**

Winter snowpacks often present problems concerning the threat of flooding, both in large river basins as well as small watersheds and urbanized communities. Monthly streamflow forecasting from snow covered terrain has been accomplished successfully using snow depth and density measurements. However, this method has not provided reasonable values for daily or hourly stream measurements.

In this research, snow-melt measurements—collected by lysimeters placed at the snow-soil interface—have been made for two winter seasons at the headwaters of the South Fork of the Snoqualmie River in the Alpental Ski Area. These data, as well as other hydrologic and meteorologic measurements, have been used to forecast short term water level changes in the system. Using eight lysimeters and tipping

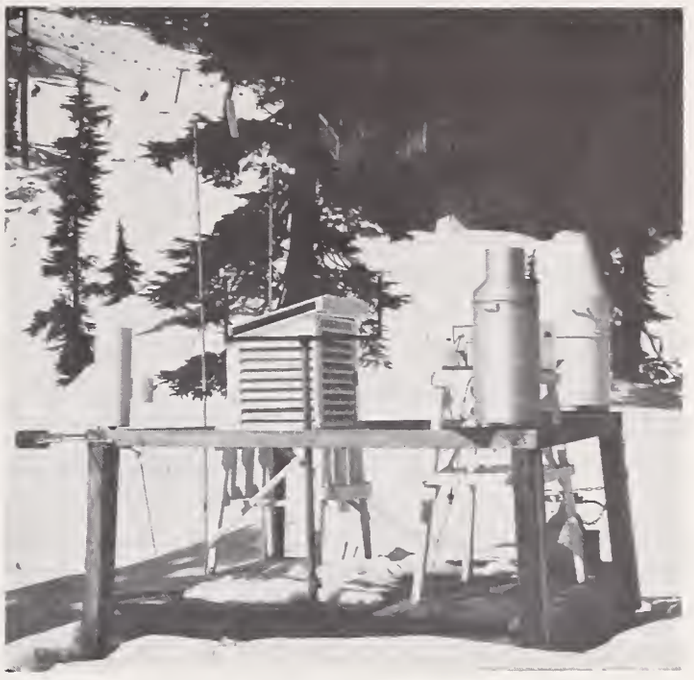

Figure 1. Meteorological station centrally located in a field of eight lysimeters collects and transmits data in this snow-melt study.

buckets—designed by the author—snow-melt measurements were made and relayed to a data logger. Snow temperatures were recorded at seven stations from the soil/snow interface upwards at 8-inch intervals. Stream level, wind speed, wind direction, air temperature, relative humidity, and precipitation were recorded in addition to solar radiation incoming, solar radiation reflected and net radiation (see Figure 1). These data were recorded on a Seaman Nuclear Data logger at 30-minute intervals continuously throughout the winter months.

Analysis of data showed that snow melt apparently occurred considerably more rapidly than did the fluctuations in the stream. This led to various attempts to "buffer" the data. By accumulating a specific number of hours of snow melt, the data were smoothed out considerably, and a technique was developed to accumulate and log data in order to make correlations with water level in order to empirically determine the most significant relationship.

In this procedure, the first 14 hours of data and last 14 hours of data cannot be used in the correlation analysis. By varying the number of hours of accumulation and lag and making an analysis of each, the peak correlation coefficient can be found as well as the standard deviation and coefficient of variation.

While this analysis is not complete, the use of lysimeters under snow and the application of the time

and lag equation provide a reasonable approach to the technique of forecasting short-term streamflow fluctuations.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 631
Snow water yield from conifer forest.
D. B. THORUD

CONNECTICUT NEW HAVEN, 408
Conserving soil moisture with a stoma-closing chemical. P. E. WAGGONER

CONNECTICUT, NEW HAVEN, 415
Waste water renovation potential of forest soils predicted by their chemical and physical properties.
D. E. HILL

UNIVERSITY OF MASSACHUSETTS, 2
Evapo-transpiration, run-off, storage, and drainage characteristics of water from forest soils.
D. L. MADER and W. P. MacCONNELL

UNIVERSITY OF MASSACHUSETTS, 8
Use of aerial photographs to evaluate the recreational resources of a river. W. P. MacCONNELL

UNIVERSITY OF MISSOURI, 163
Forest hydrology of small karst watersheds in the Missouri Ozarks. C. D. SETTERGREN

PENNSYLVANIA STATE UNIVERSITY, 1495
Forest cover and timber harvesting methods related to streamflow. W. E. SOPPER, R. E. MELTON and P. W. FLETCHER

UNIVERSITY OF RHODE ISLAND, 954
Evapotranspiration losses as related to site and vegetation differences. J. BROWN and W. GOULD

UTAH STATE UNIVERSITY, 777
Water balances in intermountain stands of Englemann spruce surbalpine fir. G. E. HART

UNIVERSITY OF WASHINGTON, 11
Water retention by foliage of tree branches.
S. P. GESSEL and D. D. WOOLDRIDGE

WASHINGTON STATE UNIVERSITY, 16
Elevation frequency analysis of cloud-engulfed forests in mountains. D. R. SATTERLUND

WASHINGTON STATE UNIVERSITY, 1913
Watershed disturbance by tractor skidding.
D. R. SATTERLUND

WASHINGTON STATE UNIVERSITY, 1925
Ecologic characteristics of elk sedge (Carex Geyeri Boott.) for erosion control. B. F. ROCHE, JR.

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Effects of simulated cloud seeding on streamflow of selected watersheds in Pennsylvania. Water Resources Bulletin 6(5):754–766. Oct. 1970.

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Simulating the effects of environment on crop and of crop on microclimate. (Abst.) Amer. Soc. Agr. Engineers Meeting. Mimeo. 3 p. 1969.

ADAPTATION TO WEATHER AND WEATHER MODIFICATION

Research Problem Area 109

The future holds many possibilities for changes in weather and climate ranging from dramatic major changes to micro-environmental changes around plants and animals. Research in agriculture has three tasks: (1) characterize existing climatic patterns and propose more effective ways of adjusting to these patterns, (2) specify modifications that are clearly desirable to farm and forest, and (3) learn how modifications proposed by others will affect agriculture or natural ecology.

UNIVERSITY OF MISSOURI, 522
Energy and water balance of forest and range sites.
G. S. COX

During the growing season transpiration in an oak–hickory stand, as measured by the water balance method, ranged from 0.26″ to 0.05″ with an average value of 0.16″. Average values as computed by Penman's and Thornthwaite's formulae were 0.16″ and 0.20″. In July, about 84 percent of the net radiation was utilized in evapotranspiration, 14 percent in sensible heat transfer, and 2 percent in net soil heat transfer. CO_2 concentration of the air reached a diurnal maximum at 0400 and a minimum at 1700 hours. Seasonal CO_2 levels were at a minimum in August and a maximum in May. In August, minimum values were 50′ above the ground (in the canopy) and the maximum at 10′. CO_2 evolution from the soil reaches a maximum in midsummer with diurnal maxima at 0600 and minima at 2000 hours.

ADDITIONAL PROJECTS

CONNECTICUT, NEW HAVEN, 403
Mathematical simulators of the effect of environment on forests and forests on microenvironment.
P. E. WAGGONER

PUBLICATIONS

PARLANGE, JEAN-YVES.
Thermal boundary-layer similarity at limiting Prandt numbers. Amer. Inst. Aeron. Astronautics. 8(3): 574–576, 1970.

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Stomatal dimensions and resistance to diffusion. Plant Physiol. 46(2):337–342. 1970.

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CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111a

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that

harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

ALABAMA—AUBURN UNIVERSITY, 904
Physiological factors affecting resistance of woody plants to certain phytocides. **M. C. CARTER**

Correlation coefficient between resistance to 2,4-D and ribonuclease (RNase) levels in twelve species of woody plants was 0.62. Red maple consistently exhibited a high level of RNase activity and the inclusion of an RNase inhibitor may increase the effectiveness of 2,4-D on this species. Green ash, also a highly resistant species, did not exhibit RNase activity as high as red maple. Levels in ash frequently were as low as those in sweetgum, a 2,4-D sensitive species. Absorption, translocation, and degradation of 2,4-D were similar in green ash and sweetgum. However, most of the 2,4-D in the roots and stem of green ash was in a freely soluble form and large quantities of the foliar applied herbicide were released by the roots of green ash. Sweetgum bound 2,4-D in stem and root and released very little into the culture medium. 2,4-D resistance in green ash may result from rapid transportation and excretion or secretion by the roots.

Prometryne gave safe and effective weed control at two of three Alabama nurseries, but was injurious to loblolly pine at one nursery. Differences in crop tolerance between the nurseries was surprising and will be investigated further.

COLORADO STATE UNIVERSITY, 317
Soil-site relationships in lodgepole pine stands in Northern Colorado and Southern Wyoming.
E. W. MOGREN

Field work was done during summers of 1968 and 1969. A total of seventy-two site locations were included in the study, representing as wide a range of soil characteristics as could be located in northern Colorado and southern Wyoming within the lodgepole pine zone. Forty-five soil and other environmental variables were related to site-index.

Data were analyzed employing the following system: 1. SNOOP (W. E. Frayer) to determine relationship between site index and individual independent variable; 2. Regression Screen (Furnival) to establish X, Y relations through analysis of sets; 3. Regress program (G. M. VanDyne) to establish multiple regressions for predicting site index; 4. Correlation matrix to locate correlated independent variables; and 5. Determination of predictability of the several selected prediction equations. Three prediction equations with R^2's of 82%, 80%, and 75% were selected. The most productive independent variables in predicting site index of lodgepole pine were: 1. Percent surface stoniness; 2. Percent rock and coarse sand in A horizon; 3. Average annual precipitation; 4. Total soil depth; 5. Percent slopes and, 6. Percent clay in A horizon.

The equations developed predict site index within one-half of a site index class.

UNIVERSITY OF HAWAII, 674-F
Exploratory studies on the physiological ecology of tropical forest communities and species.
N. P. KEFFORD

The effects upon the rain forest biome in Hawaii of past attempts to convert large blocks of natural rain forest into tree plantations have been studied. The total plant-species composition of these plantations today is the result of competition among the planted species, exotic weeds which dominate much of the disturbed lower elevations of the islands, and native plants which retain abundance only at high elevations in the relatively undisturbed rain forests (Figure 2). Investigations on species compositions of 3, 5, and 8 year old forest plantations located at the 1600–1800 foot or the 2500–2700 foot altitudinal belts, in the Waiakea Forest Reserve on the island of Hawaii, led to the following conclusions.

1. Elevation is a determining factor of species composition. Approximately one-fourth of the total number of species observed are restricted to the upper altitudinal belt and 95% of these are endemic

Figure 2. Establishment of native species from surrounding undisturbed rain forest in a plantation cleared and planted 5 years previously at 2600 ft elevation in the Waiakea Forest Reserve on the island of Hawaii.

species. Another one-fourth of the total species number is restricted to the lower belt of which 90% are introduced.

2. Age of the plantation plays an influential role in the vegetation of the lower sites which were all bulldozed during preparation and now show secondary succession from grassland to forest.

3. Availability of seed source is a probable determinant of species composition. In the upper altitudinal belt it apparently influences the dominance and distribution of strawberry guava—a weed tree. In the lower altitudinal belt it probably determines the dominance of introduced flora in the younger plantations. At both altitudes, it seems to result in the establishment of many native species in the forest flora of 8 year old plantations.

4. Habitat and topography are important factors in the 8 year old plantations of the upper altitudinal belt, where community types are apparently related to soil depth.

5. Of the three species used as plantation trees, only one is vigorous in the lower altitudinal belt. At the higher elevation, all planted species are present but are sparce and failing.

6. Within all plantations, endemic species from the undisturbed forest surrounding the plantations dominate the vegetation layer composed of low trees; planted and other introduced species dominate in other layers of the vegetation.

Basic ecological studies such as this are essential for the rational assessment of competing pressures for the use of forest lands.

UNIVERSITY OF ILLINOIS, 360

Soil moisture stress and land growth and wood of loblolly pine. **A. R. GILMORE**

Seedlings from six geographic sources of loblolly pine seed from southwestern Arkansas to Maryland were planted in southern Illinois during the spring of 1949. After 20 growing seasons, oleoresins from trunk xylem at breast height were collected from 16 trees in each seed source and analyzed for monoterpene composition. Neither diameter nor total tree height was related to terpene composition. Alpha-pinene (as a percent of the total terpene concentration) was the least in those trees from the most southerly seed source and followed a near-linear progression to the most northerly seed source (72 percent vs. 84 percent). Beta-pinene was greatest in the southern sources and least in the northern sources (20 percent vs. 11 percent). Trends for camphene, myrcene, and limonene were not as clear cut as were the pinenes. These results suggest that certain physiological differences exist between some races of loblolly pine. It further suggests that these differences might account for the reported resistance to insect attack by certain races of the species.

IOWA STATE UNIVERSITY, 1582

Photosynthesis, respiration, and growth of seedlings. **J. R. McBRRIDE**

1. A controlled-environment chamber that can be used in a variety of studies of plant gas exchange was developed, and 5 units were constructed.

2. Controlled-environment studies of a series of Scotch pine seed sources showed that:

a. Seed source does affect rates of photosynthesis and respiration. However, no large differences among seed sources in photosynthetic efficiency were found in seedlings older than one year.

b. Seed source and environmental factors such as nitrogen, temperature and light intensity can have interacting effects on photosynthesis, respiration and growth.

c. Photosynthesis, respiration and growth, as measured in these studies, are not simply related. A seed

source exhibiting rapid growth does not necessarily have a high rate of photosynthesis per unit of needle weight.

d. More physiological and biochemical research is needed if differences among sources in photosynthetic capacity, efficiency and distribution of assimilate are to be satisfactorily explained. Ideally, such research should precede the use of photosynthesis and respiration characteristics in seed source selection.

3. Controlled-environment studies of four clones of *Populus grandidentata* x *alba* showed differences in photosynthesis, growth, and distribution of assimilate among clones. No among-clone differences in dark respiration were observed, and clonal rankings in terms of photosynthesis rate were not consistent between two experiments.

MISSISSIPPI STATE UNIVERSITY, 1122

Multinodal growth shoot systems in loblolly pine plantations. **W. W. ELAM**

This study deals with the growth and development of a multinodal species of Southern pine. The growth and development of the crown is of particular interest because of potential applied aspects on stand management practices.

Linear measurement data in study trees showed that elongation of secondary branches accounted for over half of the total annual elongation until the trees were six years old, then tertiary shoot elongation made up 91 percent of the total six-year growth (Figure 3).

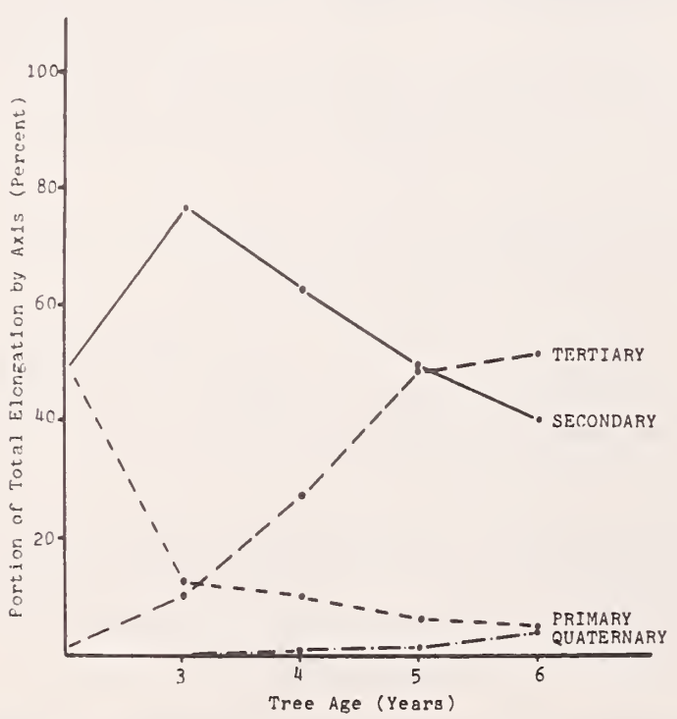

Figure 3. The relationship of axes elongation to age of young loblolly pine.

The growth contribution of overwintering buds plays a major role in total crown formation. Almost 90 percent of total six-year elongation of a typical study tree occurred in the seasonal first flush of growth which is produced by these buds. Elongation occurring on whorls of branches on the main axis which originated from overwintering buds made up more than half of the total six-year growth even though these whorls constitute less than a third of the total number of branch whorls.

Histochemical and anatomical studies concerning the physiology of multinodal growth have indicated that phenolic compounds of the phlobaphenes in the cortical region of shoots may be implicated in the multinodal growth habit of loblolly pine, perhaps through a role in the initiation and/or development of new buds. Compounds from this region were extracted and separated by chromatographic techniques. Comparison of extracts from buds and shoots at five stages of development during the growing season showed no qualitative changes. Other techniques are being employed to investigate possible quantative changes. A study of effects of selected compounds on growth and differentiation of loblolly tissue *in vitro* has been initiated. It has been possible to grow undifferentiated callus tissue for an extended period but no differentiation which might lead to possible organ formation has been observed.

UNIVERSITY OF MISSOURI, 162

Certain aspects of hardwood forest ecology.
G. S. COX and W. L. DECKER

Diurnal and seasonal relationships of the distribution of carbon dioxide within a white oak stand were studied. CO_2 concentrations were measured at heights of 10, 20, 30, 40, 50 and 60 feet above the ground at six different locations and at six different times of the year—summer, two periods in the fall, winter and two periods in the spring. The minimum average CO_2 concentration, 288 ppm, was observed during the late summer at 1700 hours. The highest average concentration, 370 ppm, was recorded at 0400 hours in midspring. The maximum diurnal variation of 55 ppm was observed during spring and midsummer while the minimum variation, 12 ppm, was recorded in winter. Stratification of CO_2

Figure 4. Instrument tower with aspirated thermistors and psychrometers.

occurred at all seasons. The greatest vertical variation was noted in late summer when the average concentration of heights of 10 feet and 60 feet differed by 17 ppm; however, for a given sampling location, average differences of 25 ppm were measured for a 10-day period. The smallest variation in the vertical profile was observed in winter, when the average difference in concentration at 10 feet and 60 feet was 3 ppm. Under stable nighttime conditions a considerable increase in the CO_2 concentration at the crown level in the stand was noted. This increase suggests the importance of the respiration rate of trees, even when dormant, on diurnal patterns of CO_2.

Slope position and aspect along a small ravine had little effect on regulating CO_2 concentrations during daylight hours. Under less turbulent conditions at night CO_2 increased in the ravine bottom during biologically active seasons. These increases were attributed to drainage into the ravine of cold CO_2-rich air which originated in the vicinity of the cooler upper-story leaf surfaces.

Changes in temperature, wind velocity, and vapor pressure were only slightly correlated with variations in CO_2 concentrations (Figure 4). On cloudy days CO_2 concentrations within the stand were lower than on sunny days.

UNIVERSITY OF MISSOURI, 606

Responses of protein synthesis to environmental stresses and resultant morphological changes.

G. N. BROWN

Repeatable changes have been observed in ratios of soluble RNAs, ribosomal RNAs, and DNA during introduction of cold hardening and dehardening in mimosa seedling epicotyls. The most interesting observations related to changes in polysome profiles, which showed a trend opposite to that theorized in the literature. Insertion of microthermocouples into stem tissues to record actual tissue temperatures during subfreezing tests for degree of hardiness have been used to document supercooling and exotherm effects as related to death points. Degree of hardiness from such tests have been correlated with the specific changes in protein synthesis mechanisms. Interpretation of these correlations suggests possible sites of regulation of protein synthesis during the induction of cold hardening, during deep hardening, and during dehardening.

UNIVERSITY OF MISSOURI, 624

Multivariate analysis of forest ecological data.

F. G. GOFF

A model for the quantitative description of the changing patterns of association during the course of succession has been developed. This approach makes use of principal components analysis to construct an initial model of species association patterns. Size classes of each species are then placed sequentially within this model, giving rise to "succession vectors" for each species. This technique has been applied to describe forest succession in Menominee County, Wisconsin and in Michigan.

Phytosociology and environmental relationships have been analyzed for a series of forests in central Missouri.

Litter production and total budget of P, K, Ca, Mg, and N have been described in the above-mentioned forest series. Over 2500 plant tissue and soil samples have been analyzed for these elements.

Phytosociology and production have been analyzed for a series of old-field in central Missouri.

UNIVERSITY OF MONTANA, 1001
Soil moisture as a determinant of plants and animals in forest communities. **T. J. NIMLOS**

This study examined the role of soil moisture in the ecology of forest communities in west-central Montana. Seven study areas, on a gradient from very dry sites to very wet sites, were subjected to detailed, systematic observations over a period of seven years. Weather, soil conditions, vegetation and faunal production, and similar parameters were measured, tabulated, and correlated. Results were summarized in two major reports (unpublished) during 1970. The study was conducted primarily on the Lubrecht Experimental Forest, and as a part of the study complete resource inventories were conducted on the Forest. These included: a geologic survey, soil survey, timber and forage inventories, mammal species list, bird species list, invertabrate species list, complete records on weather and hydrologic characteristics, etc.

The Project will be terminated on June 1, 1971, but it will be followed by a sophisticated ecosystem study which will be initiated on the Lubrecht Forest during the summer of 1971.

UNIVERSITY OF MONTANA, 1801
Nutrient culture of western larch. **J. M. BEHAN**

Nitrogen, potassium, and phosphorus field fertilization trials were remeasured at 4 locations in lodgepole pine forests in western and central Montana. Each location consists of 2 blocks of 4 treatment plots, and each plot is 0.1 acre. Results are being summarized for publication during 1971.

Diameter increments, height measurements, and foliar nitrogen, potassium, and phosphorus contents from over 500 western larch trees in 13 locations and fertilized with N, P, and K fertilizers in 1966 were obtained and analyzed for fertilizer response. Nitrogen responses were obtained in 10 of the plots and potassium responses in 2 plots. Increment responses in the treated plots ranged from an increase of 7–45% greater growth, depending upon location, than the control plots. The responses were obtained in spite of the fact that 1968 was a drought year. A good correlation between fertilizer application, increment response, and foliar mineral content was obtained. Data are being summarized for publication in 1971.

NEW YORK–STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 111-2-3
Biochemistry of seed dormancy. **E. SONDHEIMER**

Many trees growing in the temperate zone produce seeds that are dormant until they have received an adequate low-temperature after-ripening treatment. This is clearly of survival benefit to the plants since it prevents premature germination and subsequent winter killing of the sensitive young seedlings. The biochemistry of this process is not understood. Our research has centered around the hormonal regulation of this process and we have used ash tree seeds for much of our work. Excised embryos from dormant seeds will not germinate under the same conditions that those from nondormant seeds will. Our work indicates that the hormone abscisic acid may be intimately involved in seed dormancy. While all ash seeds examined contain this hormone, the concentration is significantly lower in nondormant seeds, and drops during low-temperature after-ripening. Gibberellins can be used to initiate germination of dormant ash embryos, but contrary to expectations they do not occur in these seeds nor is there any evidence for their biosynthesis during low-temperature after-ripening. We have synthesized abscisic acid with ^{14}C and are using it to look for differences in the way this compound is treated by dormant and nondormant ash seeds. So far we have seen three radioactive metabolites. Work on their structure determination is in progress and experiments to determine the physiological activity of the conversion products will be undertaken. We will also start experiments which should tell us whether the hormones that antagonize abscisic acid actions, gibberellins and cytokinins, will influence in the abscisic acid metabolism. These studies are providing new insights on the regulation of seed dormancy that will eventually find practical applications in tree management.

OHIO AGRICULTURAL RESOURCE AND DEVELOPMENT CENTER, 6
Physiology of the formation of wood in oak and pine. **F. W. WHITMORE**

Dormant red oak seedlings were allowed to break dormancy and grow under constant water stress ranging from $\Theta 1/3$ to $\Theta 6$ bars. With increasing stress,

the cambia in the stems produced fewer vessels and tracheids during the six week test period. However, the number of vessels formed from overwintering mother cells was unaffected by treatment. This observation suggests that certain dormant mother cells are predisposed to differentiate into vessels, and such differentiation is unaffected by water stress.

A study of the seasonal changes in soluble carbohydrates, starch, saponifiable fats, and phenolic compounds in the phloem and cambium of 30-year-old white pine is underway. The changes in these cell wall substrates will be compared with a cell-by-cell reconstruction of the annual ring of wood made by transverse microtome sections from samples taken weekly. One series of trees was subjected to drought by covering the ground above the root systems with plastic sheeting. Earlier work has shown that tracheids produced in the latter part of the season have a longer life span. If this study shows that cell wall substrates in the latter part of the season exceed the amounts available earlier, as suspected, the current hypothesis of the transition from thin-walled earlywood tracheids to thick-walled latewood tracheids in conifers would be strengthened.

Figure 5. Transpiration of Douglas-fir seedlings is measured to determine effect of seed source and nursery growing conditions on seedling survival under moisture stress.

OREGON STATE UNIVERSITY, 794
Transpiration of Douglas-fir seedlings.
W. K. FERRELL

The study described here was undertaken to determine the effect of a number of plant and environmental variables upon the transpirational behaviour of Douglas-fir seedlings. Transpiration rates of small, 2 to 16 week-old Douglas-fir seedlings have been measured very accurately under standard conditions of temperature, light, and humidity (Figure 5). Some of the effects of pre-treatment, age, soil and plant water potential, and ecotype on rate of transpiration have been determined.

In general, unit rates decreased with age, were higher for seedlings grown in sunlight than in shade, and decreased in response to decreases in both soil and plant water potential. Seedlings from areas of high rainfall had higher transpiration rates than did seedlings from areas of low rainfall.

The results encourage the belief that transpiration rates, and in turn survival in droughty situations, may be improved by nursery growing conditions, and by selecting seed sources with low transpiration rates. Further research, currently underway, deals with the rate of cuticular transpiration when the plant is under moisture stress and the stomates are closed. This should assist in determining how severe growing conditions and seed source affect transpiration.

OREGON STATE UNIVERSITY, 840
Primary productivity of red alder ecosystems.
D. P. LAVENDER

The biomass and the composition of 15 stands of red alder (*Alnus rubra* Bong.) on river bottom sites in Western Oregon was measured. These stands ranged in age from two to 64 years. Biomass was found to vary from 134 k/ha (kilograms per hectare) for the very youngest stand to 7700 k/ha in one of the older stands. Net productivity for the first 64 years was estimated as 97 k/ha per year. Understory biomass was found to be a very small portion, up to 2.5% of the biomass of the alder overstory for similar stands.

Composition was found to vary considerably as age of the overstory increased. Succession from a grass-herb dominated understory to a shrub-fern dominated understory was quantified. The findings appear to support an earlier prediction that lands now dominated by red alder may be dominated by brush fields

of *Rubrus spectabilis* in the future in the absence of a suitable conifer seed source.

SOUTH CAROLINA–CLEMSON UNIVERSITY, 853
Control of gas exchange in pine needles.
R. M. ALLEN

The material presented below is from a master's thesis "Effects of water stress on oxygen production of detached loblolly and white pine needles" by Ansel E. Miller.

Changes in rate of oxygen production, apparent stomatal diffusive capacity, and water content were measured concurrently in needle tips detached from loblolly (*Pinus taeda* L.) and white pine (*P. strobus* L.) seedlings. Correlations among the measured variables were determined using samples of needle tips from seedlings in varying degrees of water stress. In other experiments, water stress was imposed in detached needle tips by causing them to become desiccated from transpiration losses or by placing them in an osmoregulating solution. Responses of the needle tips to programmed environmental changes were measured.

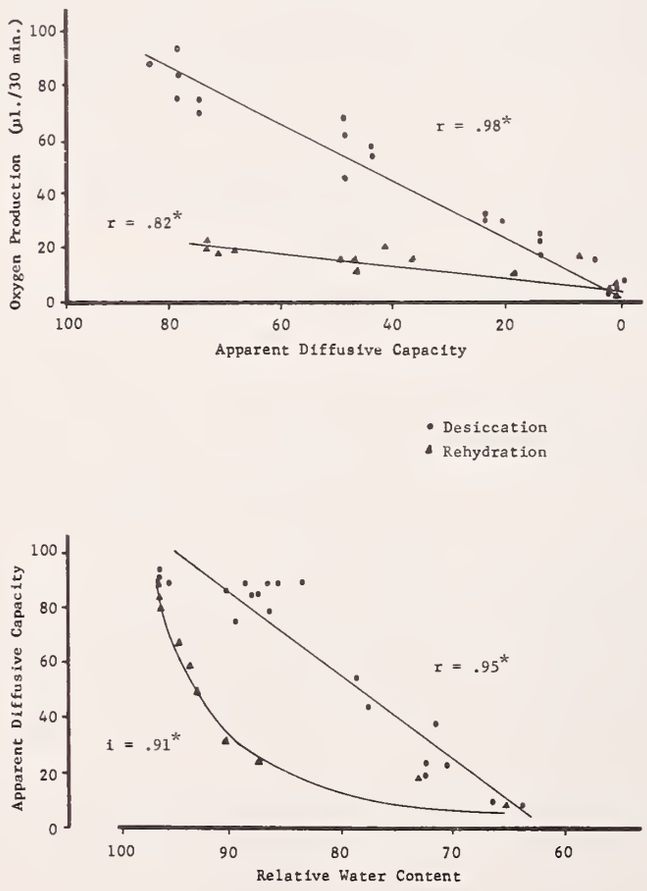

Figure 6. Oxygen production and apparent diffusive capacity in pine needles.

Oxygen productions were measured manometrically using a Warburg apparatus. The changes in apparent diffusive capacity of the stomata were determined by a fluid pressure-infiltration technique. Changes in water content were measured gravimetrically and expressed as a percent of the final water content attained. Relationships among oxygen production, apparent diffusive capacity of the stomata, and relative water content were measured using correlation analyses.

Reduced oxygen production occurred in needle tips detached from loblolly and white pine seedlings under conditions of water stress. Decreases in oxygen production were found to be associated with decreases in diffusive capacity caused by stomatal closure. The relationships between the apparent stomatal diffusive capacity and oxygen production were different when the needle was losing water than when it was absorbing water (Figure 6– Upper). The apparent diffusive capacity of the stomata decreased linearly with decreasing water content of the needles, but with rehydration the increase in diffusive capacity was quite slow until the needle were almost turgid whereupon the diffusive capacity increased rapidly (Figure 6–Lower).

SOUTH CAROLINA–CLEMSON UNIVERSITY, 887
Phenolic compounds in the flower parts of pine.
A. T. SHEARIN and R. M. ALLEN

Collections of male strobili were made from at least three trees of each of the following species: *Pinus taeda, P. echinata,* and *P. rigida.* In addition, collections were made from five putative natural hybrids. Results from paper chromatographs of the hot water extracts of the strobili indicate there were differences in the phenolic compounds among the three species that could be of taxonomic value. The variability from tree to tree in kinds and amounts of compounds extracted from the putative hybrids does not permit any conclusion as to their parentage.

SOUTH DAKOTA STATE UNIVERSITY, 551
Forest ecological succession on Missouri River reservoirs.
P. E. COLLINS

Progress since initiation, (July 1, 1970), of this study has been directed toward a survey of vegetation along two reservoirs in Central South Dakota. The lower

reservoir, Lake Francis Case, was completed in 1956. It has a significant pool fluctuation of 30 vertical feet. The upper reservoir, Lake Sharpe, was completed in 1966 and has a relatively stable pool elevation and a maximum fluctuation of 8 feet. The survey method used was a belt transect 3 feet wide laid out perpendicular to the shoreline. The upper end of the transects was started at the edge of the "zone of primary influence" which surrounds the reservoirs and ran through this zone down to the water's edge. All dominant vegetational types in the transect were identified and mapped to scale on graph paper with an accompanying profile of elevation marked to the nearest foot. The length of the transects and corresponding "zone of primary influence" varied considerably depending on degree of slope, soil permeability and current pool elevation.

Particular attention was given to tree reproduction located in the transect belt, and its location with respect to elevation and distance from the shoreline. Concentration of tree seedlings on the different transects tended to correspond to elevation, regardless of degree of slope, horizontal distance from shoreline or type of associated vegetation. A possible explanation is that water-borne seed drifted to shore in a short enough period so that pool fluctuation wasn't a factor. Another possibility is that soil moisture conditions were favorable for airborne seeds to germinate at a particular elevation of the reservoir. Initially 25 separate species of dominant vegetation in the "zone of primary influence" along the reservoirs have been identified. Included in these 25 are 4 tree species: American elm, Eastern cottonwood, willow and green ash. Herbaceous species most often associated with tree reproduction were *Xanthium strumarium* (cockle bur), *Artemisia annua* (wormwood), *Leonurus cardiaca* (wild four o'clock) and *Rumex* sp. (dock).

The zone of primary influence or that area adjacent to the reservoirs where vegetation is significantly different from the native grassland is on the average narrower around the non-fluctuating reservoir than around the fluctuating reservoir. How much of this is due to the low fluctuation or to the younger age of the non-fluctuating reservoir is as yet undetermined.

Further study of these shoreline areas will hopefully shed light on the fate of tree reproduction, some possible successional trends, stability of the shoreline and the type of recreational environment that can be developed adjacent to these reservoirs.

UNIVERSITY OF VERMONT, 9

Internal moisture content and light intensity influences on photosynthesis and transpiration of beech seedlings.

J. R. DONNELLY

The objectives of this project were to evaluate the relative effects of internal moisture stress and light intensity on photosynthesis and transpiration of beech seedlings. Objectives were accomplished under controlled laboratory conditions by monitoring rates of photosynthesis and transpiration within a closed chamber.

Light intensity accounted for 80 percent of the variation in transpiration and 76 percent of the variation in photosynthesis; in contrast, soil moisture and leaf moisture conditions only accounted for an additional 5 percent in transpiration and 3 percent in photosynthesis. Therefore light intensity, rather than moisture content may be the single most important environmental factor affecting the growth and vigor of beech seedlings.

UNIVERSITY OF VERMONT, 12

Role of cell transitions in the physiology of some northern hardwoods.

F. M. LAING and J. W. MARVIN

To study the growth periodicity of northern hardwood trees it is necessary to understand the functioning of the phloem of these trees, most especially the changes which take place in these tissues at the onset of dormancy and at release from dormancy.

Techniques for obtaining comparable specimens of bark from the species of northern hardwood trees being studied have been evaluated. Sectioning and staining techniques for making slides for microscopic study have also been evaluated and procedures adopted.

Regular collections of bark are made from: sugar and red maples, white and yellow birches, basswood, ash, black cherry, beech and hophornbeam. More frequent collections are made during the autumn period of leaf color change and the spring period of bud break.

As expected, it has been found that the sieve tubes of the bark of these trees are made inoperable by the formation of callus pads in autumn. It is not yet clear whether all of the sieve tubes become plugged; there are indications that some species, i.e., maples, retain

some conducting elements through dormancy. Variability within and between species has been found in the time sequence of sieve tube plugging and leaf color change; some trees with green leaves appear to have non-conducting phloem tissues.

It is expected that more frequent sample collections will allow closer correlations of bark and cambial cell activities with physiologic activities such as sap flow, bud break and dormancy.

UNIVERSITY OF WASHINGTON, 21
A systems approach to the analysis of a coniferous ecosystem. **D. W. COLE**

This project is now superseded by the IBP Western Coniferous Biome program. This occurred early in 1970. Work performed on the project was instrumental in many ways in developing the initial concepts and organization structures for the IBP efforts at the University of Washington.

ADDITIONAL PROJECTS

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Nutrient cycles in selected interior of Alaska forest types. **K. VAN CLEVE**

UNIVERSITY OF ALASKA, 270-0541
Forest succession and soil moisture retention on upland sites in the Fairbanks area. **B. J. NEILAND**

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Correlation of soil survey information with tree growth. **C. M. KAUFMAN**

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Sampling, estimation and model building for forest resources management. **K. D. WARE**

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Hardwood species and cultural practices needed for rapid fiber production. **W. A. GEYER**

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Effects of silvicultural treatments on wood properties of even-aged loblolly pine plantations.
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Woody fiber production and utilization of complete trees and shrubs. **H. E. YOUNG**

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Maple tree root initiation, development and geotropic response. **B. F. WILSON**

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Protein synthesis mechanisms and morphology of tree seedlings during winter. G. N. BROWN

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Survival of grass and tree species at high elevation in the Sierra Nevada. E. L. MILLER

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F. L. STONE and R. C. McKITTRICK

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Tree growth studies. H. B. TEPPER, H. E. WILCOX and F. A. VALENTINE

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Metabolism and movement of herbicides in woody plants. E. BASLER

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An ecological framework for forest land management in Southwestern Oregon. R. H. WARING

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Mechanisms of succession. M. NEWTON and W. W. CHILCOTE

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X-ray examination of seed embryos.
W. H. D. McGREGOR

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Influence of environment on quality of wood of Douglas-fir. J. S. BETHEL

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Ecology and physiology of Douglas-fir and true firs.
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Snow catch in coniferous crowns.
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Biotic communities of forest and grazing lands.
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Variation and ecology of aspen. A. A. BEETLE

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GENETICS AND BREEDING OF FOREST TREES

Research Problem Area 301

Forest practice today is based largely on wild forest trees. Unlike crop plants, trees have not undergone centuries of controlled selection and breeding to make them more useful to man. There is strong evidence that through application of genetic principles we can produce tree varieties that grow faster, resist most major destructive pests, have specified wood properties, or yield more sap or gum. It should be feasible to develop straighter form, fewer limbs and resistance to climatic extremes. Quality and yield

of timber-related crops such as naval stores, ample sap and Christmas trees can be improved through application of research findings.

COLORADO STATE UNIVERSITY, 319

Crossability and compatibility patterns in spruce.

G. H. FECHNER

Hopefully, a hybrid between blue spruce and Engelmann spruce would combine the timber qualities of the latter and the drought resistance of the former. However, complete inviability of blue spruce x Engelmann spruce seed and low viability of that obtained from the reciprocal cross in 1967 studies suggested that a highly effective hybridization barrier exists between these two species. The present study determined the previously-implied incompatibility pattern as one in which the pollen was unable to function properly in the ovule of a different species. Ovules which received no pollen did not develop.

Open-pollinated blue spruce and Engelmann spruce conelets and artificially-pollinated conelets of both species were collected every three days throughout the growing season. Completely unpollinated blue spruce conelets were collected every-other-day for 22 days.

Microscopic examination of blue spruce ovules artificially pollinated with Engelmann spruce pollen showed that many of the ovules were capable of developing normal eggs. However, in almost all instances the germination or growth of the Engelmann spruce pollen tubes was inhibited, slowed, or halted, and the blue spruce eggs began to degenerate before the pollen tubes reached them. Often the Engelmann spruce pollen tubes burst shortly after germinating and penetrating the nucellus (Figure 7). The ovules containing eggs developed to full size and continued to produce nutritive tissue even though no embryo was present. Breakdown of the hybrid blue spruce ovules was observed at all intermediate stages of development preceding the egg. Only four hybrid embryos were found, two of which died at an early stage, one that was mislocated and of small size for its time of development, and one that was normal.

Unpollinated blue spruce ovules began to degenerate 12 days after their peak receptivity. The internal breakdown of unpollinated ovules was different, depending on whether the conelet had received any pollen or not. Those in conelets that had been isolated from any pollen were smaller than normal. A common early stage showed the cellular female gametophyte protruding into the nucellus (Figure 8).

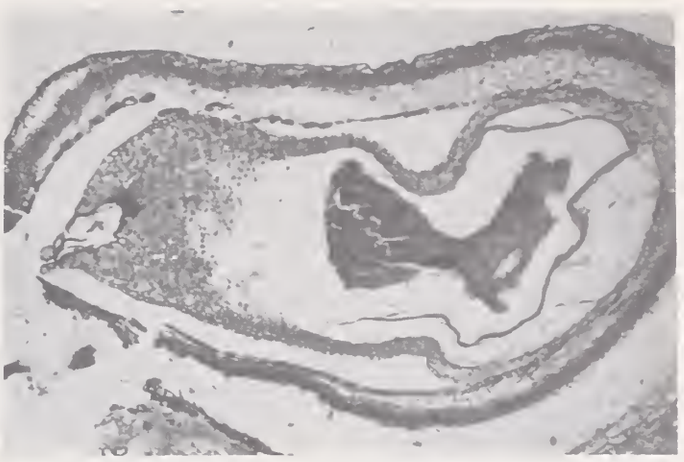

Figure 7. Blue spruce ovule 36 days after crossing with Engelmann spruce pollen. Note burst pollen tube at nucellar cap and dark, degenerating female gametophyte tissue.

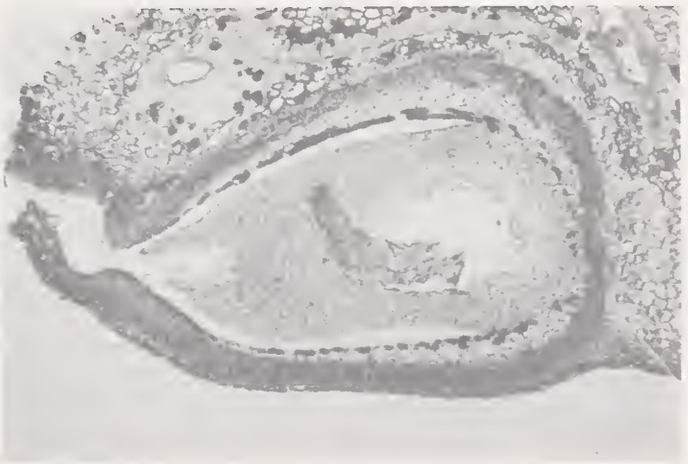

Figure 8. Early stage of unpollinated blue spruce ovule 11 days after receptivity, showing female gametophyte protruding into nucellus.

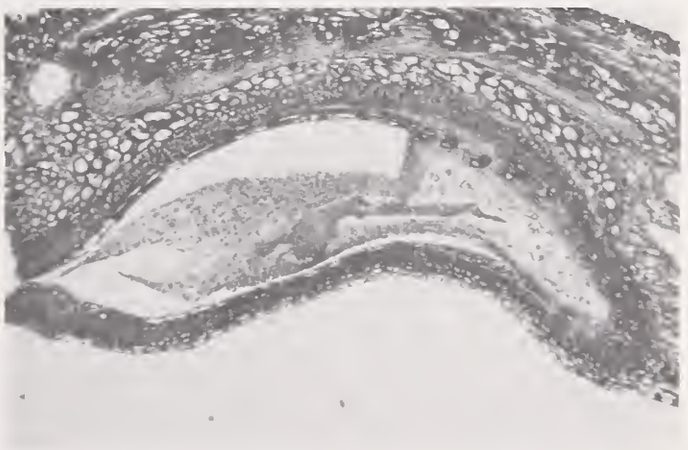

Figure 9. Unpollinated blue spruce ovule 18 days after receptivity, showing flattened, indented appearance and degenerating internal tissues.

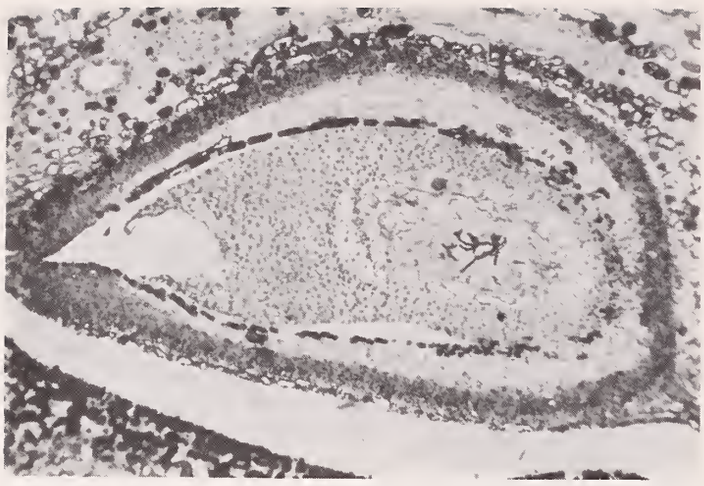

Figure 10. Early stage of unpollinated blue spruce ovule, 15 days after the cone received Engelmann spruce pollen, showing degenerating female gametophyte in the center.

In an advanced stage these ovules were usually flattened or indented due to the lack of development of the internal tissues (Figure 9). In unpollinated ovules from conelets that had received pollen, the female gametophyte remained intact prior to degeneration (Figure 10). These observed differences suggest that pollen present in some ovules of a conelet influence the ovules not receiving pollen, in the same conelet. A few of the unpollinated ovules in conelets receiving Engelmann spruce pollen did enlarge to nearly full size.

Thus, this study also shows that in order for development to maturity to occur, blue spruce ovules require at least the presence of pollen, if not its germination and penetration into the nucellus of the ovules.

SOUTHERN ILLINOIS UNIVERSITY, B-1-69
Structural studies of early and delayed graft incompatibility in Juglans. **M. KAEISER**

No one knows precisely why vegetation grafts of trees fail. Structural studies are needed to observe and record the many anatomical changes that take place in the growth of scions and stocks of our important commercial trees.

Fortunately, the USDA Forest Service has established a breeding orchard at Carbondale which has provided eighty-three pedigreed seedlings of black walnut, sixteen of Japanese heart nut, and five English walnut for grafting purposes.

Microscopic sections through the graftage area show apparent success of "takes" requires the activity of both scion and stock to provide callus tissue from which cambium arises to form both xylem (wood) and phloem which must ultimately connect with the water and dissolved mineral conducting tissue (xylem) and the food conducting tissue (phloem in the inner bark) of the entire transport systems. Particular attention is being paid to both outer and inner bark development in conjunction with formation of growth rings of the wood.

KANSAS STATE UNIVERSITY, 771
Forest tree improvement for Kansas through selection and breeding. **R. W. FUNSCH**

A study in a Latin square design of Scotch pine planted in 1968 indicates that Spanish sources have extremely slow growth, French (Auvergne) sources moderate growth, and Czech sources rapid growth. French sources, having good form from this moderate growth, would therefore be excellent for the Christmas tree industry.

Seed procurement was intensified. Black walnut and bur oak material was obtained extensively.

Survival of newly planted pecan varieties was high. Carpathian walnut, also included in this planting, showed exceptional vigor throughout the growing season.

Survival of a sweetgum, tulip poplar, and black alder planting after one growing season indicates that further studies should be done with these species.

Polyploidy studies of conifers are currently underway. Tetraploid material grown will be set out in field studies.

A rooting study of needle fascicles is continuing.

Outplanting of exotic conifers showed extremely high mortality and will be discontinued. Douglas-fir, bald cypress, Serbian spruce, bristlecone pine, and blue spruce did poorly. White pine and Japanese black pine should be studied much more extensively.

Collections of native tulip poplar reveal very low amounts of filled seed (approximately 1%). If further collections during excellent pollination years reveal similar low amounts, seed should be processed from more easterly sources.

MICHIGAN STATE UNIVERSITY, 1061

Forest tree improvement through selection and breeding. **J. W. WRIGHT**

To lay the foundation for the next generation of intensive breeding work and to obtain improved seed, a half-sib progeny test of eastern white pine was established in 1962. The seeds were collected from 123 native trees growing in 14 widely separated counties of Michigan and the trees were planted in seven test plantations in the state.

At age 9 the most striking growth differences were associated with region of origin. In Lower (= southern) Peninsula test plantations, trees grown from seed collected in the western half of the Lower Peninsula averaged 20 to 40% taller than trees grown from seed collected in the Upper Peninsula. In Upper Peninsula test plantations, the Lower Peninsula origins were 8% taller than Upper Peninsula origins.

Progenies from different stands in the same region did not differ appreciably, but there were significant differences among progenies of different trees in the same stand (no significant parent-progeny correlation, however). The heritability was such as to indicate that half-sib family selection will increase growth by 1 to 2% in addition to the gain achieved by using seed from the proper region.

Tip injury to current-year needles was evident in three Lower Peninsula plantations, and was under a very high degree of genetic control–8% of the families accounted for 49% of the damage. The cause of this damage–whether spring frost, air pollutants or some other factor–is being studied. Disappointingly, resistance to damage by white pine weevil was uniformly low.

UNIVERSITY OF MISSOURI, 607

Genetic investigations in forestation. **R. B. POLK**

Started clonal bank of 19 select *Pinus sylvestris* on *P. sylvestris* and *P. mugo* rootstocks. Added 4 clones to *P. banksiana* breeding orchard. Established field plantings of 15 commercial selections (provenances and strains) of *Pinus sylvestris.* Made field plantings of *P. sylvestris* (precocious and nonprecocious lines) and *P. mugo,* preparatory to rootstock-effect evaluation. Made field plantings of *P. sylvestris* for rootstock use in evaluating effects of subirrigation drainage and scion genotype on seed production and other factors.

UNIVERSITY OF MONTANA, 904

Hybridization of western and sub-alpine larch. **G. M. BLAKE**

Three aspects of the project were investigated during the period. The results of these efforts follow:

1. A comprehensive study of the ecology of subalpine larch was completed. The results of this undertaking have greatly increased an understanding of the fundamental differences between western and subalpine larch.

2. A range map of the two species has been updated. New areas of range overlap, where possible introgression may be taking place, have been located. Further ground reconaissance of these areas is planned.

3. The relationship of stocking level to total standard productivity in second-growth western larch is being investigated. Ten-year results are presently being analyzed as part of a Ph.D. dissertation.

UNIVERSITY OF NEBRASKA, 20-28

Tree breeding. **W. T. BAGLEY**

Ten year old green ash provenance plantings at four locations in the Great Plains Region showed that a

Figure 11. A ten year old green ash provenance planting at Plattsmouth, Nebraska, with three trees of a North Dakota source on the right of the marker in the foreground and three trees of a Kansas source on the left.

seed source can be moved about 3° north in latitude with resultant increased growth over a native source without winter injury (Figure 11). Moving a source south produced trees of good form but slow growth. Photoperiod appears to be the key factor controlling this behavior. The progeny of 100 individual green ash seed trees has been measured in the nursery. These represent 30 stands scattered throughout the Great Plains Region. The response of these seed sources to photoperiod and temperature is being studied.

Juniperus virginiana provenance plantings of 20 sources were established at three locations in Nebraska. Seedling response to photoperiod is being studied. Seven and ten year old hybrids of *Populus* sp., *P. Xcandensis,* and a *P. deltoides* clone were compared in 2 eastern Nebraska plantations. Survival, growth, leaf and bark characteristics were analyzed. One hybrid, *P. Xcandensis* 'NE-237' exhibited exceptional vigor and growth.

Cuttings of Japanese larch, red oak and Scotch pine subjected to centrifugation and IBA failed to root satisfactorily in a special chamber where temperature, light, and humidity were carefully controlled.

NORTH CAROLINA STATE UNIVERSITY, 4023
Variations of white oak in the southern Applachians.
J. W. HARDIN and M. J. BARANSKI

Samples of 450 individual trees from 104 different populations of white oak are now available. These samples include leaf specimens, ecological observations, acorns, bark photographs, flowering material, and wood core samples. Approximately 150 additional sites were essentially randomly located along the elevational gradient, without regard to presence or absence of white oak, and analyzed for composition of vegetation. Specific gravity determinations have now been included with the other comparative studies. Reciprocal transplants and reciprocal grafts (100% failure on first attempt) have been made, and are presently under observation. Further germination and seedling survival studies in the greenhouse are also in progress.

Distributional analysis of white oak demonstrates that there is no real altitudinal gap in existence between low and high elevation populations in either the Great Smokies or elsewhere in the southern Appalachians. Instead, white oak occurs continuously along the elevational gradient on sites conducive to its growth. Its uppermost limit in the southern Appalachians appears to be reached between 5200–5300 ft., with a maximum of 4600 ft. in the Smokies. The relative percentage of abundance and cover has been estimated for the entire elevational gradient available, and there are two discernible modes correlated with moisture and elevation. The ecological factors and the critical stage of the life cycle affecting its distribution have not been identified. Variability throughout the southern Appalachians is viewed as both random variation and that due to ecophenic or ecotypic differences along the elevational cline (large trees, leaves and acorns at low elevations, and small trees, leaves and acorns at high elevations). The distinction between ecophenic and ecotypic differences in natural populations has not yet been determined conclusively through use of the Phytotron.

The origin of the seed source, with respect to latitude, altitude, and moisture, would be important for any commercial plantings of white oak.

OKLAHOMA STATE UNIVERSITY, 1349
Cottonwood improvement. **R. W. STONECYPHER**

Eastern cottonwood, (*Populus deltoides,* Bartr.), is easily vegetatively propagated and has a relatively fast growth rate. It should be economically feasible to accurately and rapidly screen wild cottonwood selections in experimental plantings to minimize errors of phenotypic selection.

An index is being developed on which selections from these plantings will be based. This index will be developed using data taken from two cottonwood plantings in Oklahoma. The index will be constructed using dry-weight yield of fiber as a criterion for selection.

Criteria for phenotypic selections have been established and selection along the Red River has begun. Regression equations have been constructed for predicting total dry-weight yield in the experimental material from specific gravity, height, and diameter of the standing tree. One hundred thirty trees representing the same clones in the experimental plantings were destructively sampled to develop these regression equations. Computer programs have been developed to partition to the total variation in the experimental plantings into environmental and genetic sources and to develop the selection index.

Figure 12. Seed sources for variation and tree improvement studies in the genus *Quereus* at Clemson University.

Once gains from individual-tree selection are realized, it will be necessary to cross these selections to produce new gene combinations from which further selections and gains can be made. To facilitate these crosses, methods of pollination and forcing seed from vegetative cuttings in the greenhouse are being investigated.

SOUTH CAROLINA—CLEMSON UNIVERSITY, 717

Variation and tree improvement studies in the genus Quercus. **R. E. SCHOENIKE**

In 1965, a seed source study was started with southern red oak (*Quercus falcata* Michx.) to assess the genetic variation in the species over its range. Acorn collections were made over a three-year period, 1965—1967, by cooperators in 16 states. The acorns were kept separate by trees and each cooperator was requested to collect from five trees.

Two field plantings were made. The first, in 1968, was composed of the progeny of 65 mother trees representing 21 seed sources. In 1969, the second planting was made with the progenies from 110 mother trees representing 39 sources. There were five replications in each planting. The sources are shown on the map in (Figure 12).

After three growing seasons the mean survival for the 1968 plantation was 65 percent ranging from a low of 50 percent for the Lincoln Parish, Louisiana source to a high of 76 percent for the Oregon Co., Mississippi seedlings. Mean height for the plantation was 1.7 feet, ranging from a low of 1.3 feet for the Clarke Co., Georgia, to a high of 2.5 feet for the Colleton Co., South Carolina source. At this early age, no overall trends in either survival or early height growth could be discerned.

After two growing seasons the mean survival for the 1969 plantation was 76 percent, ranging from a low of 57 percent for the Columbus Co., North Carolina to a high of 100 percent for the Vernon Parish, Louisiana source. Mean height for the plantation was 1.2 feet, ranging from a low of 0.8 feet for the Alachua Co., Florida seedlings to a high of 1.9 feet for the Ashley Co., Arkansas source. Like the 1968

plantings, no geographic trends in either survival or height was evident.

The plantations have been so designed that it will be possible to compare the progenies of the different mother trees within the same seed source. This was not attempted with the current set of observations but will be made in the future. Although seventeen sources are represented in both plantations, the progenies of individual mother trees in each are different, hence direct comparison between the two plantations will not be possible.

WASHINGTON STATE UNIVERSITY, 1771
Genetics of multinodolness in lodgepole pine (Pinus contorta Dougl.). **R. W. DINGLE**

Progeny from 8 PNW source areas grown at Pullman showed differences in 1st year winter foliage coloration which were related to 2nd year seedling height. Those from high elevations (5000′) were early in terminal winter bud formation, fall color development, and flushing, and grew less than those from mid- and lower-elevations.

Progeny with fall color but not completely red were tallest at a mean height of 21.0 cm.; those that became completely red had a mean height of 14.8 cm.; those that remained completely green had a mean height of 13.1 cm.; these differences were significant at 0.1% probability.

First year winter foliage color may be usefully predictive for 2nd year seeding height.

In another experiment, the influence of preincubation soak treatments with 6 concentrations of gibberellic acid (GA_3) and light during incubation (an 8-hour photoperiod w/10 C-dark and 20-C-light temperatures) on germination rate and capacity of 4 coniferous species and genera, including *Pinus contorta* were tested. GA_3 had no effect, while the effect of light was highly significant though variable. Germination of *P. contorta* on the 20th day of incubation in the light was nearly 2X that in the dark; total germination in 48 days was 1/3 greater in the light than in the dark.

Some other Gibberellin than GA_3 may be found to affect shorter incubation periods for *P. contorta*, but here GA_3 had no effect. On the other hand optimum photoperiod and temperature regimes for seed incubation should accelerate rate and increase total germination.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 912
Genetics, breeding and evaluation of certain forest trees in Alabama. **J. F. GOGGANS**

CALIFORNIA—HUMBOLDT STATE COLLEGE, 11
A provenance study of coast redwood (Sequoia sempervirens). **J. H. HANSEN**

CALIFORNIA—HUMBOLDT STATE COLLEGE, 9
Transpiration reduction of transplanted coniferous forest seedlings. **D. THORNBURGH**

CALIFORNIA—HUMBOLDT STATE COLLEGE, 20
Accepting stocking levels for managed coniferous stands. **D. L. ADAMS**

UNIVERSITY OF FLORIDA, 1344
Improvement of sand pine for reforestation of the Florida sandhills. **R. K. STRICKLAND**

UNIVERSITY OF IDAHO, 3
Heritability and population structure of ponderosa pine. **C. W. WANG**

SOUTHERN ILLINOIS UNIVERSITY, 69-R-11
Genotypic variation in black walnut—growth patterns for 20 geographic sources. **P. L. ROTH**

IOWA STATE UNIVERSITY, 1872
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Cross and self incompatibility in trees.
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FUR BEARING ANIMALS, WILDLIFE, AND FISH AND OTHER MARINE LIFE

Research Problem Area 904

Research on wildlife, fur-bearing animals, fish and other marine life is needed to meet the ever growing demands of hunters, trappers, and fishermen; to develop improved production of farm reared fish and fur bearing animals; and to assure continuing supplies of marine life for food and other purposes.

To maintain and increase the supply of wildlife, fish, and other marine life it is essential to know how to maintain and enhance their habitat, and to determine the biological requirements and relationships of

each species, including cover and food for normal growth.

Increased knowledge of fish biology is needed to put commercial production of fish in farm ponds and lakes on a paying basis.

UNIVERSITY OF MASSACHUSETTS, 12
Man-Animal interactions in the northeastern forest environment. **J. S. LARSON**

We have chosen to start with studies of beaver and black bear, species which were extirpated from much of New England and now are abundant or on the increase. Both pose some measure of potential or actual conflict with man and his works. Beaver, less valued for fur than in former years, are now widespread, often plugging culverts, cutting trees and creating wetlands where none have existed since the 1700's. Transplanting nuisance individuals is impractical, live trapping is a difficult and never-ending task, and current fur prices are not a strong incentive for steel trapping. Black bear in recent years have become a numerous big game in northern New England and appear to be extending their range southward into Massachusetts.

Our initial beaver research is centered on social and construction behavior. Beaver colonies have been live trapped and color ear-tagged (Figure 13) for visual identity of individuals by sex and age class. Our results suggest that a matriarchal society is present with the female the dominant animal in both social contacts and construction activity. We expect that behavior studies will improve our understanding of the basic relationships between behavior and survival and point to more efficient ways of controlling dam construction and beaver numbers.

Figure 13. Ear tagged beaver under observation in studies of man-animal interactions in the Northeast.

Black bear research is concentrating on the history and distribution, over time, of this species in New England. We will be projecting future changes in bear distribution and making recommendations for changes in hunting regulations. Potential conflicts between man and bear in more densely populated southern New England will be more clearly identified.

UNIVERSITY OF MONTANA, 804
Recreation use of forest lands in Montana.
S. S. FRISSELL

A study of wilderness users in the Anaconda-Pintlar Wilderness Area was completed and reported in a Ph.D. thesis. Some of the significant findings are:

a. Almost exclusively trail travel. Very little cross-country.

b. More than one-half of 45 zones received no recorded use. (Use is concentrated.)

c. Use is strongly water-oriented. All use concentration points are at mountain lakes or on larger streams where fishing is good and scenic values are high.

d. Heavy use trails are those rated as easy access.

e. Large organization parties use zones overlapping areas used by other parties. Could lead to crowding and conflicts in areas such as Johnson Lake.

f. Use intensities, could be reduced and potential conflict lessened by use zoning based on trails.

g. There exists an obvious need for better area-wide planning. The Anaconda-Pintlar Wilderness is now spread between three forests and four ranger districts.

Other studies not yet completed:

a. Wilderness Ecology of the Southern Bob Marshall Wilderness Area.

b. Some Ecological Relationships of Grizzly and Black Bears in Glacier National Park.

c. Environmental Planning Along Montana's "Blue-Ribbon Trout Streams."

Figure 14. The portable telemetry system includes an antenna, a small receiver mounted under the antenna, and a portable oscilloscope.

Figure 15. Vertical "flashes" on the oscilloscope screen indicate presence of signal from subject animals. The flash rate identifies particular animals.

UNIVERSITY OF RHODE ISLAND, 955

Wildlife telemetry in forest environments.

E. F. PATRIC and R. W. SERENBETZ

During 1970 a portable wildlife telemetry system was developed (Figure 14). This system is designed for use in the dense vegetation and irregular terrain characteristic of northeastern forests. In use, small radio transmitters are affixed to subject wild animals, which are released into their native environment. The radio transmitters are timed by a tiny electronic timer to provide bursts of relatively powerful radio frequency energy at intervals varying from 5–30 seconds between bursts. The period between bursts is specific for each animal. Since the bursts are very brief, the presence of a transmitter is indicated by flashes on a portable oscilloscope (Figure 15). The direction of the subject animal is indicated by the angular position of the antenna which provides the maximum flash or vertical deflection on the oscilloscope. The system indicates the presence of and general location of particular subject animals.

In this project we are also developing precise animal position methods using hyperbolic methods of radio position finding. A description of this phase of the project is in press, New York Fish and Game Journal.

The project is a contribution of New York Pittman-Robertson Project, W-123-R, Bureau of Sport Fisheries and Wildlife, New York Department of Environmental Conservation and the Rhode Island Agricultural Experiment Station, MS955.

UNIVERSITY OF TENNESSEE, 6

Wood duck ecology on rivers and impoundments in East Tennessee. **R. W. DIMMICK**

Figure 16. The Holston River produces abundant aquatic foods for young wood ducks, enhancing its quality for rearing broods of this species.

Wood duck populations on the Holston River (Figure 16) were censused during March and September. Data have not been tabulated for these censuses. A manuscript on food habits of young wood ducks was prepared and accepted for publication. A review of literature on the behavior of mercury in aquatic ecosystems is being undertaken to obtain background information for investigating the extent of mercury pollution in the Holston River and its effect on the wood duck population.

VIRGINIA POLYTECHNIC INSTITUTE, 636136

Simulations of forest game population structure and dynamics. **R. H. GILES**

Several efforts have paid off during the year to understand past forest game population changes, to predict future populations and their effects, and to evaluate various strategies of population management. By developing several studies simultaneously, that is of data analysis and computer simulation, production of useable results seems to have been accelerated.

One study of deer harvest records in Virginia, collected by the State from 1947 to date, has produced a list of factors to which deer kill is highly correlated. Studies of these correlations have indicated high priority data collection needs and have reduced needless data collection. Other studies using the technique of multiple-regression analysis has provided equations that allow wildlife biologists and foresters to predict accurately the deer kill in forth-coming season (R^2 = 0.90 or greater) in 56% of Virginia counties. See Figure 17. These counties account for 71% of the animal statewide deer kill of about 38,000. None of the equations have more than 6 variables, thus it is possible for decision makers to easily consider before a season what the influence of

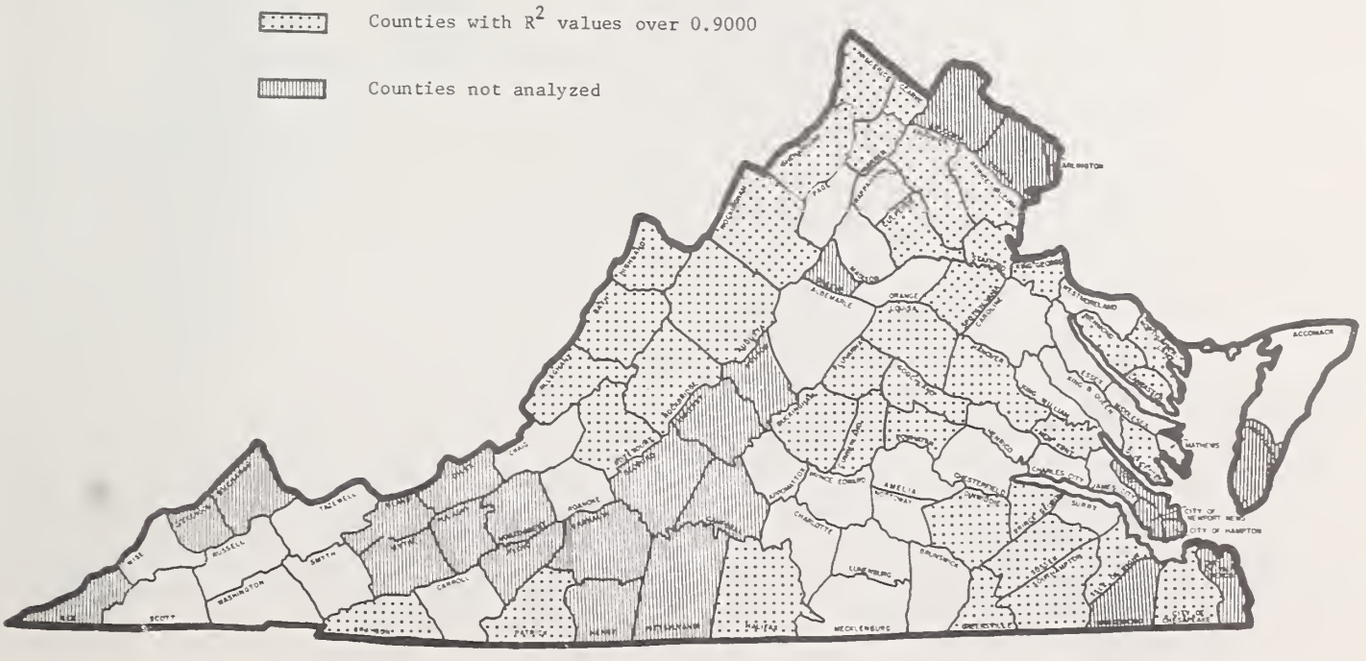

Figure 17. The counties of Virginia with R^2 values greater than 0.9000 and those counties that were not analyzed because of insufficient data.

factors like number of days, number of holidays, or rainfall on the opening day will have on the kill. Groups of counties, units, have better equations than individual counties.

Another study, that of fox and skunk population dynamics, has great consequence to outdoor recreation and nationwide rabies disease control. A computer-based model of the entire disease epidemiology and ecology of rabies was developed. Rabies has caused the death of two recreationists this year. The pathways of the disease was developed from animal to animal as the population changed, as old animals died and young entered, and all with random likelihood built in to conform to nature. The model allows the simulation of changing habitat on populations and thus on the disease. It also allows the evaluation of alternate control strategies. In one test run, with a set of reasonable assumptions, the disease was eradicated with vaccination (assumed to be by the vac-trap or now-being-developed oral vaccine in bait) of 25% of the population, while neither trapping nor oral contraceptives eliminated the disease or incidence.

Other deer population simulators have been developed and a modified version is being used as a decision "game" for training forest wildlife managers.

UNIVERSITY OF WYOMING, 31-70

Ecology and carrying capacity of summer elk range.

A. A. BEETLE

A study was initiated in the spring of 1969 to evaluate the carrying capacity of summer elk range in Teton County, Wyoming. Data collection for the first two years of the study was primarily associated with type classification, animal numbers, use patterns, and forage production and utilization.

The area studied included all summer elk range in Teton County with emphasis placed on Huckleberry Ridge (Figures 18, 19 and 20). This area was selected because of logistic reasons and provided essentially comparable resources to other summer elk range. Management decisions concerning Huckleberry Ridge could in effect be employed for similar summer range.

Figure 18. Savannah aspect which is typical of the upper portions of Huckleberry Ridge. Note the isolated patches of coniferous cover which provide important shelter for elk. July, 1970.

Figure 19. A typical dry meadow type differing from the perennial forb type by a higher percentage of grasses to forbs. August 1969.

Figure 20. Forest Service elk exclosure located on the critical savannahs of Huckleberry Ridge. July, 1969.

Figure 21. Square-foot microgrid used for the collection of data. Using this grid, information was obtained on species composition, utilization, and cover at each sampling site. July, 1970.

During the summer months of 1969 and 1970 approximately 3,000 samples were taken to determine utilization and production (Figure 21). The area was also typed and classified and observation notes were kept on animal numbers and their pattern of use. Sample results are currently being compiled and analyzed and are to be presented in a Ph.D. thesis. The final results of the study should be available by the first of March, 1971.

ADDITIONAL PROJECTS

UNIVERSITY OF CONNECTICUT, 340
Fetal sex ratio and productivity of white-tailed deer.
R. D. McDOWELL

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Habitat analyses of two northeastern cottontails.
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UNIVERSITY OF FLORIDA, 1032
Ecology of wildlife using sites prepared mechanically for pine planting. S. L. BECKWITH

SOUTHERN ILLINOIS UNIVERSITY, CW-07-67
Dispersal of white-tailed deer (Odocioleus Virginianus) from family units. W. D. KLIMSTRA

LOUISANA STATE UNIVERSITY, 1510
Population studies of woodcock in Louisana.
F. W. MARTIN

LOUISIANA STATE UNIVERSITY, 1525
Distribution and population dynamics of the wood duck. F. W. MARTIN

UNIVERSITY OF MAINE, 5005
Relationships between white-tailed deer and forest vegetation. S. D. SCHEMNITZ and F. F. GILBERT

UNIVERSITY OF MASSACHUSETTS, 5
Food and shelter requirements of ruffed grouse in relation to energy regimes.
F. GREELEY and J. S. LARSON

MICHIGAN STATE UNIVERSITY, 982
Ecology of shrubs with high wildlife food and aesthetic value. L. W. GYSEL

UNIVERSITY OF MINNESOTA, 17-85
Effect of small mammals on forest reseeding.
J. R. BEER

NEW MEXICO STATE UNIVERSITY, 2
Seasonal distribution of mule deer in relation to selected browse species and availability of water.
V. W. HOWARD and C. E. ENGELKING

NEW YORK–CORNELL UNIVERSITY, 907
Techniques for establishing vegetation for utilization by wildlife.
V. W. HOWARD and C. E. ENGELKING

NEW YORK–STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 904-1-5
Deer habitat studies. D. F. BEHREND

NEW YORK–STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 904-3-1
The chemistry of aquatic plants.
R. T. LaLONDE

NORTH CAROLINA STATE UNIVERSITY, 4026
Forest wildlife studies–gray squirrel.
F. S. BARKALOW

OKLAHOMA STATE UNIVERSITY, 1442
Compatibility of game and timber production on intensively managed lands. J. L. TEATE

UNIVERSITY OF RHODE ISLAND, 953
Movements of deer related to forest alteration.
J. KUPA

UNIVERSITY OF TENNESSEE, 3
Quail management on forest and associated lands in west Tennessee. R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 11
Physiological response of wildlife to different forest and associated habitats. M. R. PELTON

UNIVERSITY OF TENNESSEE, 12
Ecology and behavior of the black bear in the Great Smoky Mountain National Park. M. R. PELTON

UNIVERSITY OF VERMONT, 7
Habitat management and population dynamics of wood ducks, Aix sponsa (L.) R. W. FULLER

VIRGINIA POLYTECHNIC INSTITUTE, 636124
Effect of nutrient levels of reproductive function in white-tailed deer. R. L. KIRKPATRICK

VIRGINIA POLYTECHNIC INSTITUTE, 636121
Effects of selected disturbance treatment in oak-hickory stands on deer browse. B. S. McGINNES

WEST VIRGINIA UNIVERSITY, 7
The use of sonagram analyses as a possible technique for censusing game birds. D. E. SAMUEL

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Chapter 2

SILVICULTURE

Silviculture has been defined as "the art of producing and tending a forest; the application of the knowledge of silvics and the treatment of a forest; the theory and practice of controlling forest establishment, composition, and growth." Thus, silvicultural research is intended to solve practical problems in producing and caring for forests. Some of the scientific techniques and apparatus used in silvicultural research are quite complex and sophisticated. As more funds for forestry research become available, the level of refinement in technique and apparatus also advances providing more complete and dependable solutions to the problems of producing more wood and services per unit of land to satisfy the rising demand for these resources.

BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111b

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devices improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 12

The regeneration of redwood following selective cutting. **E. W. PIERSON**

With the cooperation of local timber companies 70 additional tracts of selectively logged areas were examined according to the sampling design. It was difficult to find truly selectively cut areas with respect to percentage remaining. All areas have had activity on them since the initial cut and in some cases all volume has been removed. However, regeneration on all these areas is a result of a selectively harvested stand. Because of this periodic activity the term "serial" selection is used in this project. Data from this initial research will be statistically analyzed at a later date.

UNIVERSITY OF GEORGIA, 17

Crown growth and wood formation in loblolly pine. **J. R. BECKWITH**

Publication of information from the study of crown growth and wood formation in 12-year- old loblolly pine was delayed by the length of the publication. The data were reworked and the material has since been broken down into two parts and is being submitted for publication. Examination of wood development in night-lighted trees resulted in an attempt to improve observation of pine cells. Better methods of section and surface preparation and staining have been developed and the scanning elec-

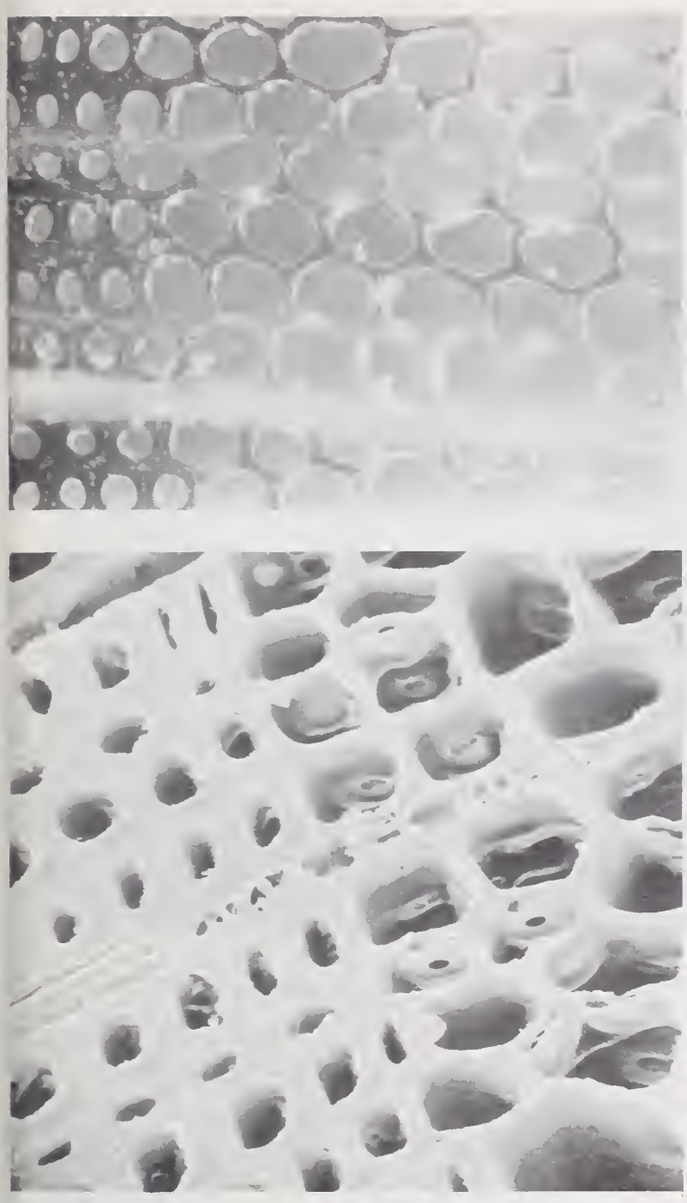

Figure 22. Cross section of southern pine early wood and latewood. A—surface reflected light, 200×. B—scanning electron microscope, 500×.

tron microscope has been used in surface examination with much qualitative information gained from it (Figure 22). The new techniques for examining such material will make future work much more precise.

INDIANA—PURDUE UNIVERSITY, 1476

Establishment and culture of black walnut, tulip poplar and cottonwood. **W. R. BYRNES**

Growth evaluation in 1970 showed that after 6 years total growth and vigor of hardwood species planted on bottomland sites continued to be superior on trees receiving chemical weed control, in contrast with mechanical or no weed control, during the establishment period (Figure 23). Hybrid poplars were infected with the disease, *Dothichiza populea,* resulting in loss of vigor and mortality on all areas. Losses were most severe on control plots where weed competition was greatest and least where chemical weed control was used. Studies on hardwood tolerance to herbicides (Figure 24) were continued with a preliminary investigation on the possible relation of black-walnut secretory structures to tolerance for herbicides. Methods for black walnut seed storage for controlled germination and for seedling growth in nutrient solutions were perfected. A radioassay technique was developed for measuring changes in ^{14}C- simazine treated black walnut.

Broadcast fertilization with N, P and K did not produce significant second-year growth responses of young black walnut in comparison with unfertilized trees. Firing of petroleum-coke bricks distributed throughout the plantation reduced frost injury and subsequent multiple stem development on young black walnut.

LOUISIANA TECH. UNIVERSITY, 2

Effects of annual burning on site quality of longleaf pine (Pinus paulstris, Mill.). **L. P. BLACKWELL**

The Roberts Plots are unique in that they are the oldest continuously measured permanent forestry plots in the Gulf South region. The plots contain adjacent, annually burned and protected areas which have been studied since their establishment in 1915. Rosin from longleaf pines on the plots was analyzed which resulted in two masters theses and two publications under the supervision of Dr. P. B. Moseley of the Louisiana Tech Chemistry Department. The publications are "Improved Methods of Rosin Analysis" by J. B. Stanley and Dr. Moseley, and "The Determination of Primary and Secondary Fatty Amines in the Presence of Large Amounts of Nitrile" by Rosemary Bolen and Dr. Moseley. Although this project is presently inactive, supplementary study on soil microorganisms in the area is being conducted. Periodic stand measurements are also continuing for future analysis of wood volume growth and site quality on burned and unburned sites.

MICHIGAN STATE UNIVERSITY, 984

Modifying site conditions for the establishment and growth of high quality black walnut.

D. P. WHITE and G. SCHNEIDER

The opportunity to gain outstanding growth from intensive hardwood silviculture is excellent with black

Figure 23. Hybrid poplar growth in response to reduction in weed competition. Chemical weed control (A) and no weed control (B) resulting in poor vigor and mortality due to disease.

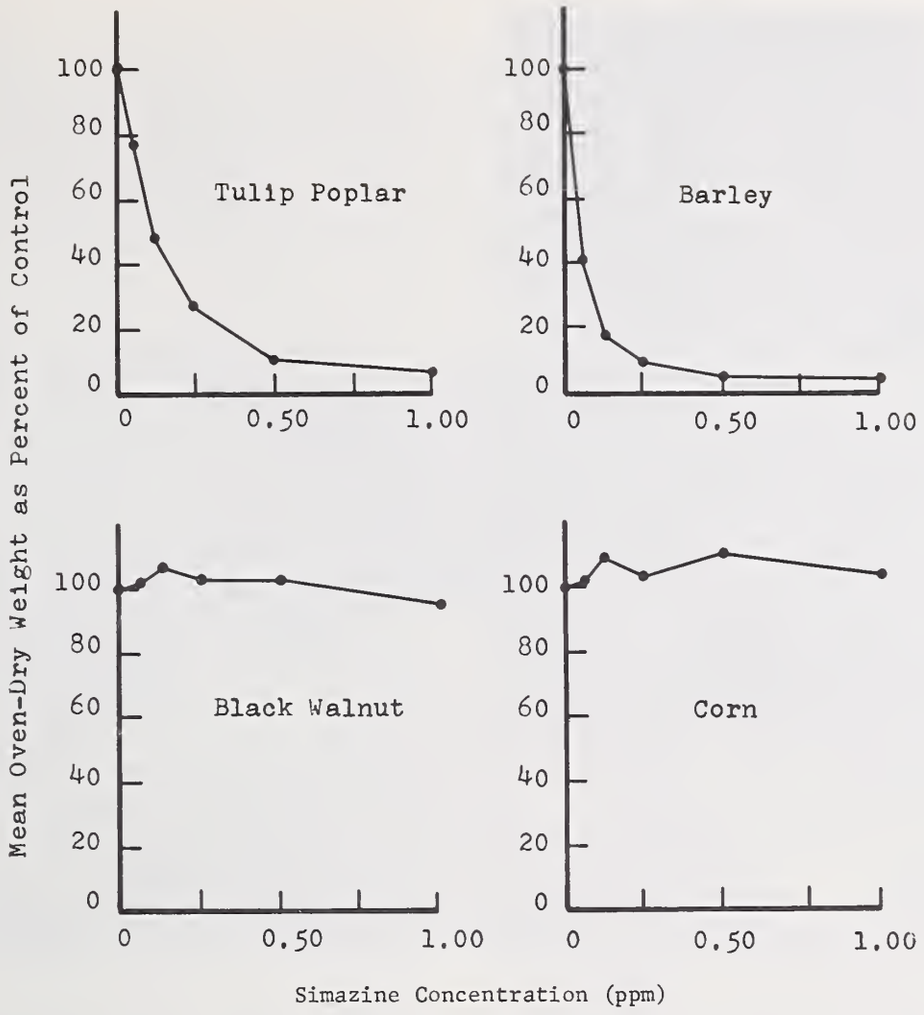

Figure 24. Expression of inherent tolerance of hardwood species to the herbicide simazine. Black walnut response curves were similar to corn, a simazine-tolerant plant; while tulip poplar paralleled barley, a simazine-sensitive plant.

walnut. We are concentrating on two approaches—improved planting and rapid early growth, and rehabilitation of established plantations or groves (20–30 years old) that have had little or no care. Placing germinated seeds into plantable containers of various kinds has made field planting of walnut seedlings possible 3 weeks after germination. In forest openings and wind protected open-field sites, these container-grown seedlings are over 3 feet tall at the end of the second growing season. The elimination of planting shock and reduction in die-back, so common when using bare rooted walnut nursery stock, has been an outstanding achievement of this approach. The best type of container used consisted of a 2-inch diameter cylinder of semi-rigid plastic mesh filled with a stack of expanded Jiffy-7 peat pellets. The superior growth in this kind of container is attributed to the optimum aeration provided during the early stages of root development. In established walnut plantations (25–30 years old), we were able to obtain a highly significant increase in both diameter growth and nut production over a four year period with soil treatments. The most effective treatment was the elimination of competing vegetation with herbicides during each of four growing seasons, accounting for a 40% increase in diameter growth. When 3/4 of a ton of complete fertilizer was combined with weed control, the average diameter increase was 51% over the control. (2.56″ –vs– 1.70″) The stimulation of nut production is more variable by seasons, but in 1970 the combined fertilizer and weed control plots yielded over 3 times as many nuts as the untreated plots.

UNIVERSITY OF MINNESOTA, 19-18

Evaluation of tubelings for forest regeneration.

B. A. BROWN and A. A. ALM

Tubelings are a specialized method of reforestation designed to extend the planting season and provide

Figure 25. Planting hoe and placement of tubeling.

flexibility, efficiency and perhaps some economy in producing field planting stock (Figure 25). They were never planned nor should they be considered as a complete replacement for conventional nursery planting stock. Species, planting date and amount and type of competing vegetation are directly related to tubeling survival. Jack pine has better survival than red pine on all treatments. Among treatments bare areas with mineral soil exposure are best followed by bare areas with ground litter, only brush removed, and control plots. Tubelings planted up to August 1 have significantly higher survival than if planted later. The early rapid juvenile growth of jack pine lends itself well to tubeling use (Figure 26). Red pine is less successful being easily overtopped and smothered by competing lesser vegetation. If red pine tubelings are to be useful their culture will have to be modified to produce a larger, better developed tubeling. New plots were established to evaluate site preparation treatments; burning, spraying, discing, mechanical scalping. Plantings made in 1970 were under extreme drought. Growing season rainfall was 59% of normal. This may be a major factor in subsequent survival.

Figure 26. Tray of 10-week old jack pine tubelings.

UNIVERSITY OF MONTANA, 302

Prescribed burning after timber harvesting in the northern Rocky Mountains. **R. W. STEELE**

This study was initiated in 1966 to determine the feasibility of using prescribed fire to thin young, overstocked ponderosa pine. Relationships among weather, ignition techniques, fire intensity and reduction in stocking were examined. Best results, in terms of crop tree release, were obtained with moderately-high intensity fires. Fires of desirable intensity could be obtained under a wide range of weather conditions by adjusting the firing (ignition) techniques. The flame height required for a desirable level of fire intensity for this type of thinning should equal the distance from the ground to the bottom of the crown of the trees to be killed. Crowns of small trees will be severely scorched and those of tall trees partly scorched. It was concluded that prescribed burning can be used to selectively thin young pine stands in Montana, but the method requires great skill and careful attention to the many factors that influence fire intensity. Results will be published during 1971.

UNIVERSITY OF NEW HAMPSHIRE, 1

Cultural practices for balsam fir Christmas trees.

P. E. BRUNS

Field work and analysis completed, results to be published. Major results as follows on trees 4 feet in height originally:

1. Low levels only of ammonium nitrate (.3 lb. per tree) and complete (N-P-K) fertilizers (1.1 lb. per tree, and up to 2.5 lbs.) significantly improved needle color characteristics, leader growth, and internodal bud and branch development. These improvements hold over into the following year making annual fertilization unnecessary. Fertilizers other than N or N-P-K combination offered no improvement.

Figure 27. Water is a commodity which is not evenly distributed on and in the surface of this earth. This pocosin scene on the Hofmann Forest in Jones and Onslow counties, North Carolina, represents an area where an over-abundance of water hinders the regeneration and growth of pines, and the harvesting of them, if they obtain marketable size.

2. Original (one time, for shaping of tree) spring shearing, followed by annual clipping increased lateral tips best, from control trees' 16.10 tip average to 42.17.

3. Preliminary "standards" for foliar content of healthy unfertilized balsam fir with good color characteristics have been established. Correlations between soil and foliar analyses could not be determined, however.

NORTH CAROLINA STATE UNIVERSITY, 4030
Bedding, ditching or furrowing, and fertilizing effects on growth of pines on wetland sites.
T. E. MAKI

Where mucks and peats exceed 4 to 5 feet in depth, growth of pine seedlings, whether naturally established or planted, is disappointing even under nominal drainage (Figure 27). For example, on a canal side area draining for 19 years, 594 pond pines per acre average 6.9 inches in diameter, breast high, but are only 29.3 feet in height; on the road-side of the same deep muck area only 256 trees per acre have passed the minimum dbh tally limit of 3.6 inches and now average 4.8 inches with a height of 19.8 feet. Nominal drainage of the road-side area was deferred for 10 years, the even poorer growth of the pond pine doubtless reflecting the influence of the early years of severe struggle with the dense pocosin brush community, under adverse conditions of excess moisture. The current study on bedding, fertilizing, intensified drainage, and related practices, is intended to develop methods that will assure acceptable pine growth on the deeper mucks and peats and superlative performance on the shallow ones (Figure 28).

OKLAHOMA STATE UNIVERSITY, 1237
Mortality in commercial timber. **T. H. SILKER**

This MS project was initiated in 1964 to evaluate physical attributes of sites and ecological factors affecting plant community function. The study covered plots demonstrating certain mortality patterns.

Figure 28. On the deeper mucks of the pocosin, no pine species will do well without some site improvement. Early bedding on the Big Opening of the Hofmann Forest was done with a 4-disc Mathis fireplow shown here. Two years after planting, loblolly and slash pines attained an average height of about 3½ feet on the berm, but only about 1.7 feet on the edge of the furrow, despite the competion-free environment.

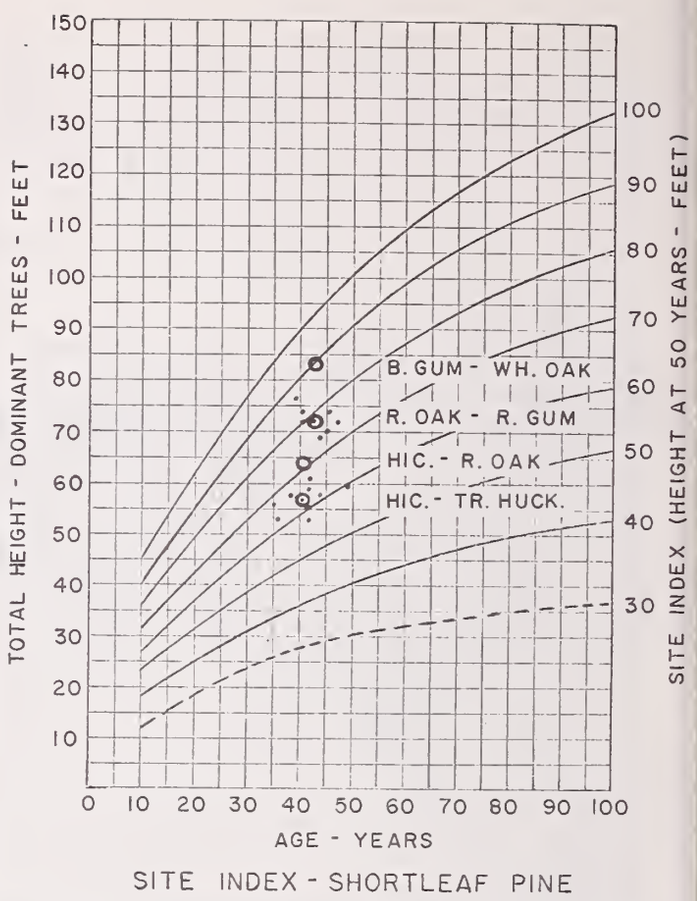

Figure 29. Mean site index values of 64, 71, 70 and 90 feet for shortleaf pine occurring with four plant-indicator groups on Coastal Plain soils in southeast Oklahoma. Average pine site index values for individual plots in the hickory-tree huckleberry and red oak-red gum associations are plotted around the mean for these groups to illustrate variance.

The limitations of site and climatic fluctuations for long-term development of some species were key factors studied. Ten field plots were studied for each of four plant associations thought to reflect increasing soil moisture availability: (1) post oak-blackjack oak-hickory-tree huckleberry, (2) hickory-red oak, (3) red oak-red gum, and (4) black gum-white oak. Plots were on red-yellow podzolic (Ultisol and Alfisol) soils on the Coastal Plain. Plots were selected irrespective of soil series or phase, in a zone of similar topography in southeastern Oklahoma, within a total precipitation zone of 45 inches.

The objective was to determine if site index of shortleaf pine associated with the hardwoods would relate to empirical soil moisture availability ratings. Mean pine site index values at 50 years for ten plots in each hardwood association are shown in Figure 29 as 64, 71, 79 and 90 feet. Thus, associate hardwood groups have a potential for interpreting relative and discrete soil moisture availability classes and land management classes; or, relative pine height documents the ranking of associate hardwoods in reflecting apparent soil moisture availability.

This study indicates overstory and understory hardwood indicator groups can be related to minimal physical features of the site and climatic provinces throughout the Coastal Plain and many highland sites having Hector-Pottsville, Linker, Hartsell or similar soils. If species requiring less moisture can be substituted for some volunteer hardwoods, we can reduce over-all mortality related to drought-stress. More efficient water conversion and unit management can then be effected on certain sites.

UTAH STATE UNIVERSITY, 806

Sampling requirements for biomass and productivity measurements in spruce and fir. **T. W. DANIEL**

This study is designed to provide information on how a tree can be accurately measured for its total mass and its total growth in the last year without the

necessity of dissecting the total tree. In order to do this the experimental trees are being totally dissected, then the values found for total biomass and productivity will have been measured with high accuracy and can be considered the parameters. Now the same values will be calculated using only part of the total dissecting data. By comparison with the parameters, the accuracy of the new values can be determined. The sample size will be reduced until the degree of error indicates a sample too small to give acceptable results. At least two trees in each size class will be handled in this fashion to check on the relative accuracy of the procedures.

During the summer two dominant Engelmann spruce trees in the 6-inch diameter class were dissected. When all the branches had been dissected, the tree was felled at a precise 30 cm stump height. The tree was bucked into 2 meter logs, top and bottom xylem diameters and phloem radii were measured, and the radial widths of the last five years of xylem and phloem were measured at the center section of each log. After the tree stem had been completed, the root system was dug out until the total root (Figure 30) was exposed up to 2.5 cm minimum diameter. The root system was sectioned and broken down into diameter classes, the total length of each diameter class was measured, and the age radial widths of the last five years of xylem and phloem were measured using one or two medium sections from each diameter class. The dry weights of all the material have been determined and the measurements of changes in specific gravity across the bark and across the stem sections and some of the larger branches are being made. The calculations of total biomass and productivity will then be made.

UNIVERSITY OF VERMONT, 1

Quality spruce and balsam fir for Christmas tree culture. **M. L. McCORMACK, Jr.**

Demand for culturally improved balsam fir Christmas trees has resulted in increased interest in better survival and early establishment of plantations. Site selection and modification, and condition of planting stock are important considerations prior to implementation of intensive practices such as shearing. Most sites planted were old fields which were low in nitrogen, 0.2 to 0.4 percent, and variable in pH due to past liming practices. Contrary to earlier opinions, best growth of new balsam fir plantations occurs on fields of pH 6.0 to 7.0 rather than fields of lower pH. Combinations of nitrogen-phosphorus-potassium in rates of 300-150-150 and 600-300-300 pounds, respectively, per acre have been applied on several sites. Preliminary observations indicate best responses at the highest rates from treatments including nitrogen. Applications without nitrogen are very similar to unfertilized controls.

Improved growth and foliage quality in cultured plantations are subject to browsing by white-tailed deer. Terminal and lateral growth is removed in the fall and late winter. This damage to small trees has been greatly reduced by using a foliage spray of thiram and an acrylic sticker mixed with water as a repellent applied in the late summer. Larger trees are not browsed but are damaged from bark stripping by deer (Figure 31). Such stem injury results in deformation and girdling of the trees. The relationship between deer feeding and improved balsam fir Christmas trees is presently under study.

VIRGINIA POLYTECHNIC INSTITUTE, 636134

Dry matter production models of forest stands. **H. A. I. MADGWICK**

This project describes the growth of forest stands mathematically. Analyses of data for both red pine and Scots pine indicate that the changes in the weight of needles both with time and vertically within the forest canopy can be predicted providing the height growth of the stand is known. Death of lower branches due to shading and dry weight growth of branches also can be predicted. Mathematical models are being extended to describe the growth of other parts of the trees particularly boles and roots. In conjunction with the computational analysis, field sampling of Virginia pine stands is being carried on to determine the answers to two main questions. First, does Virigina pine behave in a similar way to Scots and red pine. Second, does the growth of Virginia pine respond to thinning according to the models developed.

By a process of alternating experiments with computer modelling we hope to obtain better descriptions of growth of forest stands. Such descriptions have several potential uses. First, by understanding the nature of stand growth we will be in a better position to work toward increasing forest productivity. Second, we can predict the effects of cutting practices and other silvicultural treatments on different facets of the forest such as available deer browse and losses

Figure 30. Root system of Engelmann spruce.

Figure 31. Bark stripping by white-tailed deer of a fertilized balsam fir Christmas tree.

of water by interception. Third, we may eventually imitate stand growth using a high speed computer thereby allowing us to predict the results of experiments on forest stands. Experiments which would be either too expensive or take too long to perform in the field may then be simulated by computer.

ADDITIONAL PROJECTS

ALABAMA–AUBURN UNIVERSITY, 908
Nursery production of sweetgum, yellow poplar, sycamore. H. S. LARSEN

CALIFORNIA–HUMBOLDT STATE COLLEGE, 10
Removal of competing pampas grass (Cortaderia sellcana) from redwood reforestation areas.
D. THORNBURGH

CALIFORNIA–HUMBOLDT STATE COLLEGE, 18
Sowing Lupine for better seedling growth development of planted redwood and associated species.
D. THORNBURGH

COLORADO STATE UNIVERSITY, 325
Internal water stress and establishment of ponderosa pine. C. W. BARNEY

UNIVERSITY OF DELAWARE, 759
Nutrition and management of woodland trees of ornamental value. C. W. DUNHAM

UNIVERSITY OF IDAHO, 10
Influence of elk and cattle on reforestation.
F. H. PITKIN

UNIVERSITY OF IDAHO, 19
Evaluating pocket gopher damage to forest trees in Idaho. K. E. HUNGERFORD

SOUTHERN ILLINOIS UNIVERSITY, 67-R-14
Native trees for parks. D. R. McCURDY

KANSAS STATE UNIVERSITY, 721
Hardwood planting on strip-mined lands.
W. A. GEYER

LOUISIANA STATE UNIVERSITY, 1237
Producing and marketing Christmas trees.
C. W. BREWER

LOUISIANA STATE UNIVERSITY, 1266
Competition in slash, lobolly pine plantations.
T. D. KEISTER

LOUISIANA STATE UNIVERSITY, 1500
Evaluation of the use of tubelings in regenerating southern pine. B. H. BOX

UNIVERSITY OF MINNESOTA, 19-19
The development of hazel understories in northern Minnesota forests.
J. C. TAPPEINER, II and B. A. BROWN

NORTH CAROLINA STATE UNIVERSITY, 4018
Fertilization and irrigation of seed orchards.
C. B. DAVEY

OHIO AGRICULTURAL RESOURCE AND DEVELOPMENT CENTER, 1
Effects of fertilizers on sugar maple and tulip poplar.
J. P. VIMMERSTEDT

OKLAHOMA STATE UNIVERSITY, 1360
Control of undersirable woody plants. T. H. SILKER

PENNSYLVANIA STATE UNIVERSITY, 1816
A short term wood fiber production system.
T. W. BOWERSOX, W. W. WARD and W. K. MURPHEY

SOUTH CAROLINA–CLEMSON UNIVERSITY, 789
Irrigation and fertilization on upland forest.
N. B. GOEBEL

UNIVERSITY OF TENNESSEE, 2
Fertilizer and irrigation effects on tree growth.
E. R. BUCKNER

UNIVERSITY OF TENNESSEE, 14
Effect of seedling root deformation on growth and allocation of auxins. F. W. WOODS

UNIVERSITY OF TENNESSEE, 4
Forest management determinants. G. R. WELLS

TEXAS A & M UNIVERSITY, 1673
Intensive culture of hardwoods. R. G. MERRIFIELD

UNIVERSITY OF VERMONT, 2
Effect of leader damage on the growth of planted conifers. T. L. TURNER

UNIVERSITY OF VERMONT, 8
Soil, growth, and wood quality of birch.
P. R. HANNAH

UNIVERSITY OF VERMONT, 10
Influence of environment on chemical weed suppression in Christmas-tree plantations.
T. R. FLANAGAN and M. L. McCORMACK

VIRGINIA POLYTECHNIC INSTITUTE, 636120
A study of the parameters of site for certain tree species in Virginia. H. A. I. MADGWICK, R. B. VASEY and J. F. HOSNER

VIRGINIA POLYTECHNIC INSTITUTE, 636123
Resource use in the southeastern logging industry.
D. P. RICHARD

UNIVERSITY OF WASHINGTON, 25
Relations of wildlife populations to Douglas-fir forest characteristic and protection.
R. D. TABER, B. F. HRUTFIORD and C. H. NELLIS

UNIVERSITY OF WYOMING, 46-71
Vegetative history and boundary stability of park areas in Medicine Bow National Forest.
P. C. SINGLETON and L. L. PAINTER

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IMPROVEMENT OF RANGE RESOURCES

Research Problem Area 112

Research seeks to maintain and improve the forage-producing capacity of rangelands. Native range in the United States includes over 900 million acres. It represents a continuum of sites and productivity potential from the deserts of the Southwest to the prairies of the Midwest and from the sea-level grasslands of Florida to the Alpine herblands of the high Rockies. Rangelands are important as a source of feed for beef cattle and sheep, in watershed protection, soil stabilization, wildlife habitat, and recreation.

UNIVERSITY OF IDAHO, 12

Effects of livestock trampling on plant growth and forage productivity. L. A. SHARP

Various forms of rotational grazing are being adopted and implemented on the nation's forested and non-forested range lands. These programs require the concentration of animals in smaller areas than under continuous grazing management practices. Little is known of the impact that such concentrations of animals have on soil compaction, water infiltration rates and plant growth.

Studies were initiated in 1968 on a crested wheatgrass seeding in southern Idaho to ascertain the effects of livestock trampling on soil compaction and subsequent effect on plant growth. Since rest rotation grazing systems concentrate animals in a portion of the total range allotment one year followed by a year or more of no grazing, studies were made to ascertain the time required for soil compaction affects to diminish or disappear.

Figure 32. Measuring infiltration rates.

Bulk density (weight of soil per unit volume) samples of the surface one inch of soil, water infiltration rates (Figure 32), and permanently established reference planes for measuring distances to the soil surface were all used as measures of compaction. Yield of forage in permanently established exclosures was used as a measure of plant response. Compaction measurements were taken in the same exclosures as the forage response measurements.

The exclosures were constructed in each of four areas prior to grazing in 1968, 1969 and 1970. Exclosures at each site were located adjacent to the previous year's exclosure so as to minimize site differences. The four areas are used in a rotational grazing pattern by cattle.

Soils in the area of study are poorly developed and the surface is strongly subject to freezing and thawing action in the spring of the year. Dry soil conditions and cold daytime and nighttime temperatures in the spring of 1969 were not condusive to soil "fluffing." Suitable moisture and temperature conditions occurred in 1970 for noticeable surface soil "fluffing."

Compaction, as indicated by surface bulk density samples, decreased in 1970 from the values obtained in 1969 at all locations (Figure 33). Infiltration rates at the same locations were less consistent. Compaction at depths below one inch of the surface or

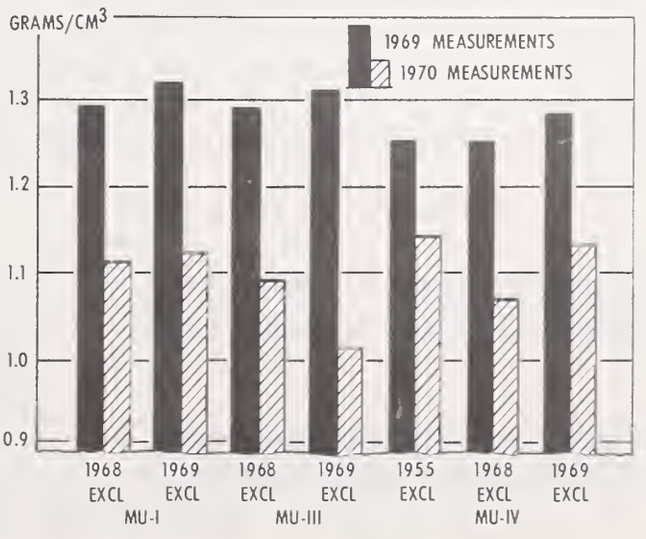

Figure 33. Bulk density of the surface soil in exclosures at three locations in two years at the Point Springs experimental area.

differences in subsoil characteristics are assumed to account for this discrepancy. Infiltration rates were consistently lower at all sites unprotected from grazing in 1970 than at any of the exclosure sites.

Forage yield obtained in 1970 appeared to be related more to plant vigor or time since grazing than to surface soil compaction or infiltration rates. Spring precipitation in 1970 was much more favorable per plant growth than in 1969. Differences in forage yield in the various exclosures consequently responded more strongly to plant vigor than in 1969.

UNIVERSITY OF MONTANA, 603
Grazing use and forage yield of forest land in western Montana. M. S. MORRIS and L. EDDLEMAN

Meadow stringers in the forest and adjacent grasslands are all over-utilized when grazed by cattle. Meadows are potentially capable of producing more forage per unit area than the grassland of forest understory.

There are no meadows to be found among those accessible to grazing by cattle which are dominated by native species. Extreme degradation to Kentucky bluegrass, white clover, and dandelion is the most common. Dry meadows have been converted from redtop and tufted hairgrass and sedges to Kentucky bluegrass and white clover. Wet meadows have been converted from sedges, and tufted hairgrass to Kentucky bluegrass and redtop. Clearcuts have also been invaded by Kentucky bluegrass to the detriment of native vegetation and tree regeneration. Heavy timber and steep slopes are used very little, however, heavily used cattle trails may pass through these areas leading to small sites dominated by preferred species. Good distribution of cattle occurs only after the meadows are depleted of their forage. Open, sunny areas in the forests are grazed before the closed, or shaded areas.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 5
Range forest on parks in ponderosa pine.
L. D. LOVE

NORTHERN ARIZONA UNIVERSITY, 8
Soil-site of ponderosa pine in Southwest.
O. B. APPLEQUEST

UNIVERSITY OF CALIFORNIA, 2500
Ecological adjustments of range plant populations to use and environment. H. F. HEADY

UNIVERSITY OF IDAHO, 18
Prescribed burning influences on the forage value of key big game browse species.
K. E. HUNGERFORD

UTAH STATE UNIVERSITY, 670
Range plant foliage removal effects on soil moisture regime. G. B. COLTHARP

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TREES TO ENHANCE RURAL AND URBAN ENVIRONMENT

Research Problem Area, 905

This research provides some of the scientific knowledge required to maintain or improve the quality of the rural and urban environment, and to enhance natural beauty through special-purpose tree planting. Technological change is multiplying the need for special tree planting to screen junkyards and highways, suppress noise, slow the movement of dust and debris, and to provide trees for shade, beauty and

shelterbelts to protect crops, animals and farmsteads. Research is needed to find species and techniques so that trees can survive smoke and air pollution, compacted soils, deficient or excess moisture, and other adverse conditions. The end product of concern in this research is a standing tree to enhance the environment.

CONNECTICUT–NEW HAVEN, 416
The attenuation of noise by vegetation. D. E. AYLOR

The attenuation of noise was measured in high density corn, dense hardwood brush, a managed red pine forest and an undisturbed hemlock planting. Comparisons between these four widely different cases allowed us logically to relate attenuation to sound frequency, ground conditions, foliage area and stem density. For example, noise passing through dense corn was attenuated substantially and especially so at higher, more annoying, frequencies. The results obtained are not limited to these four test cases but can be generalized to situations where certain, easily obtainable, quantitative information about the vegetation and ground conditions is available. Therefore, it should now be possible to specify optimal vegetative noise screens.

ADDITIONAL PROJECTS

UNIVERSITY OF NEBRASKA, 20-23
Windbreak shelter effects.
W. T. BAGLEY and N. J. ROSENBERG

NEW YORK–CORNELL UNIVERSITY, 903
Suburban forest ownership. L. S. HAMILTON and T. RADER

NORTH CAROLINA STATE UNIVERSITY, 4031
Management characteristics of urban forest space.
J. O. LAMMI

NORTH DAKOTA STATE UNIVERSITY, 1
Shelter belts in North Dakkota. E. P. LANA

SOUTH DAKOTA STATE UNIVERSITY, 475
Selection and propagation of woody plants for the Northern Plains. D. E. HERMAN

PUBLICATIONS

SOEHREN, L. A.
Biology and control of the leaf crumpler. M.S. Thesis.

Chapter 3

FOREST HARVESTING AND ENGINEERING

Forest harvesting and engineering deals with men, machines, and techniques for felling, logging, and transporting harvested trees to processing points. Other topics covered include degree of utilization and forest waste material, intermediate storage of wood in the forest, performance measurements, and forest engineering.

Some of the improvements being investigated in these areas will lead to more efficient and safer means of doing woods jobs than are currently practiced.

Chronic problems of work performance and production efficiency for woods workers will need to be thoroughly examined in order to systematically determine least-cost methods of producing wood. This should be interpreted to include the reduction of waste in the woods. Engineering techniques will probably be employed to supply most of the procedure that will decrease the costs of producing a given unit-volume of wood.

NEW AND IMPROVED FOREST ENGINEERING SYSTEMS

Research Problem Area 302

Improved forest engineering systems can reduce timber harvesting costs, increase and stabilize rural payrolls, reduce accidents and provide higher returns to industry. Over 100 billion board feet of timber in Alaska and the western states are inaccessible due to the high cost of road construction, steep terrain, soil conditions, and lack of equipment suitable for timber harvesting. In other states, because of the high proportion of small-size timber and the high percentage of defective timber, the economic feasibility of harvesting is limited.

PROJECTS

UNIVERSITY OF MASSACHUSETTS, 11
Distance-measure sampling for volume growth.
J. C. MAWSON

MICHIGAN TECHNOLOGICAL UNIVERSITY, 5
Pulpwood skidding time analysis.
H. M. STEINHILB

Chapter 4

FOREST INJURIES AND PROTECTION

Research described in this chapter deals with the well-known sources of damage to forests including fires, insects, and diseases, and could include diverse and unusual types from avalanches to volcanic ash. The techniques for protecting forests from injuries are also found in this chapter.

Research Problem Area 201, Control of Insects Affecting Forests, includes all the fundamental aspects of forest insects and associated organisms, selection and breeding of trees for resistance to insects, plus control techniques that involve safer chemicals and biological controls. Control of Diseases, Parasites and Nematodes Affecting Forests is the title of RPA 202. Research in this problem area is also integrated from fundamental studies of pathogens to the development of equipment for application of spray materials for control.

The prospects of developing non-pesticide controls for insect populations has improved rapidly in the last few years with the studies dealing with insect pheromones. Pheromones are chemical messengers used by insects. Interrupting this messenger system shows large promise as a mechanism for controlling forest insects. The indentification, isolation and synthesis of pheromones will permit them to be used in traps or as a confusion mechanism by spraying over wide areas.

CONTROL OF INSECTS AFFECTING FORESTS

Research Problem Area 201

Insects exact a heavy toll of young trees each year killing many, and damaging and reducing the growth of surviving trees. Wildlife habitat is changed and fire danger is increased. Forest insect research can provide the information needed to reduce the continuing losses to forests and forest products, including Christmas trees. A sustained flow of new information provides the basis for safe, effective methods of control.

UNIVERSITY OF GEORGIA, 18

Investigations of insects affecting pine cones and seeds in the Piedmont of Georgia.

R. T. FRANKLIN

Population of *Dioryctria* spp. on shortleaf pine second-year cones were investigated in Greene and Clarke Counties, Georgia. The populations were evaluated in terms of total insect damage to second-year cones; the number of *Dioryctria* spp. present on individual trees; and the number of cones which were damaged by *Dioryctria* spp., but which did not contain insects at sampling. Postive correlations were demonstrated for (1) the number of second-year cones per tree and the number of cones damaged by

all insects, (2) the number of cones per tree and the number of *Dioryctria* spp. per tree, (3) the number of cones per tree and the number of cones damaged by *Dioryctria* spp., and (4) the number of damaged cones per tree and the number of cones damaged by *Dioryctria* spp.

Damage to second-year cones on shortleaf pine by insects was 15.7%. The total amount of damage to second-year cones was shown to increase with increasing numbers of cones per tree. The number of cones damaged never approached the number of cones present on the tree. There was always a greater number of damaged cones than damaging insects. The difference between the number of *Dioryctria* spp. actually collected and the number of cones damaged by *Dioryctria* spp. indicates that larval migration from cone to cone is taking place.

MISSISSIPPI STATE UNIVERSITY, 1129

Study of economic insects attacking certain forest tree seeds and forest seedlings. **W. W. NEEL**

Cottonwood.—In recent years there has been a striking increase in the number of acres planted to cottonwood in the Mississippi Delta. One insect that causes considerable damage in young cottonwood plantations is the cottonwood leaf beetle, *Chrysomela scripta* Fabricius. Because of its destructive nature, detailed studies on the biology and ecology of this pest are in progress. During the past year a total of 7 generations of *C. scripta* were reared from April through October in field cages. In an effort to determine the possible future utilization of natural

Figure 34. Adult of the pteromid wasp, *Schizonotus latus* Walker, a parasite of the cottonwood leaf beetle, *C. Scripta.*

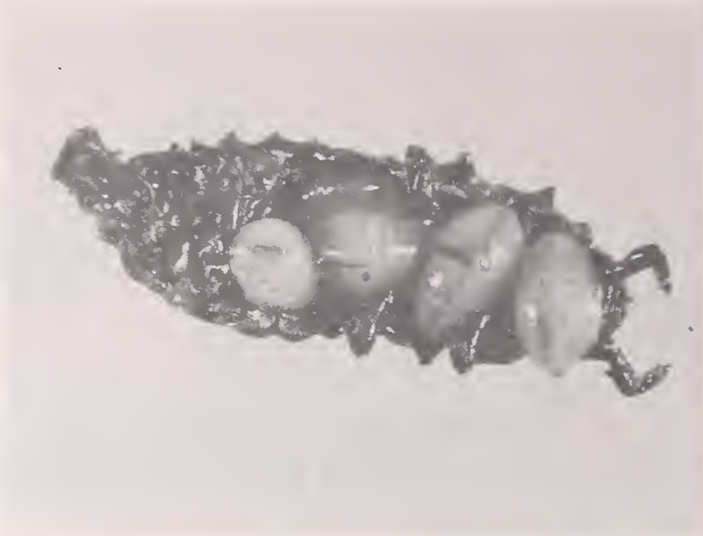

Figure 35. Larvae of the cotton leaf beetle parasite, *Schizonotus latus* Walker.

control agents, a thorough survey of predators and parasites of this insect was made. *Coleomegilla maculata* (De Geer) was one of 5 lady beetle predators collected and was by far the most numerous species during the early and mid-summer months. The highest population density of this lady beetle coincided with the lowest population density of *C. scripta,* suggesting its possible role as a natural control for this pest. A pteromalid wasp, *Schizonotus latus* (Walker) (Figure 34), was the only parasite of *C. scripta* that was observed. This wasp parasitizes late larval instars (Figure 35) and the adult parasites emerge from host pupa. Eighty-four adult parasites emerged from 24 parasitized host pupae collected in the field. This wasp appeared to be important in reducing host populations in late August and September. Further assessment of the roles of predators and parasites in the natural suppression of this insect will be made during 1971.

UNIVERSITY OF MISSOURI, 149

Insects associated with forest and plantation communities. **W. H. KEARBY**

During 1970, biogeographic and parasite diversity studies were initiated for *Rhyacionia* species throughout Missouri. Permanent sampling plots were established at 25 locations on pine plantings ranging from roadside windbreaks to those of larger acreage. Pines sampled included shortleaf, jack, Virginia, Scotch, Austrian, ponderosa, loblolly, and mugho. Only late instar larvae and pupae were collected for laboratory rearing. Since *R. frustrana* has three generations, three samples were taken during the year.

Figure 36. Galleries of *Xyleborus ferrugineus* in a buttress root of *Quercus velutina* that had been killed by oak wilt.

Rhyacoinia frustrana was reared from every species of pine, *R. buoliana* from Scotch pine, and *R. rigidana* from shortleaf, virginia, and loblolly pines. Since *R. buoliana* was recovered only from the Kansas City area, it appears that it was introduced on nursery stock brought in from other states. *Rhyacionia frustrana* and *R. rigidana* occur primarily south of the Missouri River.

The parasites of *R. frustrana* show a great diversity of species in shortleaf pine plantations. This diversity is attributed to the geographic isolation of shortleaf pine plantations within and bordering the natural range of shortleaf pine. The lack of contiguous pine appears to prevent the spread of the parasites. It was found that some species of parasites are dominant in some plantations and absent from other plantations of the same age class. Presently, parasites do not appear to be effective in reducing the level of *R. frustrana* infestations. Ecological life history studies of the more abundant species will be undertaken in 1971.

Field work with oak wilt killed trees revealed an ambrosia beetle inhabiting the buttress roots (Figure 36). The beetle was identified as *Xyleborus ferrugineus* and was a new state record. Live beetles, maserated beetles, and portions of various organ systems were plated on potato-dextrose agar to determine if the beetles carried the oak wilt fungus. Tests showed that the oak wilt fungus was not carried externally nor internally. Histological studies are underway on the mycangia (sac-like structures found inside the beetle) present in the beetle. Ecological work is being continued to determine the seasonal development of this beetle and its host relationship to oak-wilt-killed trees.

UNIVERSITY OF MONTANA, 1604

Spruce budworm defoliation in Douglas-fir stands.

J. H. LOWE

Continuing phase: Investigation of interrelation of budworm damage relative to certain stand parameters. Analysis is based on two seasons' data. Damage is defined as total tree mortality in the understory, and proportion of crown damaged in intermediates and dominants. Data were taken on twenty-five existing growth plots, the plots chosen to represent categories of basal area of Douglas-fir, percent Douglas-fir, and at various elevations, positions on slope, and aspect. Investigation is to identify correlations of the stand parameters with budworm damage. A progress report is in preparation summarizing the graphical relationships between the independent and the dependent variables.

PENNSYLVANIA STATE UNIVERSITY, 1750

Development of the eastern spruce gall aphid and its control. E. A. CAMERON

In cooperation with Dr. R. L. Campbell, USDA, 17 insecticides were screened for fall activity against the aphid. Preliminary indications show that the carbamates are effective and that late fall applications will give control, a fact which will increase f ility of growers in managing plantations.

SOUTH CAROLINA–CLEMSON UNIVERSITY, 905

The biology of pine reproduction weevils in coastal South Carolina. R. C. FOX and T. M. HILL

In all of the southern States, the pales weevil and the pitch-eating weevil have inflicted heavy losses to newly established unprotected pine stands. Earlier studies in upper South Carolina have shown a marked difference in the life cycles of these 2 insects. The different climate and more intensive forest practices in the Coastal Plain have required resolution of these life cycles there.

In 1970 a daily trapping program was maintained using freshly cut discs of pine wood as traps. Captured adults were identified, color-coded with paint and released to study emergence, migration and longevity. This study will be continued through 1971. The most interesting data now available is that the pales weevil remains active throughout the year in the trapping area but both species apparently aestivate in July and August.

An attraction theory suggested by earlier data was tested by selecting 3 pine stands with similar stand composition and topographic features and separated enough to preclude emigration. In May, each study area was subdivided into 3 smaller units and one (the control) was clear-cut, the merchantable timber removed and the slash was left. Another was burned over leaving all dead and dying trees. A third areas was clear-cut, the merchantable timber removed and the slash was burned immediately after cutting. The treatments were positioned to remove the effect of aspect and the resultant trapping program was designed to minimize border effects. All trapped weevils were removed to eliminate the confusion of internal movement with actual attraction. This study will be completed during early 1971 and should indicate if prescribed burning or wild fire has an attractive effect on these weevils.

ADDITIONAL PROJECTS

UNIVERSITY OF ARKANSAS, 611
The control of pine sawflies in Arkansas with special reference to the use of biological control age.
L. O. WARREN

UNIVERSITY OF ARKANSAS, 656
Significance of IPS bark beetles and associated fungi causing death of pine in Arkansas.
W. C. YEARIAN

UNIVERSITY OF ARKANSAS, 662
Control of insects affecting seed production of loblolly and shortleaf pines in Arkansas.
W. C. YEARIAN

UNIVERSITY OF IDAHO, 13
Bionomics and control of cone and seed insects.
J. A. SCHENK

UNIVERSITY OF IDAHO, 17
The influence of natural and manipulated stand characters on S. ventralis population and damage levels.
J. A. SCHENK

KANSAS STATE UNIVERSITY, 671
Biology and control of insects and related arthropods attacking forest and windbreak tree species.
H. E. THOMPSON

UNIVERSITY OF MAINE, 5007
Biology and control of the balsam gall midge.
E. A. OSGOOD and J. B. DIMOND

UNIVERSITY OF MARYLAND, H-083
Loblolly pine cone insects.
W. E. BICKLEY

UNIVERSITY OF MARYLAND, H-101
Survey and evaluation of Maryland forest insects.
A. L. STEINHAUER, F. E. WOOD and J. A. DAVIDSON

MICHIGAN STATE UNIVERSITY, 942
Investigations on autostability of the arthropod component in single species conifer.
J. A. BUTCHER and W. E. WALLNER

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3119
Biological control of pine bark aphid in forest nurseries.
N. F. SLOAN

UNIVERSITY OF NEW HAMPSHIRE, 4
Oribatei and Collembola in soils of white pine cover type.
R. M. REEVES

NEW JERSEY—RUTGERS STATE UNIVERSITY, 425
Low host density population dynamics of the gypsy moth.
F. C. SWIFT

NEW JERSEY—RUTGERS STATE UNIVERSITY, 436
Metabolism of insecticides by the gypsy moth (Porthetria dispar).
A. J. FORGASH

NEW MEXICO STATE UNIVERSITY, 7
Biology and host-finding mechanisms of the ponderosa pine cone beetle in New Mexico.
H. G. KINZER

OHIO AGRICULTURAL RESOURCE AND DEVELOPMENT CENTER, 3
Integrated control of the insect and mite pests of pine trees.
D. G. NIELSEN

OKLAHOMA STATE UNIVERSITY, 1235
Bionomic, ecology and control of the Nantucket pine tip moth. R. D. EIKENBARY

OREGON STATE UNIVERSITY, 824
Biology of the hemlock Hylesinus in western Oregon. W. P. NAGEL

OREGON STATE UNIVERSITY, 868
Seed and cone insect pests of Douglas-fir. W. P. NAGEL

TEXAS A&M UNIVERSITY, 1525
Electrophsiology of pheromone reception in the southern pine beetle and related bark beetles. T. L. PAYNE

UNIVERSITY OF WASHINGTON, 22
A study on the orientation of bark beetles (Coleptera:Scolytidae). R. I. GARA

UNIVERSITY OF WISCONSIN, 1263
Population dynamics of sawflies associated with coniferous plantations. D. M. BENJAMIN

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CONTROL OF DISEASES, PARASITES AND NEMATODES AFFECTING FORESTS

Research Problem Area 202

Forest disease research is essential to protect and enhance the social and economic value of trees in forests and farm woodlots. Diseases reduce the utility of trees for wildlife habitat and timber production. They kill trees, discolor foliage, retard growth, and cause decay leading to breakage and windfall. Prolonged droughts, wet periods, and changing climatic conditions accentuate tree disease problems.

UNIVERSITY OF ARIZONA, 713
Diseases and decay of woody plants on Arizona watersheds and recreational areas.
R. L. GILBERTSON

A study of basidiomycetes associated with decay of ponderosa pine has been completed. A total of 187 species were found fruiting in association with decay of living trees and dead standing trees, logs, stumps and slash. Four previously undescribed species were found in this research, 3 of which have been published as *Byssocorticium neomexicanum, Resinicium chiricahuaensis,* and *Trechispora pallidoaurantiaca.* A manual with keys, descriptions, and illustrations of microscopic characters of all species has been completed for publication.

An apparently undescribed fungus has been discovered associated with a white butt and root rot of southwestern white pine. Observations to date indicate it is very limited in distribution in southern Arizona, as we have found it only in two mountain ranges in the southeastern corner of the state. It is consistently associated with fire scars on large, overmature trees and produces large, perennial basidiocarps at the ground line. A publication describing this fungus as a new species and also presenting its cultural characteristics has been completed.

Other investigations are in progress including a study of diseases and decays of canyon hardwoods on several major recreational areas in southern Arizona.

UNIVERSITY OF ARKANSAS, 663
Organelles of fungi causing forest-tree diseases.
C. L. WILSON

Research at the University of Arkansas has contributed much to the understanding of organelle behavior in fungi that cause diseases of forest trees. Nuclear behavior in particular has been elucidated and other organelles are being studied intensively. Lysosomelike bodies were identified and partially characterized in fungi that cause diseases of forest trees. These organelles appear to govern life processes of the fungal pathogens and are concerned with disease development in forest trees. Lysosomelike bodies in these fungi appear comparable to animal lysosomes. The lysosomelike bodies were studied under ultraviolet light, dark field and transmitted light using the photomicroscope, and fine structure was determined with the electron microscope. Histochemical reactions revealed that various hydrolytic enzymes were associated with these bodies. Using a laser microbeam, selective damage was inflicted within the cell of a fungus without causing death of the cell. Techniques such as this will allow further studies of morphological and genetic effects that result from microirradiation of cells of fungal pathogens. The ultrastructure of *Arceuthobium pusillum,* the eastern dwarf mistletoe, in a compatible and noncompatible host was defined (research at the Univ. of Minnesota being completed at the Univ. of Arkansas).

UNIVERSITY OF CALIFORNIA, 2348
Microbiology and pathology of wetwood in California firs.
W. W. WILCOX

The bacterium found consistently associated with wetwood in white fir remains unidentified but has a number of similarities to *Corynebacterium*

Figure 37. Scanning electron micrograph of surface of pit membrane for wood which had been incubated in a nutrient medium inoculated with the bacterium isolated from white fir wetwood. Bacterial cells are shown on the surface of the membrane which appears intact despite their presence (⟝ = 1 μm).

humiferum isolated from wetwood in poplar (Figure 37). The bacterium has been found not to be a wood-destroying organism; it can grow using substances in wood, probably primarily starch, as a sole carbon source but does not destroy ray parenchyma cell walls or pit membranes as do the bacteria responsible for excessive porosity in ponded pine, for example. Wood from areas of the tree showing the most typical wetwood symptoms accounted for about 1/3 of the lumber volume from test logs and consisted of material with relatively high moisture content, the highest specific gravity, toughness, radial and tangential shrinkage, and the lowest longitudinal shrinkage and relatively low liquid absorptivity in comparison to material from the rest of the tree. Based on these data it appears unlikely that wetwood is associated with reduced wood quality in white fir. Data on external indicators, collected with the data on wetwood, revealed that the presence of true mistletoe in white fir logs may have a negative effect upon lumber grade while the presence of dwarf mistletoe and frost cracks may not. However, differences in log size may account for much of the variation and futher analysis is necessary.

UNIVERSITY OF FLORIDA, 1446

Epidemiology of fusiform rust. **R. A. SCHMIDT**

Preliminary studies on the effects of fertilizer on the incidence and severity of fusiform rust (*Cronartium fusiforme*) on slash pine (*Pinus elliottii* var. *elliottii*) seedlings grown in the greenhouse indicated that N, P and K treatments had little effect on the disease. However, the response of the seedlings to the nitrogen treatments was other than expected and information gained in this study is being used to redesign future experiments. Effects of duration of atmospheric moisture and dew on the infection of slash pine seedlings by basidiospores of the rust fungus have been partially defined under growth-chamber conditions. A field installation to study the microclimate of the infection court on slash pine has been started and preliminary instrument testing has begun. Production of inoculum and its arrival at the infection court will also be studied in relation to the microclimate of the infection court. Data on the incidence of fusiform rust on 1200 plots in slash pine stands in Florida and Georgia has been partially summarized and when completed will provide a basis for the definition of high hazard sites to be used in macroclimate studies of disease incidence, location of rust-free nursery sites and in selection of rust-free phenotypes.

UNIVERSITY OF MINNESOTA, 22-17

Ecology of wood decay. **D. W. FRENCH**

Large numbers of viable basidiospores of *Fomes igniarius* were collected using plastic boxes over sporocarps. Spore dispersal was inhibited when webbing was produced by an insect in the *Mycetophilidae* and when relative humidity was high for long periods of time. Sporocarps produced small spores as sporocarps deteriorated. Basidiospores germinated on fresh and 2-day old sapwood wounds after May and before August 4. Sapwood was favorable to germination of basidiospores, heartwood was favorable to mycelium. Glucose stimulated spore germination. Wood rotting fungi were isolated from insects and marked beetles, *Boletotherus cornutus,* usually covered with basidiospores were traced during their association with *F. applanatus.*

Over 500 trees have been inoculated with spores of mycelium of *F. robustus* and closely related species. Average incidence of cankers in red oak caused by *F. robustus* was 3.8%. The fungus entered trees through branch stubs or mechanical wounds. The cankers were on the average 1.3 meters above ground and average age of the tree at time of infection was 27 years. In 34 trees the average decay volume was 448 cubic cms. Cankers without sporocarps had 52 and cankers with sporocarps had 522 cubic cms. of decay. Spore dispersal is related to high temperature, starting usually in June and ending in September.

PENNSYLVANIA STATE UNIVERSITY, 1825

An annual canker of maple. **W. W. WARD, F. A. WOOD and T. W. BOWERSOX**

Previously reported studies have indicated a strong correlation between the incidence of maple canker disease and the occurrence of stands on either poorly drained or excessively drained soils.

The holding of flood waters at Curwensville Reservoir, Pa., for a two week period during initiation of spring growth in 1969 provided an unexpected opportunity to observe the development of cankers in a mixed stand of sugar maple and other hardwoods. All sugar maples and 88 percent of the red maples in the flooded zone developed annual cankers similar to those described in previous reports (Figure 38). Severely cankered and in danger of dying were 50 percent of the sugar maples and 37 percent of the red maples (Figure 39). Black-cherry, white oak, ash,

Figure 38. A–Cankered red maple before bark removal. B–Cankered red maple after bark removal.

Figure 39. Severely cankered sugar maple with bark removed.

hickory, basswood and birch trees also developed similar cankers, but none appeared to be as drastically affected as sugar maple.

None of the sugar maples, cut and sectioned, had been cankered previous to the flooding of 1969. In 1967 and 1968 the flood waters had receded from the tree zone at least two weeks prior to leaf initiation.

UNIVERSITY OF WISCONSIN, 1264

Oak wilt, its development, spread and control.

J. E. KUNTZ

To supplement our knowledge of host-parasite relations in disease development, a study of leaf abscission in juvenile red oak has shown abscission induced by *Ceratocystis fagacearum* to be very similar to natural abscission (Figure 40). *C. fagacearum* invaded petioles, midveins and veins of leaves prior to symptom development. All leaves were not infected when the first symptoms appeared and colonization of leaf tissue was not a prerequisite for leaf abscission. Leaves began to fall several days after necrosis and drying appeared.

Growth regulators were detected in ethyl acetate and ether extracts of oak tissues. Three zones of growth

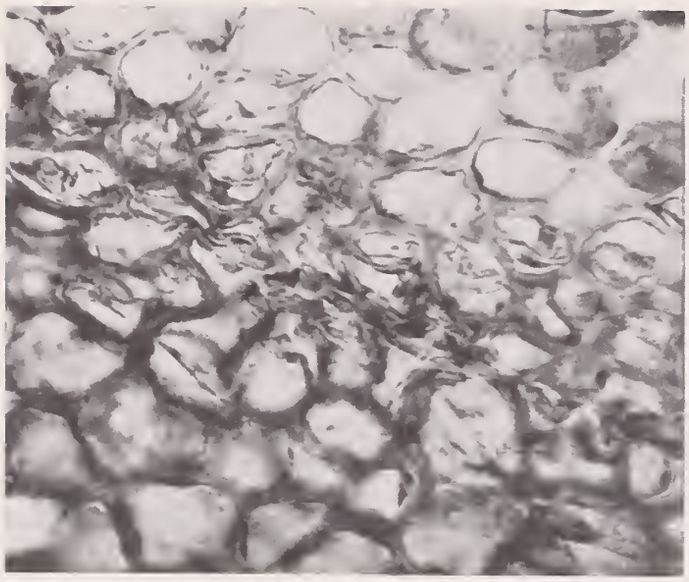

Figure 40. Abscission layer in leaf petiole of a juvenile red oak produced as a result of oak wilt. This closely resembled natural abscission anatomically. Lysis of cells within the abscission zone occurred without previous cell division and resulted in leaf fall.

regulator activity were detected by bioassay. Two zones showed growth stimulation as measured by the coleoptile straight-growth assay, while the other strongly inhibited growth. One zone of growth stimulation corresponded to indole acetic acid controls. All zones were detected in extracts from healthy as well as wilting trees.

Several small two-month old red oak seedlings were successfully inoculated with *C. fagacearum* (Figure 41). Small seedlings may provide a more uniform plant system than larger potted or field grown trees for physiologic studies of the oak wilt disease.

The effect of growth regulators in oak wilt is being measured in field, greenhouse and growth chamber studies. Regulated dosages of BAP-R (Benzylaminopurine-riboside, a soluble cytokinin) introduced by trunk injection have effectively reduced symptom expression in trees that were then inoculated with *C. fagacearum*. Subsequent cultural tests indicate that fungal distribution is limited, for recovery attempts at various distances from the inoculation site have failed. Additional testing in 1971 will confirm whether this condition persists. Meanwhile, the light and electron microscope are being used to clarify the effects of BAP-R. Testing of Benlate (benomyl, DuPont 1991) a systemic fungicide, continues. Applications by soil drench and trunk inoculation have either eradicated or suppressed fungal growth within vascular tissues and therefore limited foliage wilt.

Figure 41. Paper cone on trunk of small red oak for injection of cytokinin. Two knife cuts were made under surface of solution in paper cone.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 907
Fungal pathogens associated with littleleaf and seedling diseases of southern pines. **W. D. KELLY**

ALABAMA—AUBURN UNIVERSITY, 911
Ingression of Hypoxylon atropunctatum and Hypoxylon puctulatum into southern oaks. **T. C. DAVIS**

UNIVERSITY OF CALIFORNIA, 2383
Studies on epidemiology and control of Fomes annosus root rot. **F. W. COBB**

UNIVERSITY OF HAWAII, 721-F
Natural microbial antagonism in forest soil of Hawaii. **W. KO**

UNIVERSITY OF HAWAII, 715
Ecology of Phytophthora cinnamomi Rands in forest soils. **E. E. TRUJILLO**

LOUISIANA TECH UNIVERSITY, 5
Pine oak gall rusts in the South in relation to conifers and angiosperms. F. F. JEWELL

LOUISIANA TECH UNIVERSITY, 22
Effects of controlled burning on soil microorganism populations in Robert's Plots, Urania, Louisiana. J. MURAD

LOUISIANA TECH UNIVERSITY, 51
The cultivation of Cronratium fusiforme on selective artificial media. J. WHITE

UNIVERSITY OF MARYLAND, J-101-(MC-I)
Forest tree seedlings and soil fungi relationships. W. L. KLARMAN

UNIVERSITY OF MASSACHUSETTS, 1
Etiology of maple tree decline in Massachusetts. W. M. BANFIELD and W. B. BECKER

UNIVERSITY OF MICHIGAN, 15
Isolation of microorganisms from preservative treated wood and effect on wood preservatives. H. L. MORTON

MICHIGAN STATE UNIVERSITY, 1049
Decay and termite resistance of Michigan woods and derived products. E. A. BEHR

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3028
Decay and discoloration associated with sugar maple borer injury. G. A. HESTERBERG

UNIVERSITY OF MINNESOTA, 22-18
Dwarfmistletoe-infection, spread, detection and control. D. W. FRENCH, M. P. MEYER and F. D. IRVING

NORTH CAROLINA STATE UNIVERSITY, 4012
Ecology of forest tree diseases and wood deterioration. L. F. GRAND and E. B. COWLING

OHIO AGRICULTURAL RESOURCE AND DEVELOPMENT CENTER, 8
Disease problems in plantation trees of Ohio. CURT LEBEN, H. R. KRIEBEL and BART THIEGLES

OREGON STATE UNIVERSITY, 819
Phytophthora root rot. L. F. ROTH

PENNSYLVANIA STATE UNIVERSITY, 1702
Epidemiology of forest tree diseases. F. A. WOOD

UNIVERSITY OF TENNESSEE, 7
Blight resistance in American chestnut. E. THOR

TEXAS A&M UNIVERSITY, 1526
Etiology and control of live oak decline. E. P. VAN ARSDEL

UNIVERSITY OF WASHINGTON, 8
Fomes annosus under stand management in Northwest. C. H. DRIVER

UNIVERSITY OF WISCONSIN, 1434
Etiology epidemiology and control of forest plantation root diseases. R. F. PATTON

UNIVERSITY OF WYOMING, 928
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Chapter 5

FOREST MENSURATION

Forest Mensuration has been described as a science dealing with the measurement of volume, growth, and development of individual trees and stands, and the determination of various products obtainable from them. Included in the subject-matter dealt with under forest mensuration are assessment of site quality, age determination, stand density, survey, and mapping. Thus forest mensuration research is highly mathematical.

APPRAISAL OF FOREST AND RANGE RESOURCES

Research Problem Area 110

Periodic appraisals of forest and range resources of the nation are essential to determine the adequacy of public conservation policies and programs and to guide the development of private forest and range enterprises.

The timber resources of the nation, including some 500 million acres of commercial forest land, vary greatly in productivity and availability for industrial use. They show widely divergent trends in growth, depletion and quality. The increasing use of resource data to evaluate future needs for Federal and State forestry programs and to provide guidance for the continuing expansion of wood-using industries in various regions makes it imperative that appraisals of timber resources be intensified and kept up to date.

The range resources of the Nation vary widely in productivity, condition, and potential importance for sustaining livestock and wildlife. There is growing need for a comprehensive appraisal of range conditions and opportunities for improving capacity and use to meet future demands for livestock forage, for water yield and for wildlife habitat.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 17
Vegetation habitat types of the Salmon Mountains, northwest California. **D. A. THORNBURGH**

The Klamath Mountain Region of northwest California has been called the "center of western American forests" because the species of the Pacific Northwest, Northern Rocky Mountains and California meet in the region. It is considered to have the largest natural concentration of conifers anywhere in the world. The Russian Peak area of the Salmon Mountain Range in the eastern end of the Klamath was chosen for initial studies because it has a very diverse mixture of Pacific Northwest and California mountain conifer species. The optimum location of each conifer species in relationship to elevation and moisture gradient was determined.

Vegetation habitat types were developed from a total of 328 sample plots taken in the Salmon Mt. Range. These vegetation habitat types are being used to help explain the distribution of the relict conifer stands that occur in this region. Productivity values are being developed for most species on each habitat type. An identification key will be developed to enable land managers to inventory wildlands by these types. This will enhance the coordinated decision making of wildland managers in the area.

UNIVERSITY OF CALIFORNIA, 2520

Mathematical simulation of forest stands.

L. C. WENSEL

The efforts of the past year have been mainly concerned with the development of a system of mathematical relationships to be used in the generation of artificial forest populations for a forest sampling simulator. This simulator will then be used to study the efficiency of various sampling designs. The approach taken here is mainly concerned with generating arrays of data points consisting of the physical location of each tree in a forest and the physical characteristics (basal area) of that tree. The parameters of this generation are to be measures of stand density, distribution (regular, random, or contigous), and the size class distribution of the individual trees.

At present the lines of inquiry follow two more-or-less separate lines. The first is the development of a method of generating individual tree characteristics. For this a stand table projection model is being developed. The second line of inquiry has to do with the actual generation of Cartesian (X,Y) coordinates for individual trees.

OKLAHOMA STATE UNIVERSITY, 1247

Tree stem frequency distribution. N. WALKER

Present project completed, manuscript finished and is being evaluated. Results are: (1) with appropriate parameter values for the negative binominal distribution, forecasts of stem distribution may be made with limited sample data (2) forecasts of association between diameter classes may be made with association coefficients derived from observed joint frequency tables. The same type information may be obtained with use of the bivariate negative binomial distribution, from limited amounts of field data. Group-selection forests show the strongest degree of association, mixed hardwoods the weakest. (3) Relative frequency tables may be used for representative area determinations. (4) Frequency may be used to show the effects of both cutting, and periodic growth without cutting, upon the forest. (5) Frequency forecasts may be used as a basis for allowable cut estimates. (6) Proportional cutting by frequency (density) classes restores the original distributions in regulated forests. (7) Partitioned frequency tables may be used to find inventory surpluses and deficiencies in unregulated forests, and the cutting plans needed to improve the distributions are revealed. (8) Isolation of special products requiring associations of limited contigous size classes is accomplished with observed joint frequencies, and may be forecast with association coefficients or with bivariate negative binomial fittings.

OREGON STATE UNIVERSITY, 841

Three-P sampling and optical dendrometer for cubic-foot growth on forest areas. J. F. BELL

An analysis was made of the comparative merits of two different unequal probability sampling methods (Hartley-PPS and Three-P) when used in combination with the Barr and Stroud optical dendrometer for estimating cubic-foot volume growth on long-term research study plots.

The combination of unequal probability sampling and the optical dendrometer makes it possible to eliminate tree-volume tables along with their inherent errors and express the results on an area basis. Repeated computer drawn samples were used to analyze the sampling methods.

The Three-P sampling method was examined in depth. Tariff volume table values, various powers of diameter, and local volume table values were used to determine which estimate of the tree characteristic of interest gives the smallest variance. The repeated computer drawn samples indicated that tariff table values and diameter squared are effective in reducing the coefficient of variation.

An analysis was made of data for sample estimates from 50 repeated computer samples each for Three-P and Hartley-PPS sampling representing four measurement times. The estimated total volumes varied little from the actual total volumes. The Hartley-PPS sampling method is recommended for estimating cubic-foot volume on long-term research plots rather than present methods.

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 1

Cubic-foot yield of old-field unthinned loblolly pine plantations. I. D. LENHART

With the assistance of numerous public and private forestry groups throughout the Interior West Gulf Coastal Plain, sample plots in 219 plantations were measured during the latter part of 1970.

Using these data sets, site index and survival analyses are being conducted. The primary goal of the project is to adapt the diameter distribution yield prediction concept to the old-field plantations. Preliminary plottings and analyses indicate strong relationships between plantation parameters and components of the yield model.

When the unified yield prediction system is completed, it will provide mensurational information needed by landowners to plan their management schedules.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 3
Past vegetation and climates of ponderosa pine zone in northern Arizona. D. W. BERRY

UNIVERSITY OF ARIZONA, 662
Development of volume tables for ponderosa pine from aerial photos. G. S. LEHMAN

UNIVERSITY OF CALIFORNIA, 2350
Methods of estimating long-range timber supply.
H. J. VAUX

CONNECTICUT, New Haven, 414
Multivariate analysis of hardwood plot data.
P. E. WAGGONER

UNIVERSITY OF GEORGIA, 21
Prediction of growth and yield of loblolly and slash pine plantations. J. L. CLUTTER

UNIVERSITY OF IDAHO, 1
Site relationships and productivity of foothill woodland-shrub grazing lands in Idaho. E. W. TISDALE

SOUTHERN ILLINOIS UNIVERSITY, 4-67
Dendrochronology of shortleaf pine. W. C. ASHBY

INDIANA–PURDUE UNIVERSITY, 1586
Design of forestry data processing system.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3012
Development of standardized program for automatic data processing of forest measurement records.
W. METEER

UNIVERSITY OF MISSOURI, 167
Determination of optimum photo scale and type of film for Missouri forest conditions. A. J. NASH

NEW YORK–STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 110-0-8
Sampling systems for inventory of forest resources.
C. A. BICKFORD

NORTH CAROLINA STATE UNIVERSITY, 4014
Estimation of parameters in non-linear models of tree growth. W. L. HAFLEY

OREGON STATE UNIVERSITY, 843
Prediction of growth and yield of young growth Douglas-fir stands. D. P. PAINE

SOUTH DAKOTA STATE UNIVERSITY, 556
Visual documentation of successional changes of the Black Hills pine forest. D. R. PROGULSKE

SOUTH DAKOTA STATE UNIVERSITY, 561
Tree encroachment into Black Hills grassland: ecology and management options.
F. R. GARTNER, W. W. THOMPSON and E. M. WHITE

TEXAS A&M UNIVERSITY, 1761
Growth and yield of pine plantations in East Texas.
D. M. MOEHRING and R. G. MERRIFIELD

UTAH STATE UNIVERSITY, 757
Conifer distribution in the Great Basin and adjacent mountains. R. M. LANNER

UNIVERSITY OF VERMONT, 4
Volume equations for major forest trees.
C. C. MYERS

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BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111c

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

NORTHERN ARIZONA UNIVERSITY, 1
Ponderosa pine stand density measures. C. O. MINOR

Ten-year basal area growth predictions, based upon age, site, and original basal area, have been calculated for 121 plots from the basaltic soils near Flagstaff. These growth figures exceed previous predictions by as much as 50 percent, particularly in those stands with initial basal areas of 140 square feet per acre or higher, on the better sites. Next, the prediction equations should be tested against growth from stands that have been thinned to specific basal areas. Over 90 such plots have been measured on the NAU School Forest. Growth data will be computed and tested against the equations.

UNIVERSITY OF NEW HAMPSHIRE, 5
Forest management control in non-industrial woodlands. R. R. WEYRICK

A Fortran IV computer program for processing inventory data in a format that would provide control capability was completed and tested under field conditions in UNH woodlands. A study of vegetation and use relationships on the summit of Mount Washington was conducted in cooperation with the Mount Washington Commission and personnel in the Departments of Botany and Plant Science. A final report and map were completed and will be included in the final commission report. A study of the income effects of various forest ownership and timber management situations in small southern New Hampshire communities is in final stages.

WASHINGTON STATE UNIVERSITY, 2002
Growth and yield of even-aged forest stands.
L. V. PIENAAR

A computer program that fits a four-parameter generalized growth model to growth data has been written for an IBM 360, model 67, in FORTRAN IV G. Input data to the program consist of information on size with every observation on size tagged with a time dimension. Maximized relative likehoods, to be used in inference procedures, are calculated for the four parameters in the model.

Adequacy of the model for tree growth was rationalized on gross physiological grounds. It was demonstrated with data obtained from complete stem analyses of individual trees representing different crown classes in a 170-year old spruce stand. The model provided a satisfactory fit for the development of total tree height, cross sectional area of the stem at breast height, and stem volume of these individual trees.

The rational basis for the model was extended to stand growth (per acre growth) and its adequacy demonstrated in terms of the development of total net basal area (at breast height) per acre. For this purpose a set of experimental plots representative of a wide range of initial stocking densities (number per acre) in even-aged slash pine (*Pinus elliottit*) stands, was used.

ADDITIONAL PROJECTS

CALIFORNIA—HUMBOLDT STATE COLLEGE, 16
A growing stock thinning test of Douglas-fir and associated species. E. W. PIERSON

CALIFORNIA—HUMBOLDT STATE COLLEGE, 21
Effect of nitrogenous fertilizer on the growth of Douglas-fir and redwood. D. THORNBURGH

UNIVERSITY OF GEORGIA, 22
Quick coppicing hardwoods for fiber yield.
J. R. MAY

LOUISIANA TECH UNIVERSITY, 1
Yields from Chapman loblolly pine thinning plots.
L. P. BLACKWELL

UNIVERSITY OF MAINE, 5002
Factors affecting growth of commercial forest tree species in Maine.
C. E. SCHOMAKER and R. A. STRUCHTEMEYER

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3117
Forecasting value growth on northern hardwood forest land. W. R. WYND

UNIVERSITY OF MINNESOTA, 19-45
The study of forest stand dynamics by means of stochastic stimulation models.
D. J. GERRARD and E. I. SUCOFF

NEW YORK—STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 111-5-5
Dynamic models on growth of stands for determining allowable cut. T. CUNIA

PENNSYLVANIA STATE UNIVERSITY, 1805
Stochastic models for the simulation of even-aged forest stand systems. P. E. DRESS

SOUTH CAROLINA—CLEMSON UNIVERSITY, 706
Timing harvest in even-aged timber stands.
J. R. WARNER

VIRGINIA POLYTECHNIC INSTITUTE, 636122
Growth of mixed hardwoods.
A. D. SULLIVAN and H. E. BURKHART

WEST VIRGINIA UNIVERSITY, 5
Growth and yield of hardwoods. D. L. KULOW

UNIVERSITY OF WISCONSIN, 1675
Quantification and simulation of forest growth.
A. R. EK

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REMOTE SENSING

Research Problem Area 113

Programs in agriculture and in agricultural development are heavily dependent on having timely information for decision-making. Opportunities for increasing and sustaining the productivity of natural resources and for facilitating product flows in agriculture are dependent on accurate, comprehensive, and timely information on resource use, availability, productivity potential, and other characteristics. The paucity of such information is a major obstacle in the economic development of the undeveloped regions of the world and a significant obstacle to the formulation of important policies and programs in the more fully developed regions.

Generally such information on natural resources has been obtained from ground surveys. These surveys are costly, and in the more remote and inaccessible regions of the world, they are difficult, if not impossible, to make.

The space age offers new, potentially powerful tools for use in the development of information gathering systems. Ways to exploit the advantages of earthorbiting spacecraft in acquiring many types of data need to be explored.

UNIVERSITY OF MONTANA, 1610
Photo-interpretation of forest understory.
W. R. PIERCE

Techniques for stereo-photographic recording of forest understory vegetation and forest range vegetation have been perfected and tested. A pilot trial of the technique was begun in 1969 and completed in 1970. This trial was conducted in conjunction with a standard forest inventory in Sanders County, Montana. Results will be reported in a Master's thesis in June 1971.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 909
Standardized forest condition classes for aerial forest inventory. E. W. JOHNSON

NORTHERN ARIZONA UNIVERSITY, 7
Aerial surveys of land and timber resources.
T. E. AVERY

UNIVERSITY OF CALIFORNIA, 2180
Multiband spectral reconnaissance for forestry.
R. N. COLWELL

NEW YORK—CORNELL UNIVERSITY, 906
Classification of rural lands based on remote sensor surveys. L. S. HAMILTON and E. E. HARDY

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Chapter 6

FOREST MANAGEMENT

Forest management is the application of business methods and technical forestry principles to the operation of forest property. Research in forest management may deal with several important types of considerations including: theoretical aspects of yield and growing stock; annual or periodic yield and yield regulation; the business aspects of forestry; calculations of costs and profits, and forest valuation; accounting and other financial aspects.

ECONOMICS OF TIMBER PRODUCTION

Research Problem Area 303

Timber production efficiency research investigates how income can be increased through effective use of labor and capital. Such information is generally lacking for the wide variety of forestry investments possible in different areas. Returns of expenditures for planting, stand improvement, and other timber growing activities vary widely throughout the nation and depend on many cost factors including the quantity and quality of timber yields, and local market conditions. Identifying the most profitable opportunities for management of public forestry programs and for private investments on forest lands is basic to efficient allocation of the funds available for timber growing.

UNIVERSITY OF MISSOURI, 543
Financial aspects of silvicultural practices.
R. C. SMITH

Utilization of trees removed in thinning shortleaf pine stands for alternative products to maximize gross revenue to landowners was reported in an M.S. thesis by J. L. Powell. Trees less than 11 inches dbh resulted in maximum revenue when marketed for posts and poles. Larger trees should be sold as sawlogs.

Cost savings under several intensities of forest m agement to grow pulpwood relative to open-mar purchases of wood were compared from the vi point of a pulp and paper firm. The best solution offered by intensive forest management includ frequent thinnings utilized for pulpwood with main stand sold for sawlogs in exchange for p wood. Openmarket purchases should be considere a partial source of wood supply until competition pulpwood forces price increases.

Based on periodic measurement of 190 sample p five-year growth in value of upland hardwood tir was related to the landowner's investment in growing stock. Analysis yet to be completed sh show optimum amounts to growing stock requir attain an owner's guiding rate of return.

The profitability of managing stands of shortleaf under given costs of stand establishment was rep in SB 875. Cost of stand regeneration and site had a substantial effect on the prospective ra return but length of rotation did not.

NORTH CAROLINA STATE UNIVERSITY, 40
A study of computer simulation and its pot benefit to forestry and the wood using industrie
A. G. MU

A simulation model, using IBMs general p

simulation system III, was developed for a southern plywood mill through the lathe process. The model simulated bucking log to length, movement to steam chambers, removal from steam chambers, removal from steam chambers, removal to the lathe infed deck, lathe loading and turning time in lathe. It was shown that the steam chambers may limit mill efficiency during cold weather. The economics of adding additional steaming space was included in the model but not checked in the actual mill situation because the mill was sold. The developed model can process up to 1200 events simultaneously. This was adequate through the lathe operation when logs were considered the units being processed but inadequate when considering sheets of veneer. The model can be sectioned to allow processing of veneer, only at the expense of realism. Two additional simulation models were developed for teaching purposes, a simulation of three skidders operating in a harvesting system, and a model to analyze the impact of demand and lead time fluctuations on inventory policy.

OREGON STATE UNIVERSITY, 833
The economics of chemical brush control.
C. F. SUTHERLAND

Research in the use of herbicides in brush control in western Oregon has reached a point where treatment schedules for operational spraying are feasible. What is not known are the costs and benefits of such treatments from an economic standpoint. This study was designed to provide this type of information.

The costs of chemical control of several brush species are being compared on forest land areas of varying site qualities for Douglas-fir and other commercial species. By relating these costs to the additional returns realized for several rotation periods, it will be possible to estimate the influence of chemical brush control on production of the desired tree species, and the return on the investment. The economic analysis will be completed in May. At that time, suitable guidelines should be available for the regeneration forester to determine the economic feasibility of herbicidal control of brush as a reforestation aid on specific areas.

UNIVERSITY OF TENNESSEE, 10
Economics of alternative timber-growth practices in tennessee hardwood stands. G. R. WELLS

Statistical analyses have been made of data from all hardwood plantations established at Ames Plantation Forest. Significant differences among survival and heights were found for species and replications. After two growing seasons, yellow-poplar and cherrybark oak have competed well in comparison with loblolly pine in height growth. Survival of cherrybark oak was the poorest of the three species, averaging 46 percent. Site factors appear to have an appreciable effect on survival. The results after two growing seasons are encouraging, given the difficulties generally encountered in establishing successful hardwood plantations, especially oak.

A masters thesis is being prepared which will evaluate natural versus artificial established hardwoods including the costs (inputs) of each alternative.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2349
Determination of optimum forest production schedules by mathematical programming.
D. E. TEEGUARDEN

UNIVERSITY OF CALIFORNIA, 2447
Financially optimum thinning regimes for mixed conifer forests of California. R. F. GRAH

UNIVERSITY OF GEORGIA, 19
Cash flow and forest management policy as related to income and taxes. J. L. CLUTTER

MICHIGAN STATE UNIVERSITY, 978
Financial evaluation of forest management opportunities. V. J. RUDOLPH

UNIVERSITY OF MISSOURI, 168
Allocation of inputs among timber production opportunities. R. C. SMITH

UNIVERSITY OF NEW HAMPSHIRE, 7
Economic guidelines for timber stand improvement in New Hampshire. P. E. BRUNS

SOUTH CAROLINA–CLEMSON UNIVERSITY, 707
Logging costs. W. A. SHAIN

UNIVERSITY OF VERMONT, 14
Forest management by parametric linear programming. F. H. ARMSTRONG

UNIVERSITY OF WASHINGTON, 7
Timber haresting in Pacific Northwest second growth stands. G. STENZEL

UNIVERSITY OF WISCONSIN, 1571

Computer simulation of sampling designs and management practices in forestry. L. G. ARVANTTIS

PUBLICATIONS

ARVANITIS, L. G. and S. AHUJA.

Multivariate sampling allocation: A computer program to estimate the polynomial coefficients of a generalized covariance matrix. Research Division, College of Ag. and Life Sc., Res. Report No. 70 (1970), 11 p.

WILSON, L. F. and V. J. RUDOLPH.

Early basal pruning to control forest pests. Journal of Forestry 68:10 632-634. 1970.

Chapter 7

MARKETING OF FOREST PRODUCTS

Quantitative aspects of marketing—demand and supply—are to be found in this chapter. Prices, results of intermixing of demand—supply factors, are also given attention. Other major potential contents of this chapter are: trade customs and policies; marketing administration; economics of forest transport; and economics of the forest products industries.

DEVELOPMENT OF MARKETS AND EFFICIENT MARKETING OF TIMBER AND RELATED PRODUCTS

Research Problem Area 502

Development of markets and efficient marketing of timber and related products may help to maintain the incomes and employment associated with the timber industry. Non-wood products have penetrated many traditional markets for wood materials in construction, manufacturing, shipping, and other uses. Research to evaluate opportunities for market expansion through more efficient processing and marketing of timber products is essential to maintain and improve the competitive position of wood, and wood and timber related products.

UNIVERSITY OF MARYLAND, A-26-BY
Forest market structure.
R. F. McDONALD and D. W. THATCH

The final phase of this project dealt with the Maryland Christmas tree industry. Plantations of Christmas trees are relatively new in Maryland and little information is available on the state-wide production and marketing of these trees. A survey of growers helped fill this knowledge gap by clarifying the structure of the Maryland Christmas tree industry. Maryland was found to have two distinct Christmas tree growing areas on the basis of climate, topography, and soil. One area (the Piedmont region) was close to metropolitan areas while the other (the Western region) was more distant. Even though the regions were physically distinct, the per tree costs of production in the two regions were not significantly different. State-wide, the average production cost per tree was $0.72 with a standard deviation of $0.24.

Growers in both the Piedmont and Western regions marketed trees by a variety of methods. However, most trees were wholesaled at roadside in the Western region while retailing trees by "choose and cut" was most popular in the Piedmont region. Although still in an experimental stage, selling balled and burlaped trees was being tried by increasing numbers of growers in both regions.

Wholesaling was found to be the least expensive way of marketing trees, retailing by "choose and cut" was next, and selling live trees was most expensive. In reverse order, balled and burlaped trees were most profitable, "choose and cut" operations were second and wholesaling cut trees was least lucrative. The average profit per acre for growers in the state was $134.00. In the Western region a profit figure of $87.00 per acre was obtained and in the Piedmont region average profits per acre were $173.00. Thus, the production costs between the regions were

essentially the same, but location and the costs and methods of marketing significantly influenced profits.

NORTH CAROLINA STATE UNIVERSITY, 4022
Wood residue production and feasibility of conversion to a saleable product. **D. H. J. STEENSEN**

Primary objectives are to determine the locations, volumes and types of wood-residues produced by the primary wood-using industry of North Carolina: locate those areas capable of supporting a residue-using industry; and determine the economic feasibility of converting wasted wood to a saleable product. Also, to be determined is whether the primary wood-using industry or any segment thereof is contributing significantly to air and ground pollution. Valuable insights will be gained as to the dispersal and/or concentration of these forms of pollution.

One of the problems presently confronting the State is the continuing migration of underskilled persons from the rural and small-town communities to the large city complexes and to other states. One obvious solution to this problem of small community stabilization is to maintain the existing industry at a viable level while creating new opportunities through the inducement of new industry. The primary wood-using industry, especially the sawmill industry, is generally rurally oriented and comprised of small producers who are experiencing trouble remaining competitive under conditions of rising costs and stable prices. It is these producers who currently are suspected of generating large amounts of unused wood-residues which can be utilized to manufacture paper pulp, fiber boards and particle board or can be reprocessed to be used as soil amenders, chicken litter or used in a variety of other applications.

Data for this investigation are being obtained by means of comprehensive questionnaires which are taken in the field by trained survey crews provided by the North Carolina State Division of Forestry. Wood residue conversion factors based on log diameters have been derived for veneer and plywood mills, chip-and-saw type mills, and for each of the existing configurations of band and circular mills. Computer programs have been developed to estimate the amount and types of residues produced from inputs provided by the 1,150 primary wood-using firms in the state.

Final evaluation of this study depends on whether existing wood residues are sufficiently concentrated and are adequate to sustain additional residue-using firms, and if such firm(s) can be induced to avail themselves of these raw materials. The addition of any firm which would convert waste materials to saleable products would be a step in partly achieving the common goals of modern society: rural stability; alleviation of pollution; aesthetic improvement; and, conservation of a natural resource.

UNIVERSITY OF WISCONSIN, 1364
Technological change in the forest industries.
W. R. BENTLEY

The most significant results were 1) Technological change in the forest industry conforms to long-standing hypotheses regarding direction, and the lags between stimulus and affect are similar to those observed in other industries. 2) Efforts to empirically test hypotheses generally were frustrated by lack of precise data on appropriate variables. Similarly, an effort to quantify cost curves for pollution control in the pulp and paper industry was generally unsuccessful. It is possible, however, to improve trend projections of change for purposes of timber trends studies. 3) Policy manipulation of market environment (e.g. public timber sales) may lead to socially desirable technological change in capital-intensive, quite complex processing of timber, but this is unlikely in lumber, plywood or simple pulp processes. 4) Preliminary investigation of technological change in the timber production process itself suggests that (a) great productivity changes are feasible and can be directed, and (b) various environmental and social values should be integrated into strictly managerial investigations of the problem.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA. 2538
Economic analysis of wood procurement systems.
W. L. M. McKILLOP

UNIVERSITY OF MISSOURI, 166
Wood industries management. **K. T. ADAIR**

UNIVERSITY OF MONTANA, 202
Marketing Montana lumber. **R. W. WAMBACH**

TEXAS A&M UNIVERSITY, 1524
Requirements and distribution of wood products manufactured and used in Texas.
H. B. SORENSON, W. A. SMITH and G. T. OLSON

PUBLICATIONS

BENTLEY, W. and J. GORDON.
Wood production in an industrial society. Wisc. For. Res. Note No. 150. 1970.

BENTLEY, W. R.
Technological change in the forest industries—a problem analysis. Wisc. For. Res. Note No. 151. 1970.

SORENSEN, H. B.
"Future trading in plywood," Extension Letter (May 1970).

THATCH, D. W. and R. F. McDONALD.
"Christmas trees: production in Maryland." Agricultural Experiment Station Publication MP728, University of Maryland, 72 pp., 1970.

THATCH, D. W. and R. F. McDONALD.
"Christmas trees: marketing in Maryland." Agricultural Experiment Station Publication MP732, University of Maryland, 44 pp., 1970.

IMPROVEMENT OF GRADES AND STANDARDS OF FOREST PRODUCTS

Research Problem Area 512

Grades and standards describe the characteristics of a product so that producers and processors, and buyers and sellers can gage product utility. Tree grades provide a means of more effectively valuing growing stock, thus assisting the producer to set specific goals for silvicultural practice and to obtain true value for stumpage. Log grades reduce the uncertainty in product transactions and permit segregation of logs for their highest use, to the benefit of both buyer and seller. Standards for processed forest products likewise assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Because wood is by nature a very heterogenous material, the efficiency of the whole structure of wood markets depends to a large degree on the existence of accurate and understandable grades and standards.

UNIVERSITY OF WASHINGTON, 23
Models for wood quality—processing problems
J. S. BETHEL

The model of the lumber manufacturing operation is being developed. This model simulates the conversion of logs to lumber in terms of yield and costs of operation. It will include stochastic elements in both input functions and operating functions.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2357
Marketability of veneer and plywood from young-growth California pines and redwood.
F. E. DICKINSON

UNIVERSITY OF KENTUCKY, 601
Improved hardwood log breakdown.
D. B. RICHARDS

WASHINGTON STATE UNIVERSITY, 1929
Factors affecting the vibrational parameters of structural lumber. R. F. PELLERIN

Chapter 8

FOREST PRODUCTS: MANUFACTURING AND UTILIZATION

Topics range from studies of anatomical elements in structure of wood and bark through the phases of mechanical and chemical conversion, assembly and finishing processes, to products in use. Research to maintain a competitive position for wood to more efficiently utilize wood resources is essential. This is particularly important in these times of concern with the environment. Many people are suggesting that other materials be used for building instead of wood. However, the substitution of non-renewable resources for wood, which is obviously a renewable resource, is likely to cause greater deterioration to the environment than is the use of wood. This means we must learn how to use wood more economically in those places where it is now used as well as develop new uses for wood.

NEW AND IMPROVED FOREST PRODUCTS

Research Problem Area 401

The objectives of forest products research are to develop (1) lower cost products with greater desirability, serviceability, and performance, and (2) greater use of low-quality timber, little-used species, and materials now remaining as waste.

There is a continuing decline in quality of available timber because of the lack of adequate replacements for the larger and better quality trees. Demand for timber products is expected to go up 80 percent by the year 2000. Research is needed to develop ways to convert more low-grade material into useful products. Where such timber is abundant it may be possible to establish new industries and enhance economic growth. Improved wood utilization also provides a profitable means for upgrading residual stands. Use of low-quality trees frees space for better growing stock.

ALABAMA—AUBURN UNIVERSITY, 905
Anatomy of figured wood. **H. O. BEALS**

Figure apparently occurs in all species, geographical locations, and sizes of trees although normally not reported in non-commercial woods. Exact mechanism of figure formation is not known but appears to be the result of differential elongation of certain cellular elements causing localized lateral shifting from the normal vertical alignment of tissues. Figure appearance is due to optical illusions produced by differential light absorption and refraction due to orientation of the fiberous elements.

ALABAMA AUBURN UNIVERSITY, 914
Mineral composition of figured and unfigured wood.
H. O. BEALS and E. S. LYLE JR.

Preliminary work has been concerned with calibration and operation of X-ray equipment to be used for spectrographic analysis of samples. A number of samples have been prepared for analysis and trials

have been made. Standards are in the process of being prepared.

UNIVERSITY OF CALIFORNIA, 2553
Heating methods in the drying of wood.
D. ARGANBRIGHT

The data from a study on the leveling of moisture in predried veneer using microwaves and hot air was analyzed and the results published. Major results were that microwaves are an effective method of removing moist spots within veneer sheets. Drying selectivity was due to a greater microwave absorption in the wetter areas. Drying times differed for different species, thicknesses and initial moisture contents studied. Differences in drying characteristics between different species were due primarily to differences in specific gravity and moisture distribution. Gluability of microwave dried veneer was equal to or better than that of hot air redried veneer. Use of microwave redrying prevented overdrying and kept the veneer more flexible. A 25 kW microwave dried of 915 MHz frequency donated by industry to the laboratory was installed and made operational. This drier which can also be used with or without impinging hot air was then used in an impingement drying study on the influence of thickness on the drying rate of Douglas-fir heartwood veneer. The results of this study are still being processed. A technique for measuring the heat transfer coefficients has been developed and is undergoing additional study. This method can be used to study heat transfer in both industrial and scientific drying facilities.

COLORADO STATE UNIVERSITY, 322
Properties of lodgepole pine infected by dwarf mistletoe.
D. L. CREWS

Dwarf mistletoe (*Arceuthobium americanum* Nutt. ex Engelm.) is the most serious disease known in the western coniferous forests based on the loss of forest productivity. Rocky Mountain lodgepole pine (*Pinus contorta* Dougl.) stands are severely attacked. The most effective means of control still lies in removing the infected trees from the stand, but there is a question whether the wood properties of infected trees are comparable to non-infected trees.

The study underway investigates the effects of dwarf mistletoe on: bending strength, specific gravity, tracheid length, tracheid orientation, fibril angle, and longitudinal shrinkage. Increased knowledge on these factors is needed in order to determine how they affect wood quality. This investigation should provide valuable information concerning the anomaly of dwarf mistletoe infected lodgepole pine. Preliminary observations show a definite reduction in the elasticity of infected wood and the severe distortions that exist in the cellular elements (Figure 42).

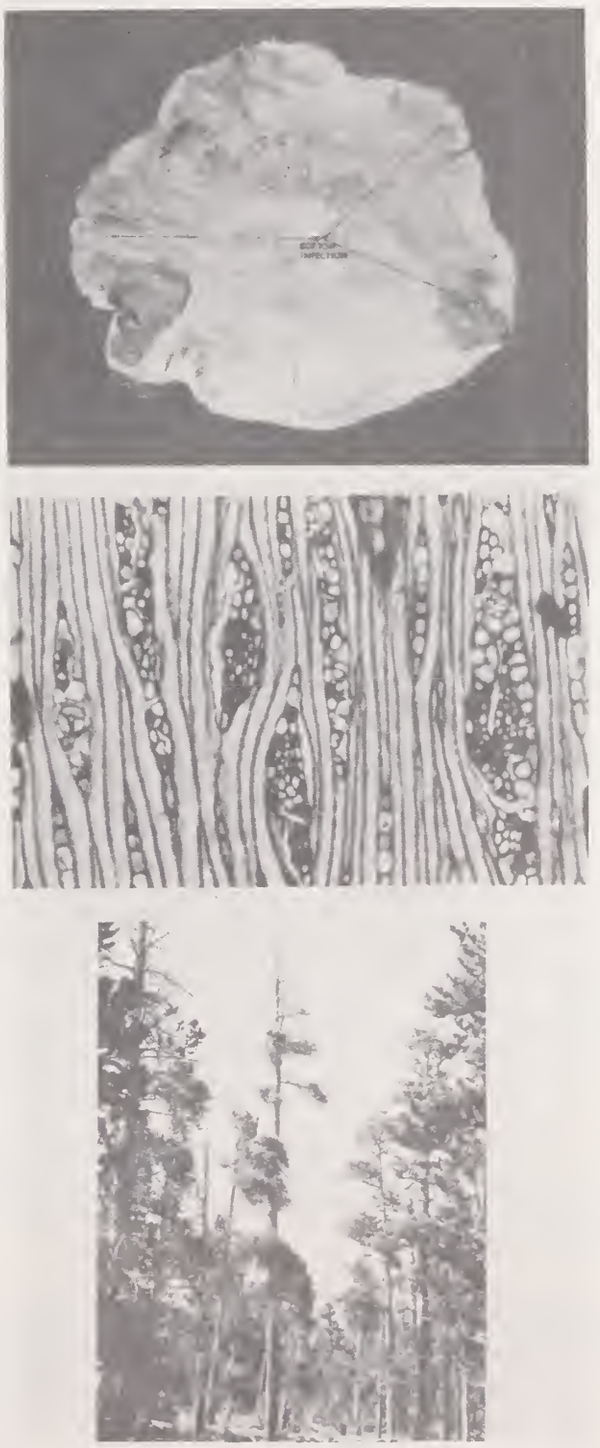

Figure 42. Lodgepole pine infected with dwarf mistletoe–top cross section showing deformation; center, microscopic view (400X) showing distortion of cellular elements; bottom, infected stand showing the formation of witches broom.

UNIVERSITY OF GEORGIA, 15

Technology of exterior grade building components made from wood-glue composites. J. R. RICE

In one series of experiments, the results strongly indicate the desirability of using lower board densities and high resin contents in order to achieve higher flakeboard durability. Although an effect of wood density was anticipated, it was not evident in these tests. This work has been written up in a graduate thesis entitled, "A study of the influence of wood density, board density and resin content on flakeboard durability."

A new series of experiments has been undertaken to study the role and mechanism of resin permeation into wood and its relationship to basic adhesive bond durability. The study is confined to southern yellow pine, and early findings indicate that the xylary rays, in addition to early-wood tracheids, play a major role in conducting resin adhesive. The movement of resin into the rays results in an appreciable absorption by latewood tissue as well as earlywood. Figure 43 illustrates the general nature of resin adhesive penetration into earlywood and latewood. In each case the glue mix used was the same and of the normal southern pine plywood type.

UNIVERSITY OF IDAHO, 7

Unit fiber stress in rings of Douglas-fir.

A. D. HOFSTRAND

Data from perpendicular to grain compression tests were analyzed using BIOMED stepwise regression program. Analyses of variance was used to test significance of growth ring angle, moisture content, rate of growth and specific gravity on maximum stress, stress at proportional limit, modulus of elasticity, and the ratio of maximum stress to stress at proportional limit. Polynomial regression analyses were used to determine the type of curve to best fit the data.

1. Direction of load application with respect to growth ring orientation has a significant influence on modulus of elasticity regardless of moisture level.

2. Modulus of elasticity decreased as growth ring angle progressed from 0 to 45 degrees and then increased as the angle approached 90 degrees.

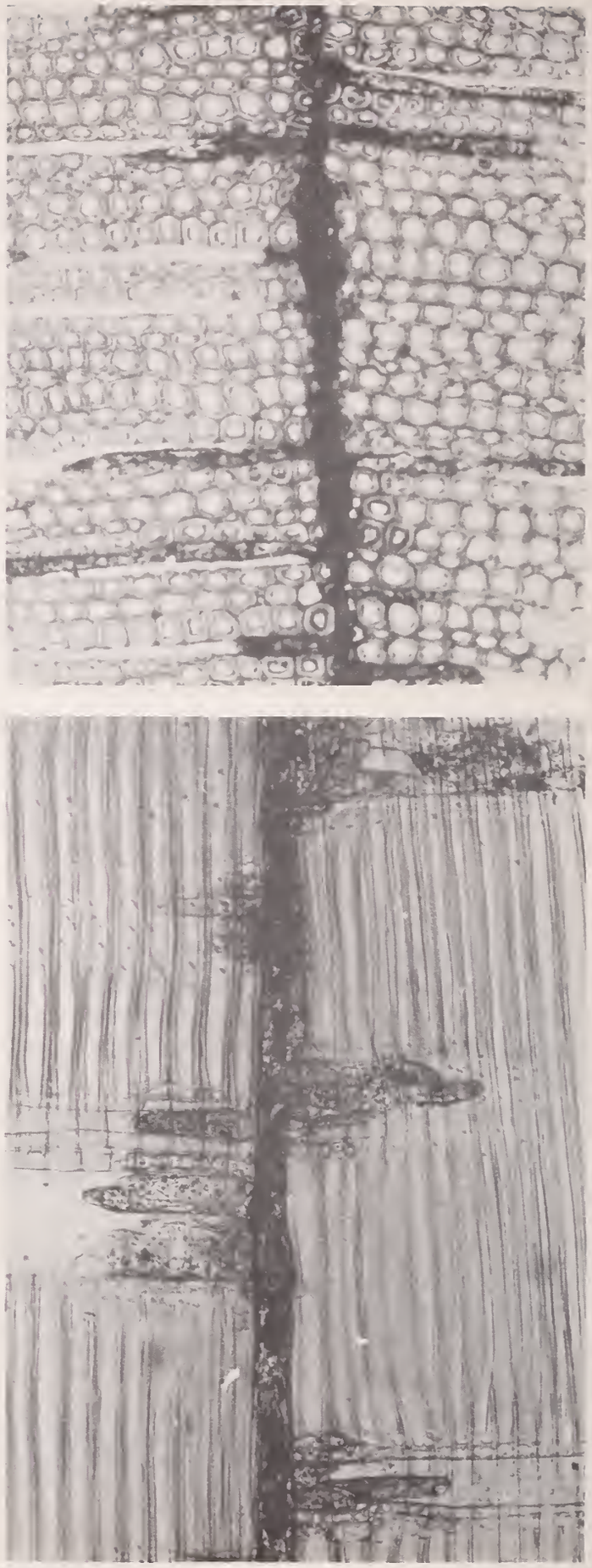

Figure 43. The movement of resin into ray cells results in appreciable absorption by latewood tissue as well as earlywood of southern pine. In both A and B the glue mix was the same.

Average moduli of elasticity of specimens tested at 0 and 90 degree growth ring angle were approximately twice that of specimen tested at 45 degrees.

3. Moisture content level has a significant influence on modulus of elasticity regardless of growth ring angle. Average modulus of elasticity of specimens tested at six percent moisture content was almost twice that of specimens tested in the saturated condition.

4. Specific gravity has very little influence on stress values regardless of growth ring orientation or moisture content level.

5. Stepwise regression analyses indicate rate of growth, expressed as number of rings per inch, contributes significantly to the stress values. However, the level of significance is low and therefore can not be used to make predictions.

6. Average values of stress at proportional limit, maximum stress, modulus of elasticity and the ratio of maximum stress to stress at proportional limit decrease up to thirty feet from the ground and then increase up to base of the crown.

7. Second-degree curves best fitted data for modulus of elasticity, stress at proportional limit and ratio of maximum stress to stress at proportional limit.

UNIVERSITY OF ILLINOIS, 334
Penta-treatment, and strength of Douglas-fir.
C. S. WALTERS

The study concerned dimensional change taking place in Douglas-fir during the heating, Lowry-pressure, and strain-recovery periods. The interacting effects of wood moisture content (8 or 29%), solution temperature (100° or 200° F.), and pressure (150, 300, 450, or 600 psig) on linear measurements, dimensional changes over time, and on solution absorption were studied.

Decreases in the radial plane ranged from 0.08% (no collapse) when specimens were treated at 100° F., 8% moisture content, and 450 psig to 18.51% (collapsed) when treated at 200° F., 8% moisture, at 600 psig. The change in the tangential plane ranged from 0.07% (no collapse) when treated at 100° F., 8% moisture, and 200 psig to 7.94% when treated at 200° F., 8% moisture content, and 600 psig (severe collapse).

The dimensional change for wood treated at 200° F. was 86 times greater than it was at 100° F. During the pressure period, the greatest dimensional change was in radial specimens treated at 29% moisture, 100° F., and 600 psig. Compression set during the post-pressure period was greatest in the tangential specimens treated at 29% moisture at 200° F., and 450 psig. At the same moisture-temperature conditions and 600 psig, it was only one-third as much. The difference was attributed to high pressure, which kept moisture liquid until the cylinder was returned to atmospheric pressure. The water in the hot wood was then converted to steam, which brought about partial recovery. Absorptions ranged to 15 lb./cu. ft., the solution absorption for wood treated at 8% moisture content in 200° solution and at 600 psig.

SOUTHERN ILLINOIS UNVERSITY, 70-R-5
Fiber-tracheid characteristics in Ailanthus altissima Mill.
A. A. MOSLEMI

Ailanthus altissima, the Tree of Heaven, is a native of Asia which grows well on poor soils in the United States. This "tree that grew in Brooklyn" is at home on urban land fills as well as on the scarred remains of strip mined hills and fields. Earlier laboratory work indicated that the wood of Ailanthus can yield satisfactory pulp for paper making so the present study was designed to determine exact fiber characteristics of native grown specimens. Samples of trees found in Illinois, Ohio, and Missouri compared favorably to medium density American hardwoods. The next step would be to establish experimental plantings on abused land to help restore favorable soil conditions and also produce a source of wood fiber as the Ailanthus forests are thinned.

IOWA STATE UNIVERSITY, 1663
Solution and diffusion of vapors in wood.
J. D. WELLONS, III

The properties of wood-plastic composites vary with the amount of cell wall and cell lumen bulking. Plastic located in the wall increases dimensional stability; located in the lumen, plastic should improve mechanical properties.

This research has developed solvent exchange techniques by which engineered wood-plastic composites

can be made. Green wood is soaked in one or more intermediate solvents to displace the water. The intermediate solvent(s) may be flash evaporated from the wood and plastic vapor impregnated in its place in the cell wall, eliminating up to 60% of normal drying shrinkage and increasing non-polar plastic concentration from 2 to 15% in the cell wall. Polar plastics are concentrated even more. The intermediate solvent may be directly replaced by liquid plastic precursor without flash drying. The amount impregnated in the cell wall is controlled by residual water and solvent deliberately left trapped in the wall; lumen impregnation is controlled by normal pressure vacuum methods.

Twelve solvent exchange systems were studied. The diffusion rates and equilibrium concentration in wood of plastic, solvent and water are reported in the publications below. Drying shrinkage and selective retention of solvents were studied. A technique to cure acid catalyzed plastics with γ-radiation was also developed.

UNIVERSITY OF KENTUCKY, 602

Glued wood corner joints of high strength.

D. B. RICHARDS

Glued finger-scarf joints are currently used extensively for commercial end jointing of lumber and laminated timbers. Their commercial use as high strength structural corner joints has been limited by a tendency for the stress concentration at the inner corner of such joints to cause failure under long-term loading. By the use of photoelastic techniques and failure analysis, this stress concentration has been studied (Figure 44). Subsequent design changes have largely eliminated it as a cause of joint failure. By the addition of properly designed undercut fillets, structural sized corner joints have been fabricated that exceed the strength of similar joints without the undercut fillet. The best of such designs will be subjected to long term dead loads in order to evaluate them structurally and to establish appropriate working stresses.

Where space and design allow the deepening of the corner joint, additional strength can be gained by use of a conventional fillet. Either the undercut fillet or the conventional fillet is further strengthened by laminating one or more veneers to the inner curved surface. These joints strengthened by the addition of material show great promise for structural use and will be included in the long-term loading study mentioned above.

Figure 44. Photoelastic strain pattern around an undercut fillet. Such model work together with photoelastic coating studies of wood corner joints with undercut fillets aided in a study of the effectiveness of undercut fillets in reducing stress concentrations at least at the qualitative level.

LOUISIANA STATE UNIVERSITY, 1440

Liquid and gas permeability of wood as an indication of treatability with creosote and copper sulfate.

E. T. CHOONG

To date, measurements have been made on gas (nitrogen) permeability in the three structural directions of wood on representative samples (sapwood and heartwood) of more than 40 domestic species. Also, within-tree variations (tree height and distance from pith) of permeability in several southern woods have been measured. The data are being analyzed. The "true" permeability of wood was obtained from the superficial gas permeability value by the Klinkenberg effect.

A technique for measuring water flow in woods of low permeability has been developed. As a result of air blockage, some difficulties are still being encountered in obtaining completely saturated wood and/or maintaining steady-state condition during measurement. It is believed that cavitation by mechanical shock and ultra-filtration technique will solve most of these problems.

It is anticipated that further studies will be made in an effort to determine the relationship between gas and liquid permeability, between permeability and treatability, and between permeability and diffusivity.

LOUISIANA STATE UNIVERSITY, 1444

The development of timber harvesting systems for the southeastern United States. R. W. McDERMID

It was determined that grapple skidders produce more volume per hour than choker skidders on southeastern Louisiana logging operations. At distances of more than 250 yards grapple skidders were also less expensive to operate per unit of production than choker skidders. Operator performance and amount of under brush present on the operation significantly affected daily productivity of rubber-tired skidders.

It was determined from a study of ten log loaders in southeastern Louisiana that, on the average, only 38 per cent of total time was occupied in actual loading operations. The remainder was unproductive, primarily because of poor scheduling of log cutting or truck transportation.

LOUISIANA STATE UNIVERSITY, 1477

Construction and evaluation of a fluidized bed for drying green southern pine wood veneer.

W. E. LOOS

Green loblolly pine veneer of two thicknesses (1/10″ and 3/16″) was dried at three temperatures (250, 325 and 400 degrees F) in two media (sand and Ceraspheres) at two air velocities (30 and 60 cfm) in a fluidized bed. Drying time required to reach 5% MC was as low as 1 3/4 minutes for 1/10″ veneer dried at 400 degrees F at the higher air flow in sand. Drying rates were three times faster for sand and two times faster for Ceraspheres than those for jet driers run at the same temperature. Increasing temperature had the greatest effect on increasing drying rate. Sand gave faster drying rates than Ceraspheres. Air-flow rate had an effect at lower temperatures in Ceraspheres. Preliminary gluing studies indicated that there is some difficulty in gluing fluidized bed dried veneer; however, these difficulties can probably be easily overcome. A manuscript, "Fluidized bed drying of southern pine veneer," was prepared for publication.

UNIVERSITY OF MAINE, 5004

Maine wood properties and grades for product utilization. J. E. SHOTTAFER, T. J. CORCORAN and C. E. SHULER

The project, implemented in 1964, has emphasized investigation of lumber and plywood products, together with operations analysis and design related to the conversion of the forest resource of Maine.

A predictable relationship has been established between modulus of elasticity and rupture strength in flexure for eastern spruce structural lumber, and a subsequent trial of a stress grading system, employing an electro-mechanical stress rating device, proved moderately successful. Subsequent analysis of estimated and actual test strength values has indicated that existing grading rules do not adequately reflect the strength qualities of eastern spruce lumber. An analysis of air drying conditions within the state has been prepared to assist producers in the processing of lumber, and a study of the use of low-grade material for pallet manufacture has confirmed the technical feasibility of such an enterprise.

The potential conversion of the Maine spruce resource as structural plywood has been investigated with favorable results. A study of the yield of over 100 rotary-cut bolts revealed an estimated recovery factor of 2.3 square feet per board foot, primarily in the C and D grades of veneer. No serious problems have been noted in the manufacture of structural plywood from eastern spruce, and such production appears feasible, presuming an adequate resource base.

Methods for the conduct of logging time studies, employing the use of video tape, and a descriptive technique for the dissemination of timber harvesting systems information have been developed and proven satisfactory. A small sawmill design utilizing very limited personnel, and a cost accounting system specifically applicable to the small mill have been completed. A viable mathematical model for a pulpwood procurement system, applicable in the northeast region, has been developed.

Upon the revision of the project in 1970, this series of related studies has been continued, with current emphasis on lumber, plywood, and particle board products.

UNIVERSITY OF MASSACHUSETTS, 4

Wood properties of red pine.

H. B. GATSLICK, W. W. RICE and W. S. McNAMARA

One drying project compared yield of red oak dimension parts against drying red oak lumber and subsequent dimension part cutting. Results favored lumber with cup the primary degrade in parts. This work suggested need for systems development in restraining dimension parts in drying to prevent warp, and mechanical stacking and handling which would reduce costs, increase yield and reduce manufacturing wastes.

Automatic kiln operation (Data-Trak) equipment is being installed and will be utilized to develop improved drying schedules for northeastern species.

There is a substantial market and price advantage for industrial and construction plywood produced from northeastern species (both softwood and hardwood), particularly to meet projected low-cost component and modular housing requirements.

Pilot plant for making particleboard has been completed and homogeneous boards of white pine, red pine, hemlock and red oak of different geometries are being produced and tested. Wood residues in Northeast are not being substantially or economically utilized.

Impregnating 1/4″ hardboard with phenolic resins with vacuum-pressure cycles produced boards with substantially increased dimensional stability, MOE, MOR and hardness. Modified impregnated hardboard from northeastern species has a wide range of product potential.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 23118

The feasibility of a particleboard core sandwich type composite transport trailer deck.

G. A. HESTERBERG, B. C. SUN and C. A. TRIPHAHN

The particleboard core sandwich-type composite deck designed in this research project was produced to determine its feasibility with respect to the strength requirements set by trailer manufacturers. Trailer decks are currently produced from strips of maple, oak and other hardwoods laminated into 1 x 40 foot sections which are planed and machined for installation. The advantage of a particleboard deck would be the ability to laminate large sections thus reducing the materials handling encountered in manufacture of wood trailer decking. In addition to lowering cost some procedures used in laminating the hardwood deck could be eliminated. This type of deck would be welcomed, therefore, by both trailer and particleboard manufacturers.

The original particleboard deck design, used in this research incorporated a surface material of vulcanized fiber, a core of two 5/8″ sheets of particleboard and a steel epoxy matrix on the lower surface. The deck was compared to laminated oak with regards to static- and impact-bending, abrasion resistance, nail withdrawal resistance and the "Janks" hardness test. The static bending strength of the particleboard deck was dictated by the low shear strength of the particleboard core. The load carrying capacity of the original particleboard deck, 1,300 pounds, exceeded the load specifications of 1,250 pounds set by the trailer manufacturers. However, this was only about 40% of the strength of laminated oak. In order to increase the shear strength of the deck a modification of the structure was incorporated to reinforce the deck core. This modification increased deck load carrying capacity to 2240 pounds or approximately 70% of the strength of oak. Other tests show this deck to be harder and more abrasion resistant than oak. The plain particleboard deck possesses approximately 60% of the nail withdrawal resistance of oak and this is substantially higher than the withdrawal resistance of Douglas-fir plywood of the equivalent thickness.

UNIVERSITY OF MINNESOTA, 19-60

The properties, production and trade acceptance of aspen studs. **R. D. THOMPSON**

Incising-drying projects performed on 10 commercially important species. Results show benefits if species heartwood is over 50% M/C. Incised 2 x 4's of high M/C species dried faster, more uniformly than unincised (See Figure 45). Findings could be economically important because of new industry sizes and dry-green American Lumber Standards regulations.

A Chip-N-Saw sawing project using 3 diameter classes of aspen logs was done at Elk Lake, Canada in August 1970. Volume recovery of studs, chips, sawdust, other lumber was compared volume of wood in logs. Data will be valuable in selecting proper equipment to

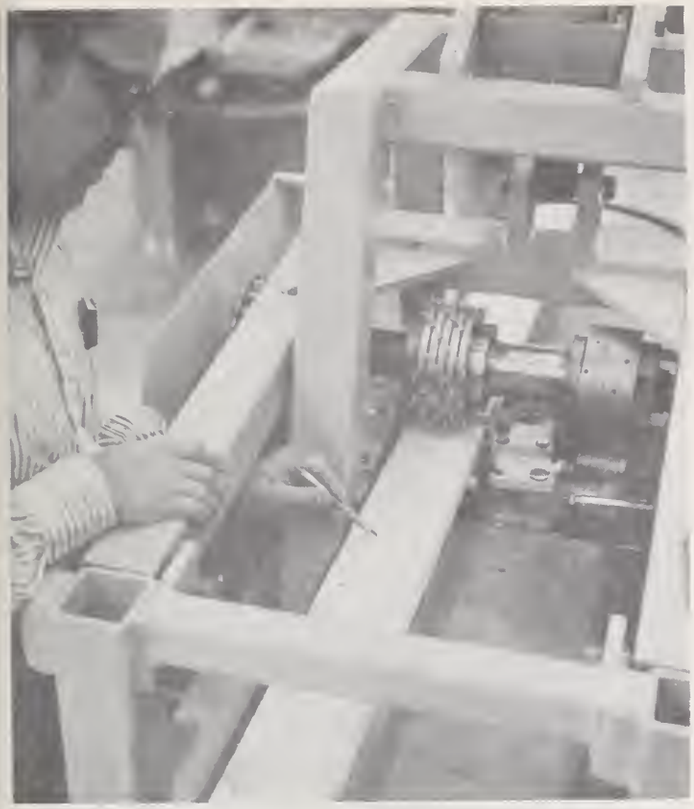

Figure 45. Incising a 2 x 4 with machine developed for this project. Incision marks are 3/8" deep in rows 1/2" apart. Incising green aspen 2 x 4 studs has shown to aid in drying.

produce aspen studs. Canadian Government interested in project, contributed funds, arranged use of sawmill and log procurement. Ottawa Forest Prod. Lab conducting drying experiment with some of lumber produced. Total of 2297 pc. 2x4, 392 pc. 2x3 produced. Grading and treating completed on 1796 pc. 2x4, and 388 pc. 2x3 at St Paul. Mobile homes will be built using 2x3's. Manufactured homes and regular construction tests will use 2x4's. Considerable interest in producing aspen studs has been indicated among lumber, paper and wood fiber products manufacturers in U.S. and Canada. Trial sawing of studs has been done at a mill in Wisconsin. A 60 MMBF mill is being constructed in Alberta, Canada.

UNIVERSITY OF MISSOURI, 535
Growth-quality evaluation of the wood of oak, pine and red cedar. **E. A. McGINNES**

Growth-quality evaluation of oak, pine and red cedar wood completed to the extent that at least one study for each species was undertaken and reported (published). Growth rate found to be poorly correlated with quality indices in each instance. Ultrastructure investigations were not undertaken for normal wood; however, techniques for such studies were mastered during later stages of this research.

Ultrastructure of ring shake in oak investigated and possible relationship of shake to biodegradation of wood shown. Frequency of various shake-types in oak and black walnut established and reported. Within tree variation of xylem properties (fiber length, extractives, growth rate, specific gravity, etc.) of oak, pine and red cedar established and reported. Red cedar shows a trend of decreasing specific gravity from pith to bark at breast height; this is a significant departure from usual specific gravity patterns for coniferous woods.

PENNSYLVANIA STATE UNIVERSITY, 1869
A thermogravimetric analysis of adhesive and wood fiber behavior. **F. C. BEALL, W. K. MURPHEY and G. A. ZIEGLER**

The sorption part of the project is in the developmental stage. The balance and RH equipment are thermally insulated for accurate temperature control over the range of 25-50 C. Chamber and balance access ports have been completed. A flowing gas RH system is being built. The adhesives portion of the study will be delayed until sorption data collection is completed.

PENNSYLVANIA STATE UNIVERSITY, 1781
Knife variables associated with slicing wood. **W. K. MURPHEY, P. C. KERSAVAGE and L. E. RISHEL**

Final tests were conducted on slicing wood using three knife configurations and a rolling nose bar. Slicedwood was evaluated by making laminates and by press drying individual slices. Degrade and drying rate data were recorded. All samples were tested in static bending. There were no significant strength differences among the knife configuration series. Differences existed at the 5 percent level between slicewood and sawn controls. A stiffer, stronger laminate was produced using sawn lamella. Slicedwood dried faster than sawn wood. No degrade was observed in drying wood produced by either sawing or slicing.

TEXAS A&M, 1650
Potential Formosan termite damage in Texas and an evaluation of control methods. **A. E. LUND**

180 laboratory colonies have been studied with respect to food and substrate, moisture content, temperature requirements, and treatment with two commercial preservatives. Moisture contents evaluated were 5, 10, 15, and 20%. Insects functioned and effectively attacked test blocks at all moisture content levels. Greatest attack occurred at the 10-15% moisture level. Three temperature levels were tested: 70, 80, and 90° F. Termites were most active at 90° F, effecting considerable damage to test blocks. Activity decreased with decreasing temperature. Insects were only able to slightly damage test blocks at 70° F. Higher moisture contents were required as the temperature decreased. At 70° F, most activity occurred at 20% M.C. Optimum conditions: 80-90° F and 10-15% M.C. Two preservatives, CCA and creosote, were effective against the Formosan termite when applied at recommended ground contact retentions. Insects attacked lower retentions of CCA, but total mortality occurred within the test period in each case. Blocks treated with two pounds per cubic foot of creosote were attacked with little resulting mortality. Slight attack occurred at 4 and 6 pcf. It appears that the Formosan termite will probably be able to thrive in all but the arid area of Texas. Contrary to some reports, the preservatives used for protection against our native termites appear effective against the Formosan termite.

UNIVERSITY OF WASHINGTON, 24
Minimizing deterioration of exposed structural wood members. **H. D. ERICKSON**

Several case studies were made of buildings with exposed laminated arches which had decay (Figure 46). In one case, decayed beams had been cleaned of rotted wood, filled with epoxy resin and nearly encased with fiberglass. Two years later, decay was found to be extensive and had shifted somewhat. Decay was often severe between the steel side plates at the base of the beam and just forward of this area. Moisture content was often far over the amount required for decay. A special pressure injection system of a water soluble preservative gave fair treatment to the lamellae in the butt zone. Specially designed protective covers of plywood were also installed which allowed ventilation and promoted drying of the beams. Periodic moisture readings over one year shows it was effective in reducing the moisture in the wood to a level safe from decay. The decayed areas have been repaired by filling with epoxy resin to maintain the strength of the beams.

Figure 46. Decay in exposed laminated arch.

Five different fungi were isolated from decayed beams, four of them are *Poria* brown rots.

The study shows that repairing decayed beams with resin fill is not sufficient if the moisture in the beam is allowed to remain high. Fiberglassing such a repaired beam is harmful and causes rapid decay. Beams in poor condition can be dried out, in place, saving extremely costly replacements. No single fungus is responsible; but one, *P. Monticola,* seems to be the most common.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 910
Strength of plastic-overlaid pine plywood and particleboard. **E. J. BIBLIS**

UNIVERSITY OF ALASKA, 270-7503
Logging costs and economic accessibility of interior Alaska forests. **R. SNYDER**

NORTHERN ARIZONA UNIVERSITY, 2
Wood quality of southwestern ponderosa pine in relation to growth characteristics. **G. VOORHIES**

UNIVERSITY OF CALIFORNIA, 2181
Wood machining process. F. E. DICKINSON

UNIVERSITY OF CALIFORNIA, 2495
Chemistry and utilization of bark. A. WONG

UNIVERSITY OF IDAHO, 8
Grain angle and strength of grand-fir.
A. D. HOFSTRAND

UNIVERSITY OF IDAHO, 15
A problem analysis of precision thin sawing.
K. SOWLES

INDIANA–PURDUE UNIVERSITY, 1355
Mechanical behavior of wood-base composite media.
M. O. HUNT

UNIVERSITY OF KENTUCKY, 1028
Wood fiber mechanics. R. C. TANG

UNIVERSITY OF KENTUCKY, 1029
Composite pole laminates. R. C. TANG

UNIVERSITY OF MAINE, 5009
Anatomy and fundamental properties of Maine woods. N. P. KUTSCHA, G. BAKER and J. E. SHOTTAFER

UNIVERSITY OF MASSACHUSETTS, 3
Rheology of wood restrained from swelling.
R. B. HOADLEY

MICHIGAN STATE UNIVERSITY, 980
Hardwood utilization and marketing.
O. SUCHSLAND

MICHIGAN STATE UNIVERSITY, 1048
Measurement and analysis of hygroscopic dimensional changes of wood composite products.
O. SUCHSLAND

UNIVERSITY OF MINNESOTA, 19-62
Methods of improving and predicting the long-term behavior of particleboard. J. G. HAYGREEN and R. O. GERTJEJANSEN

UNIVERSITY OF MINNESOTA, 19-56
Characteristics and potential of freezing as pretreatment for accelerated drying of important species.
R. W. ERICKSON

MISSISSIPPI STATE UNIVERSITY, 3622
Preservation of southern pine poles and piling.
W. S. THOMPSON

MISSISSIPPI STATE UNIVERSITY, 3623
Wood properties of delta hardwoods.
W. S. THOMPSON

MISSISSIPPI STATE UNIVERSITY, 3624
Efficiency in lumber manufacture.
W. S. THOMPSON and W. R. FOX

MISSISSIPPI STATE UNIVERSITY, 3625
Development of wood adhesives. H. R. ROGERS

MISSISSIPPI STATE UNIVERSITY, 3626
Laminated hardwood lumber for furniture manufacture. J. YAO

UNIVERSITY OF MISSOURI, 165
Anatomy and properties of Missouri woods
E. A. McGINNES, JR.

UNIVERSITY OF MONTANA, 401
Variability of western larch wood.
J. P. KRIER and J. L. FAUROT

UNIVERSITY OF NEW HAMPSHIRE, 3
Wood drying stresses and improved kiln practice.
J. L. HILL

NEW YORK–STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 401-4-2
A study of the deposition of arabinogalactan in larch wood. T. E. TIMEL and G. C. HOFFMANN

NORTH CAROLINA STATE UNIVERSITY, 4005
Wood fiber properties and paper quality.
E. ELLWOOD, A. C. BAREFOOT and R. G. HITCHINGS

NORTH CAROLINA STATE UNIVERSITY, 4008
Sizing of paper and paperboard. C. G. LANDES

NORTH CAROLINA STATE UNIVERSITY, 4019
Preparative fractionation of cellulose by gel permentation chromatography. W. BROWN

NORTH CAROLINA STATE UNIVERSITY, 4024
Photo induced modifications in the structure of lignin. P. K. KRINGSTAD

NORTH CAROLINA STATE UNIVERSITY, 4027
A fracture model for wood with localized defects.
R. G. PEARSON

NORTH CAROLINA STATE UNIVERSITY, 4029
Isolation and characterization of cellulase lignin.
H. CHANG and E. B. COWLING

OKLAHOMA STATE UNIVERSITY, 1246
Wood properties of shortleaf pine.
R. W. STONECYPHER

OREGON STATE UNIVERSITY, 647
Gamma radiation induced reactions of flavonoid compounds from bark. M. L. LAVER

OREGON STATE UNIVERSITY, 763
Permeable and refractory western hemlock.
R. L. KRAHMER and R. T. LIN

OREGON STATE UNIVERSITY, 786
Douglas-fir bark. R. L. KRAHMER

OREGON STATE UNIVERSITY, 812
Electrical properties of wood below radio frequency.
R. T. LIN

OREGON STATE UNIVERSITY, 825
Environmental and genetic effects on pulping characteristics of Oregon woods. W. J. BUBLITZ and M. D. McKIMMY

PENNSYLVANIA STATE UNIVERSITY, 1625
Increasing the operating efficiency in forest products industries. P. C. KERSAVAGE

PENNSYLVANIA STATE UNIVERSITY, 1823
Rhelogy of wood cellulose in situ.
W. K. MURPHEY, F. C. BEALL and L. E. RISHEL

SOUTH CAROLINA–CLEMSON UNIVERSITY, 888
Relationships of longitudinal permeability to traumatic tyloses of Appalachian hardwoods.
T. E. WOOTEN

SOUTH CAROLINA–CLEMSON UNIVERSITY, 925
Wood properties of trees selected for Clemson University superior tree program. T. E. WOOTEN

UNIVERSITY OF TENNESSEE, 9
Hardwood characteristics. H. A. CORE

TEXAS A&M UNIVERSITY, 1773
Chemical utilization of southern yellow pine bark.
I. S. GOLDSTEIN

VIRGINIA POLYTECHNIC INSTITUTE, 636119
Accelerated seasoning of large-dimension wood products. R. E. MARTIN and G. IFJU

UNIVERSITY OF WASHINGTON, 9
Surface properties of wood of conifers to gluing.
B. S. BRYANT

UNIVERSITY OF WASHINGTON, 13
Mathematics of fiber assemblages. G. G. ALLAN

UNIVERSITY OF WASHINGTON, 15
Solution of problems in orthotropic and anisotropic elasticity. B. A. JAYNE

UNIVERSITY OF WASHINGTON, 26
Component theory of wood and fiber composite systems. B. A. JAYNE

WASHINGTON STATE UNIVERSITY, 1772
Dynamic strain and piezoelectric effect in wood.
R. F. PELLERIN

WASHINGTON STATE UNIVERSITY, 1942
Influence of wood structure on shear strength of Douglas-fir. A. F. NOSKOWIAK

WEST VIRGINIA UNIVERSITY, 2
Growth rate and specific gravity of hardwoods.
J. R. HAMILTON

WEST VIRGINIA UNIVERSITY, 3
Utilization of sprout black cherry. C. B. KOCH

WEST VIRGINIA UNIVERSITY, 4
Alternate methods of lumber handling D. E. WHITE

UNIVERSITY OF WISCONSIN, 1518
Avoiding checks in wood and wood products.
H. J. KUBLER

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SUPPLY DEMAND AND PRICE ANALYSIS–FOREST PRODUCTS

Research Problem Area 513

Improved forecasts of supply, demand, and prices of forest products are essential to more efficient and orderly planning for production and marketing. Individual producers, processing and marketing firms, and end users base decisions upon information about the forecasts of future supply, demand and price conditions. Sound public policy of forest conservation is dependent upon such information. The forest supply industries need similar data on goods and services purchased by producers so that they may make orderly adjustments to prospective changes in supply demand and price of production inputs.

UNIVERSITY OF ALASKA, 003
The Alaska market for softwood lumber.
R. SNYDER

Lumber used in Alaska is chiefly produced outside of the state even though almost 250,000,000 board feet of sawn products were exported in 1968. Both intra-Alaska shipments and in-state consumption of Alaska have declined since 1961 largely because of increased efficiency in transportation between the Pacific Northwest and Alaska. Activity by the petroleum industry in the Arctic has created a limited market for locally sawn rough timber, but the Alaska producer faces serious constraints in this market. Quality and dependable availability are the major impediments to expansion of the local market for indigenous lumber. A "Research Note" describing this study will be available in the Spring of 1971.

NEW MEXICO STATE UNIVERSITY, 8
Economic analysis of market opportunities for New Mexico forest mill by-products. J. R. GRAY

With disposal of 157,000 tons of sawdust and 87,000 tons of bark presently causing environmental problems in New Mexico, an in-state market is needed for these forest mill by-products. Statewide restrictions are being enforced to prohibit burning of these materials in the traditional disposal process.

Five questionnaires were developed to determine mulching, bedding, decorative cover or miscellaneous other uses of these by-products by various kinds of potential users in New Mexico.

Preliminary results indicate nurseries are the major suppliers of sawdust and bark to urban and suburban consumers, while only small amounts are used by agricultural producers in rural areas. Approximately 40 percent of the nurseries marketed bark in 1969 while 13 percent of them sold some sawdust as a separate mulching material. In the livestock producer group, 20 percent of the poultrymen and 19 percent of the dairymen used shavings as bedding material in 1969. Few of the other livestock producers reported any use of this material. Also, few producers (6 percent or less) used sawdust as bedding.

These preliminary results indicate that sawdust and bark do not enjoy a substantial market in New Mexico and that a market promotion program is needed. Price resistance has not been a factor based on responses of those contacted. Rather, resistance is based on some misconceptions regarding adverse effects of forest products when used as bedding or mulches. Evidence now available to correct this misinformation has not reached consumers.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2505
The role of oligopsony and monopoly in markets for publicly owned timber in California.
H. J. VAUX

UNIVERSITY OF MARYLAND, A-018-BF
Economic Analysis of the pine forest resources on Maryland's eastern shore. I. W. HARDIE

VIRGINIA POLYTECHNIC INSTITUTE, 636118
An economic model for southern industrial forest regulation. E. F. THOMPSON

UNIVERSITY OF WASHINGTON, 19
Structural change in the forest products industries of the Pacific Northwest. T. R. WAGGENER

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HOUSING FOR RURAL & URBAN FAMILIES

Research Problem Area 801

Housing, as individual units and collectively, has a significant impact on the quality of rural living. Tremendous opportunities exist for research to reveal effective, economical procedures and materials for renovating and modernizing existing houses as well as in design and development of new housing.

ADDITIONAL PROJECTS

INDIANA–PURDUE UNIVERSITY, 1353
Analytical design of trussed rafters.
S. K. SUDDARTH

IOWA STATE UNIVERSITY, 1744
Methods for assessing consumer preferences for housing Iowa case study. D. R. PRESTEMON

UNIVERSITY OF KENTUCKY, 1015
Use of Appalachian lumber. O. M. DAVENPORT

PUBLICATIONS

WILLIAMS, R. M. and J. N. WALKER
"Laterally loaded panels with tension stressed plywood skins" Paper No. 70-409 American Society of Agricultural Engineers. Annual meeting Minneapolis, Minnesota, July 1970.

ALLEVIATE SOIL, WATER, AND AIR POLLUTION

Research Problem Area 901

Soil, water, and air are being polluted with a variety of substances, both inorganic and organic. Some of the more apparent contaminants are organic pesticides, radionuclides in fertilizers, growth regulating chemicals, animal and crop wastes, mulching materials, pathogenic microorganisms, heavy metals, salts used on roads for de-icing, lead from fuel combustion, allergins, and radioactive fallout. Agricultural research must be primarily concerned with alleviating pollution initiated by agricultural and forestry practices.

COLORADO STATE UNIVERSITY, 326
The effect of rainfall acidity on coniferous trees.
W. E. MARLATT and W. D. STRIFFLER

Over the past decade the concentration of sulphur compounds in the air has risen appreciably. This increase has been reflected in the increased acidity of precipitation in some regions of the northern hemisphere. Although little is known concerning the relationship between SO_2 emission from industries and subsequent acidity of rainfall, some work is being done.

This study is initially concerned with the effect of increased acidity of rainfall on western conifers. The initial phase of the study is being confined to the green house where seven species of conifers are being sprayed weekly with dilute acid solutions. The seven species being tested are lodgepole pine, ponderosa pine, Douglas-fir, Colorado blue spruce, Engleman spruce, white fir, and western larch. Treatment levels include pH 6,5,4,3, and 2. Since treatments have recently been started, no effects are yet evident. However, seedlings will be examined for needle length, color, tip burn, bud development and short length. Results should help to explain some of the potential dangers and problems associated with atmospheric pollution and the forests of the Western United States.

ADDITIONAL PROJECTS

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3210
Effect of pulp residual hemicelluloses on cyclic dried paper strength.
B. C. H. SUN and G. A. HESTERBERG

NORTH CAROLINA STATE UNIVERSITY, 4017
Survey of pulp and paper mill effluent control and treatment. **C. N. ROGERS**

NORTH CAROLINA STATE UNIVERSITY, 4025
Pulp industry pollution abatement through process modification. **K. CHANG, K. P. KRINGSTAD and W. T. McKEAN**

NORTH CAROLINA STATE UNIVERSITY, 4028
Water reuse in pulp and paper manufacturing.
C. N. ROGERS

PUBLICATIONS

HENDERSON, G. S. and E. L. STONE
Interactions of phosphorus availability, mycorrhizal and soil fumigation on coniferous seedlings. Soil Sci. Soc. Amer. Proc. 34 (1970) 314-318.

P. J. KLEPPE and C. N. ROGERS
Survey of water utilization and waste control practices in the southern pulp and paper industry. Report No. 35. Water Resources Research Institute of the University of North Carolina, Raleigh, N. C. June 1970.

Chapter 9

FORESTS AND FORESTRY FROM THE NATIONAL POINT OF VIEW

During 1970 there was an increasing concern for the environment and the effects that man is having on the environment. The forests are considered by some to be an irreplaceable type of resource which, if once removed, would never be replaceable. Such groups of amateur environmentalists are interested in reserving large areas for "wilderness" to be used for recreation by a rather select group. These desires have to be balanced against the clamor of a much larger part of the public for more and better housing. Thus we have several desires from various portions of the population which creates some very complex problems in developing forest policy.

It is essential to find solutions to these opposing points of view. The options available are not simply either-or alternatives such as, "timber or recreation," but must be well planned combinations or compromises—based on facts and less emotion.

ALTERNATIVE USES OF LAND

Research Problem Area 104

Alternative uses of land need to be evaluated to determine which ones will provide the greatest short- and long-range social and economic benefits. Population growth, advances in agricultural technology, changing consumer demands, urban and suburban growth, needs of people at home and abroad, recreational needs, and other factors result in changing demands upon our nation's fixed supply of land. Soil conservation, and water, watersheds, recreation and community development programs and policies should be based upon the relative advantages of alternative land uses.

UNIVERSITY OF DELAWARE, 715-E
Wild-land ecology and urban impact. R. E. JONES

Half of the twelve woodland areas under study were severely affected by human impact during this year (Figure 47). Damage ranged from a portion of an acre clearing for highway construction to complete destruction of one 14 acre woodlot for a housing development. Bird populations were evaluated in all woodlands prior to this human impact. An effort is now under way to evaluate the impact of these changes to the bird populations. Yellowjacket wasp populations were low this season, less than half that of the previous year. The wasps did not respond well to a series of 23 chemical attractants placed in the field near the nests. Detailed studies of wood thrush populations, movements, and nesting survival and growth rates were made.

PUBLICATIONS

JONES, R. E. AND J. R. LONGCORE
Reproductive success of the woodthrush in a Delaware woodlot. Wilson Bull. 81 (4): 396-406. 1969.

Figure 47. Heavily compacted areas with leaf litter cover removed are subject to sheet-erosion and lowered available moisture.

STINER, F. M.
Overwintering by Protocalliphora metallica (Diptera: Calliphoridae). Annals Ent. Soc. Amer. 62 (5): 1205-1206. 1969.

JONES, R. E.
Analysis of a Delaware gray squirrel population. Trans. N. E. Sec. Wild. Soc. 27: 97-106. 1970.

OUTDOOR RECREATION

Research Problem Area 902

Outdoor recreational research provides information to guide the use and management of forest and rural lands for recreation, and to help coordinate this use with other land resource uses. The research involves problems in management of the resource and socio-economic relationships of users to the resource. Recreation demands continue to increase, and are becoming more varied and more complex, at a time when pressure on all land resources is accelerating.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-18
Study of visitors to the proposed George Rogers Clark Recreation Way. D. R. McCURDY

Most of the visitors were unaware of the George Rogers Clark Recreation Way proposal; yet many of these people who were unfamiliar with the proposal were in favor of it. Therefore, it can be concluded that the George Rogers Clark Recreation Way development will be accepted by the people, but that the purpose and objectives need to be emphasized and made more clear to the public. Of the people who were familiar with the proposal, most were from local areas. From this, it can be seen that if the George Rogers Clark Recreation Way is to appeal to all recreationists and tourists, not just local visitors, a massive advertisement campaign will be needed.

Because most of the visitor groups were families, it follows that future programs and facilities should be family oriented. Also, the camping and picnicking units should be constructed larger than normal to better accommodate these family groups.

IOWA STATE UNIVERSITY, 1857
Ecological aspects of outdoor recreation planning and development. J. McBRIDE

At the time of termination of this project data collection was just completed on three aspects of the total project. In one substudy dealing with the natural replacement of disease killed *Ulmus Americana,* tentative results indicate a shift in composition to species with animal dispersed seed. These post elm forest have high percentages of hackberry on stream flats. Data from an establishment and seedling growth of hardwood species on compacted soil study suggests that seedling establishment is not impaired by levels of soil compaction used in these experiments. Seedling growth, however, is depressed as soil compaction increases. A preliminary examination of data from a study of tree growth of hardwoods at Ledges State Park infers that the reduction of competition from herbaceous species and shrubs offsets the deleterious effects of soil compaction in picnic grounds. The data that suggests these preliminary conclusions has not, as yet, been analyzed statistically.

UNIVERSITY OF MAINE, 5010
Recreation and forest land use planning.
J. C. WHITTAKER, A. D. NUTTING and T. J. CORCORAN

A study is underway to estimate the demand for and supply of second, vacation homes (Figure 48) in Maine. All known homebuilders in Maine are being surveyed to determine their recent and planned production of second, vacation homes. Information will be collected on numbers, types, price ranges, and places that such homes are shipped. This survey will provide an estimate as to how much of the demand for second, vacation homes Maine producers can supply. The second part of this study involves a survey of a sample of Maine households to determine the probable demand for second, vacation homes by state residents. Household heads that anticipate the purchase of a second, vacation home will be asked questions about the type and price range of the unit they plan to buy, as well as where they wish it to be located. A scalar technique will be used to weigh each person's likelihood of actually buying a second, vacation home. Additionally, an estimate of each person's purchasing power will be derived in order to weigh his capacity to purchase the kind of second, vacation home preferred. Potential non-resident consumers and out-of-state producers will be studied as soon as possible.

A study of snowmobile operators to determine basic socioeconomic characteristics, use patterns, and

Figure 48. An example of a pre-manufactured, modular constructed vacation home designed for erection on natural sites near Maine's abundant skiing, hunting and water-sport opportunities.

opinions about possible use regulations is in process. The study involves a mail survey of registered owners and field interviews of operators. Recent observations of snowmobile activity within the town of Brewer, Maine suggests that many users may be adolescents and not necessarily the registered owners. It is apparent that mechanized sledding is rapidly replacing the traditional winter outdoor activity participation by youth in Maine. If this is so, a need may exist for within-town trails and open field areas to accommodate this growing sport. Adult use patterns likely differ from those of adolescents, hence resource needs will also likely be different. Adults may be more in need of unplowed woods roads and service

facilities in remote areas. Numerous suggestions for regulating snowmobile operation are being voiced these days. Some people would like to see operators licensed at some minimum age. Regulations as to allowable exhaust noise have already been set in some states, and more are forthcoming. At least one manufacturer has limited engine horsepower available to general consumers, and regulations in this area are anticipated. Some local governments have imposed regulations as to hours of night-time operation and more are expected to follow. Private landowners are becoming very concerned with regulating where and when snowmobiles may use their lands; information about operator use patterns and opinions about regulations will aid their planning very much. Public recreation management agencies are also very much in need of the kind of information this study will provide.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3016
Recreational opportunities on industrial forests in the Keweenaw Bay area, Michigan.
C. R. CROWTHER

Recreational resources inventory revealed that many recreation resources exist in the area, with only slight development to date. Most of these are inland lakes and associated forest lands. Scenic areas and trout streams are other recreational attractions. The undeveloped state of these resources provides an opportunity for conservative, sound development to improve the opportunities for recreation in the area.

The five factors listed most frequently by land managers, as favorable to recreation programs are: 1) Public pressure for outdoor recreation opportunities; 2) Desire of company to maintain public good-will; 3) Desire to educate the public in forestry and resource conservation principles; 4) Opportunity for financial profits; 5) Effort to reduce damage to roads, buildings or other facilities or equipment.

Five factors most frequently identified as unfavorable to recreation are: 1) Legal liability in event of injury to recreationists; 2) Cost of developing recreation sites; 3) Cost of maintaining recreation sites; 4) Interference with logging operations; 5) Increased taxation resulting from recreational improvements.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3023
Sylvania National Recreation Area and its local economic influence. **W. R. WYND, C. R. CROWTHER and T. L. KELLY**

The Sylvania Recreation Area is a part of the Ottawa National Forest, located in the Upper Peninsula of Michigan. The southern boundary of the 18,000-acre Sylvania tract coincides with the Wisconsin-Michigan state line.

The user study was designed primarily to determine the dollar value of expenditures made by visitors, the purposes for which these expenditures were made, and the places at which they were made in the surrounding area. Home residence of users, types of recreational activity in which they engaged, and estimate of summer visitation to Sylvania through the use of automatic traffic counters, also were investigated. About 38 percent of Sylvania visitors gave Michigan as their home state; 35 percent resided in Wisconsin and 15 percent in Illinois. Average length of stay in Sylvania was 2.56 days per person. Total number of visitor-days spent in Sylvania between June 21 and September 1, 1969, was estimated at 38,252. In the economic study of Watersmeet Township, an effort was made to relate changes which occurred between 1966 and 1969. Four variables were used: gross sales, employment, building permits, and real-estate activity. A business survey was undertaken to determine the extent to which Sylvania affected local business. The economic impact on Watersmeet Township of summer visitation to Sylvania appears to have been modest in 1969, possibly because of the limited recreational facilities which provided only for day-use recreation and wilderness-type camping.

TEXAS A&M UNIVERSITY, 1660
Outdoor recreation management. **R. L. BURY**

Scales to determine the attitudes of owners of forest tracts toward recreation and forestry were developed using an adaptation of Thurstone's equal-appearing intervals technique. Based on critical reviews of scale development procedures, the present approach used six points along the continuum rather than 11 divisions as used by Thurstone. The recreation scale was constructed from 167 original items and was sorted by 50 judges. The coefficient of determination for the A and B forms of the scale was .53 using 87 subjects. The forestry scale was constructed from 84 original statements sorted by a second team of 50 judges. Results of 85 subjects taking the A and B forms showed a coefficient of determination of .61. Final forms of both scales, consisting of 20 items each, were administered to 100 noncorporate owners

in East Texas, each of whom owned at least 1000 acres of forested land. Approximately 78 additional owners were contacted. Two interviewers traveled approximately 9500 miles in 32 counties comprising the commercial pineywoods area of East Texas during June through August, 1970. Data have been coded for analysis and are now being processed.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 620
Forest recreation demand analysis. D. A. KING

NORTHERN ARIZONA UNIVERSITY, 6
Management of the forest recreation resource in Arizona. L. D. LOVE

CALIFORNIA—HUMBOLDT STATE COLLEGE, 13
The optimum mix of undeveloped and developed land within a hyleopolis. G. L. PARTAIN

UNIVERSITY OF CALIFORNIA, 2351
Relation of composition and distribution of vegetation to fuels on wildlands. A. M. SCHULTZ

UNIVERSITY OF CONNECTICUT, 390
The role of the forest in open-space planning in Eastern Connecticut. M. J. GRATZER

UNIVERSITY OF IDAHO, 4
Methods for estimating recreational visits and use on unattended recreation sites. H. R. ALDEN

SOUTHERN ILLINOIS UNIVERSITY, 67-R-23
Techniques for measuring recreation use. D. R. McCURDY

IOWA STATE UNIVERSITY, 1824
Demand patterns for outdoor recreation in Iowa. H. H. WEBSTER

LOUISIANA STATE UNIVERSITY, 1232
Effect of state forests and parks on public recreational use of private forests in Louisiana. R. W. McDERMID

UNIVERSITY OF MARYLAND, T-016
Forest recreation—the values placed on trees for recreation environment. F. H. FORSYTH

MICHIGAN STATE UNIVERSITY, 1038
Recreational trail use and user characteristics in Michigan. M. CHUBB

UNIVERSITY OF MINNESOTA, 19-43
Relationships between recreation land management and user satisfaction. L. C. MERRIAM, JR.

UNIVERSITY OF MINNESOTA, 19-77
The ecomanagement of forest vegetation on parks and wilderness areas. H. L. HANSEN, E. V. BAKUZIS and V. KURMIS

UNIVERSITY OF NEVADA, 673
Recreation potential of the Truckee River Basin from Lake Tahoe to Pyramid Lake. C. S. SALADINO, III

NEW YORK—CORNELL UNIVERSITY, 909
Snowmobiling impacts and resource development. F. F. WINCH, B. T. WILKINS and C. A. HILL

NORTH CAROLINA STATE UNIVERSITY, 4032
The evolution of outdoor recreation policy among federal land managing agencies. L. W. MONCRIEF

PENNSYLVANIA STATE UNIVERSITY, 1842
Effects of land use changes in the scenic qualities of Pine Creek, Pennsylvania. P. W. FLETCHER

PENNSYLVANIA STATE UNIVERSITY, 1836
Wildland recreational management. J. L. GEORGE and G. W. WOOD

PENNSYLVANIA STATE UNIVERSITY, 1494
Wildland recreational management. J. L. GEORGE

UNIVERSITY OF TENNESSEE, 5
The recreation resources of large private forest ownerships. K. F. SCHELL

UNIVERSITY OF TENNESSEE, 13
Characteristics of campers in forest recreation areas in Tennessee. K. F. SCHELL

UTAH STATE UNIVERSITY, 778
The nature of urban recreation on the public forests of Utah's Wasatch Front. R. A. OGLE

UNIVERSITY OF VERMONT, 15
Comparative economic analysis of public recreation land in forested areas of Northeast. F. O. SARGENT

UNIVERSITY OF WASHINGTON, 3
Recreational uses of forest lands. G. W. SHARPE

UNIVERSITY OF WASHINGTON, 27
A systems analysis of the forest ecosystem of the Snohomish River Basin.
J. S. BETHEL, K. J. TURNBULL and B. B. BARE

WASHINGTON STATE UNIVERSITY, 1914
A method for selecting public recreation investments which will increase social benefits.
C. D. MATTSON, W. BUTCHER and G. M. SOUTHWARD

PUBLICATIONS

BROWN, T. L. and L. C. MERRIAM, JR.
A comparative study of Twin Cities state and city park users with emphasis on state park campers. Minn. For. Res. Note No. 213. 4 pages. Jan. 15, 1970.

BROWN, T. L. and L. C. MERRIAM, JR.
The Twin Cities camper and the state park environment. Minn. For. Res. Note No. 215. 4 pages. April 15, 1970.

GRATZER, MIKLOS J.
Visual pleasure and the search for criteria of beauty in nature. Milestones 14(1): 10-11, 1970.

HILL, GREGORY A.
Recreational snowmobiling: Some problems and answers. Conservation Circular 8 (1). Dept. of Conservation. N.Y.S. College of Agr. 4 p.

HUMMER, JOSEPH W.
Age, composition, physical condition, seasonal movements, mortality, and productivity of white tail deer (Odocoileus virginianus) on the Quehanna Wilderness Area. M. S. thesis, The Pennsylvania State University. 1970.

JOHANNSEN, NEIL C.
About beavers: The natural history of Castor canadensis, Pacific Search, Journal of Natural Science for the Pacific Northwest, December, 1970.

KELLEY, T. L.
Sylvania recreation area and its local economic influence, 1966-1969. M. S. thesis, Michigan Technological University, 1970.

KING, DAVID A.
"Economics of recreational land use", in Proceedings of Conference on Mining and Ecology in the Arid Environment, College of Mines, Univ. of Arizona, pp. 181-185, 1970.

KING, DAVID A. and JAMES R. OWINGS
"Tucsonans use of four recreation areas," Progressive Agriculture in Arizona, Vol. XXI, No. 3, pp. 10-11, May-June, 1970.

KURMIS, VILIS, D. D. NESS and H. L. HANSEN
Characteristics of forest stands in relation to edaphic conditions in St. Croix State Park, Minnesota. Minn. For. Res. Notes No. 216. April 15, 1970.

KURMIS, VILIS, A. FEDKENHEUER, M. GRAFSTROM and R. A. HESSE.
Tree reproduction and shrubs in relation to stand and site conditions in St. Croix State Park, Minnesota. Minn. For. Res. Notes No. 217. April 15, 1970.

LINDSAY, J. J.
Socioenvironmental relationships between Pineview Reservoir, Cache National Forest and the residents of metropolitan Weber County, Utah. PhD dissertation. Utah State University, Logan, Utah. 1970.

MARLOW, GLENN RAY
A study of the visitor to the parks and recreation areas along the proposed George Rogers Clark Recreation Way, Southern Illinois. Masters Thesis, June, 1970.

McDOWELL, ROBERT D.
The extrinsic value of diversity in aesthetic mensuration. Rept. from Transactions of the Thirty-Fourth North American Wildlife and Natural Resources Conference: 281-282. (1969).

WEBSTER, HENRY H.
"Decision-making in outdoor recreation". Proceedings of short course in Outdoor Recreation Planning and Design, sponsored by Iowa State University. Pages 5-11. 1970.

MULTIPLE USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

Research Problem Area 903

Most forest areas and related resources can be devoted to widely varying uses depending on the

owner's objective and the allocation of investments for resource development. On more than 300 million acres of National Forests and other public lands, for example, guidelines are needed to determine the best combination of uses or systems of managing forest land for timber, water, forage, recreation, wildlife, or other purposes.

Forestry programs to increase production of timber and related forest resources need to be evaluated to determine their relative costs and effectiveness. These programs cover a wide range of activities including protection against fire, insects and disease; reforestation; timber stand improvement; and improved timber harvesting.

UNIVERSITY OF MISSOURI, 617
Assistance programs on private forestry.
J. M. NICHOLS

Land ownership changes, objectives of ownership, and current forest and market values in Missouri have been studied by graduate students and the results prepared as theses. Changes in land use are small. Few owners indicated timber growing as their primary interest. Prices of land were relatively low for timber production objectives but substantially higher where recreational or residential use was intended. One manuscript will be completed by June 30 entitled "Forest Land Market Values in Six Missouri Counties". Two additional manuscripts "History of 24 years of operation of the Missouri Forestry Act", and "History of 10 years forest land tenure in Wayne County, Missouri", are in preparation.

UNIVERSITY OF MONTANA, 2001
Evaluating forest resource multiple uses.
W. K. GIBSON

In general, the following conclusions were drawn from the study: That the incorporation of systematic resource analysis through economics establishes an impartial (highly professional) method of alternative construction and evaluation. That there is an evident need for additional detailed resource inventory, classification and management manipulation information in order to provide a more sophisticated analysis of alternative courses of action under a multiple use objective. This is especially true in the Northern Rocky Mountain Region in such areas as wildlife, timber, water, grazing and recreation.

That the incorporation of the indirect costs (i.e. social costs) associated with the evaluation can be adequately incorporated into the evaluation scheme as "side calculation" or if they can be identified in quantifiable terms.

That many contemporary resource conflicts can be analyzed more rationally and intelligently when planning units are small. These units would be small enough so that a detailed investigation of resource problems can be accomplished in depth. Currently, planning levels are too broad and heterogenous both from a resource and use standpoint.

NEW JERSEY—RUTGERS STATE UNIVERSITY, 256
Evaluation of the multiple uses of New Jersey's public forest land resources. **R. F. WEST**

In order to strengthen our study of camping and ascertain trends in camper characteristics, motivations, attitudes and activities since 1964, a resurvey was conducted of campers at the Stokes and Bass River State Forests in New Jersey during 1970 using same procedure and questionnaire. Seventy-nine schedules by interview were obtained. Statistical summaries of results were completed and comparisons made with 1964 data. It was found that the greatest concern of campers was directed to the quality of the campsite area as expressed by spacing and density of vegetative cover between individual campsites. A detailed study of camping activities showed that about 70% of the campers' total time is spent at his individual campsite. These results strongly suggest that managerial and planning aspects of public campgrounds should concentrate on protecting and enhancing the campsite area. Also noted were significant increases in use of different types of camping vehicles, visitations to private campgrounds, and greater participation in camping by people in the "blue collar" types of employment.

NEW YORK, STATE COLLEGE OF FORESTRY AT SYRACUSE UNIV., 903-0-4
Decision tree results. **R. GETTY**

Results of this study provide resource management executives with profiles of how they quantitatively perceive the elements that influence three important types of decisions. The experiment attempts to wipe the foggy window of decision-making so one can see the frame of reference a little more clearly. With a

clearer understanding of the big picture, executives can systematically determine if they wish to change any priorities in decision-making that they feel will more effectively increase, reduce, or hold constant various facets of recreation demand patterns.

Next, study results provide a reference point for measuring any future changes in the decision-maker's perception of important influences in the decision-making process. Such changes in perception may be caused by future re-orientation of management procedures, changes in policy, or unexpected recreation demand patterns.

Furthermore, study results permit executives in one agency to better understand what their counterparts in other agencies think are the important constraints in the decision-making process. This information, in turn, provides decision makers throughout all agencies with a clearer understanding of the problems involved in trying to provide recreation facilities and opportunities throughout a metropolitan-suburban-rural-wildland spectrum.

Finally, from a research standpoint, the relevance tree values developed in this study help delineate subject matter areas (the upper quartile items) in the decision arena where recreation research may be needed most urgently to assist decision makers.

UNIVERSITY OF WISCONSIN, 1714
Economic analysis of alternative forest land use allocations. J. D. BRODIE

The project was initiated on July 1, 1970. Initial efforts have concentrated on computer techniques for handling extensive data on land characteristics and land-use alternatives. A simulation program comparing alternate forest product rotations was developed and simulation and optimization programs comparing commodity production (timber) and service production (developed and undeveloped recreation) are being prepared. The initial program will be highly simplified, but useful for demonstration if not research purposes.

An appropriate multiple-use area in which to undertake the applied aspects of this study will be selected in the near future, in cooperation with Wisconsin Department of Natural Resources and U.S. Forest Service Consultants. Data collection and compilation should thus commence in early 1971.

ADDITIONAL PROJECTS

COLORADO STATE UNIVERSITY, 328
A model for multiple use resource decisions in the ponderosa pine. H. W. STEINHOFF

SOUTHERN ILLINOIS UNIVERSITY, 69-R-B
A study of the trend in forest land exchange in southern Illinois. R. M. MISCHON

INDIANA–PURDUE UNIVERSITY, 1354
Management of outdoor recreation resources. D. M. KNUDSON

UNIVERSITY OF NEW HAMPSHIRE, 6
Forest land resources in the economy of New Hampshire. B. B. FOSTER

UTAH STATE UNIVERSITY, 807
Public timber harvesting policy and regional economic stability. A. A. DYER

IMPROVEMENT OF RURAL COMMUNITY INSTITUTIONS AND SERVICES

Research Problem Area 908

This research supplements that on improving income opportunities in rural communities. It will help identify the ways by which rural communities can develop the organizations, agencies, services, and leadership needed to make them attractive places to live, work, and establish businesses.

Some rural communities are greatly in need of research information to help in adjusting to sharp increases or decreases in population. Modern transportation and communication have contributed to the development of trading and social centers serving large geographic areas, and have caused the decline or elimination of a great many small centers. Uncoordinated development and other changes in land use, with no reference to any overall plan, often make it impossible to provide public services economically. These are among the reasons why rural communities encounter severe difficulties in meeting the changing needs of people at a cost they can afford.

LOUISIANA TECH UNIVERSITY, 6
Workmen's compensation and safety in timber harvesting and wood-using mills. Arkansas and Louisiana. J. E. CAROTHERS

Workmen's compensation (WC) is a term applied to a general group of state laws which provide for recovery of damages for personal injury sustained by an employee in the course of employment, or for death resulting from injuries so sustained. Compensation is paid in accordance with rates set by the states for various kinds and degrees of injuries without regard to fault. The cost of workmen's compensation (WCI) is paid by the employer.

Workmen's compensation has traditionally been a costly burden to the wood-using industry in Louisiana. Manual rates in Arkansas have usually been far below those in Louisiana; however, because of a change in the WC law (December 11, 1968), Arkansas rates have increased sharply. One must recognize, though, that to make strict comparisons of rates among states is not possible, e.g., benefits or payments received for injuries are not on an equal basis.

This investigation is exploring methods of administration: Louisiana has the "court system"; Arkansas has the "commission system." Exploration of WCI rates for company timber harvesting crews and independent contractors were attempted but abandoned as comparable conditions were not formed.

Types of WCI are being considered. These are self, mutual, and stock. In addition, this investigation is exploring possible economies of size, e.g., large wood-using mills which employ safety engineers are keeping WC costs at low levels or below manual rates. When mills in general operate safely the manual rates decrease. However, there is *no* indication of economies of size in timber harvesting in either Arkansas or Louisiana. Pre-employment physical examinations appear to be important in reducing WC costs in the wood-using mills; data are insufficient to reach a conclusion in regard to timber harvesting.

Major problems are found (1) among small sawmill owners, who are either ignoring WCI or are carrying accident policies at nominal costs with a particular life insurance company, and (2) among pulpwood dealers, who do not mention or stress safety practices in contracts or agreements but who are paying the WC premiums.

ADDITIONAL PROJECTS

MICHIGAN STATE UNIVERSITY, 1052
Planning procedures for public forests.
R. J. MARTY

UNIVERSITY OF MONTANA, 205
Montana forest property taxing procedures.
W. K. GIBSON

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Workmen's compensation and safety researched. American Pulpwood Quarterly, Technical Papers of the American Pulpwood Association, pp. 17-18. (July 1969).

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Selected phases of workmen's compensation and safety in the wood-using industry and in timber harvesting, Arkansas and Louisiana. Paper presented at the Southwestern Technical Division, American Pulpwood Association, Monroe, Louisiana. Mimeographed 7 p. (November 11, 1970.)

CAROTHERS, J. E.
Workmen's compensation and safety. Paper presented at the Annual Safety Workshop, Southern Forest Products Association, Jackson, Mississippi, Mimeographed 7 p. (February 5, 1971.)

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	778	Urban Recreation	R. A. Ogle	100
	780	Distribution and Soil Moisture	J. D. Schultz	6
	806	Biomass and Productivity Measurements	T. W. Daniel	44
	807	Public Timber Harvesting	A. A. Dyer	103
Vermont	1	Christmas Tree Culture	M. L. McCormack	45
Univ. of	2	Leader Damage, Growth, Conifers	T. L. Turner	47
	4	Volume Equations	C. C. Myers	67
	7	Wood Ducks	R. W. Fuller	36
	8	Wood Quality of Birch	P. R. Hannah	47
	9	Light and Internal Moisture	J. R. Donnelly	17
	10	Chemical Weed Suppression	T. R. Flanagan	48
	11	Sap Flow in Sugar Maples	J. W. Marvin	19
	12	Cell Transitions; Hardwoods	F. M. Laing	17
	14	Management by Programming	F. H. Armstrong	73
	15	Public Recreation Land	F. O. Sargent	100
Virginia	636118	Forest Regulation	E. F. Thompson	93
Polytechnic	636119	Wood Products	R. E. Martin	88
Institute	636120	Site Parameters	H. A. I. Madgwick	48
	636121	Oak Hickory Stands	B. S. McGinnes	36
	636122	Mixed Hardwoods	A. D. Sullivan	70
	636123	Resource Use	D. P. Richard	47
	636124	White Tailed Deer	R. L. Kirkpatrick	36
	636125	Ribosomal System	R. E. Adams	19
	636134	Models of Forest Stands	H. A. I. Madgwick	45
	636136	Game Population	R. H. Giles	29
Washington	16	Cloud-Engulfed Forests	D. R. Satterlund	8
State Univ.	41	Plantation Christmas Trees	R. W. Dingle	29
	1771	Genetics of Multinodalness	R. W. Dingle	28
	1772	Piezoelectric Effect in Wood	R. F. Pellerin	88
	1849	Snow Catch in Crowns	D. R. Satterlund	19
	1913	Watershed, Tractor Skidding	D. R. Satterlund	8
	1914	Recreation Investments	C. D. Mattson	101
	1925	Characteristics of Elk Sedge	B. B. Roche'	8
	1929	Vibrational Parameters	R. F. Pellerin	77
	1942	Structure, Shear Strength	A. F. Noskowiak	88
	2002	Even-Aged Forest Stands	L. V. Pienaar	69
Washington	1	Nitrogen; Growth	S. P. Gessel	19
Univ. of	3	Recreational Land Uses	G. W. Sharpe	101
	4	Environment; Quality of Wood	J. S. Bethel	19
	6	Ecology and Physiology	D. R. M. Scott	19
	7	Harvesting; Second Growth	G. Stenzel	73
	8	Fommes Annosus; Management	C. H. Driver	63
	9	Surface Properties; Wood	B. S. Bryant	88
	11	Water Retention by Foliage	S. P. Gessel	8
	12	Fire, Forest Soil	D. W. Cole	5
	13	Mathematics; Fiber Assemblages	G. G. Allan	88
	15	Problems in Elasticity	B. A. Jayne	88
	16	Genetic Studies; Hardwoods	R. F. Stettler	29
	17	Investigation of Forest Soils	F. C. Ugolini	3
	19	Forest Products Industries	T. R. Waggener	93
	20	Snow-Melt Water	D. D. Wooldridge	7
	21	A Coniferous Ecosystem	D. W. Cole	18
	22	Bark Beetles	R. I. Gara	57

State	Proj. No.	Abbreviated Title	Project Leader	Page
Washington	23	Model for Wood Quality	J. S. Bethel	77
Univ. of	24	Wood Members	H. D. Erickson	86
	25	Wildlife Populations	R. D. Taber	48
	26	Composite Systems	B. A. Jayne	88
	27	Forest Ecosystems	J. S. Bethel	101
West Virginia	1	Selection, Valuable Hardwoods	F. C. Cech	29
Univ.	2	Growth and Density	J. R. Hamilton	88
	3	Sprout Black Cherry	C. B. Koch	88
	4	Lumber Handling Methods	D. E. White	88
	5	Growth and Yield	D. L. Kulow	70
	6	Surface-Mined Lands	R. Lee	4
	7	Sonagram Analyses; Game Birds	D. E. Samuel	36
Wisconsin	1262	Genetics; Trees	D. T. Lester	29
Univ. of	1263	Population Dynamics; Sawflies	D. M. Benjamin	57
	1264	Oak Wilt	J. E. Kuntz	61
	1350	Metabolic Antitranspirants	T. T. Kozlowski	19
	1364	Change in Forest Industries	W. R. Bentley	76
	1434	Plantation Root Diseases	R. F. Patton	63
	1518	Checks in Wood	H. J. Kubler	88
	1571	Sampling Designs; Management	L. G. Arvanitis	74
	1675	Forest Growth	A. R. Ek	70
	1714	Forest Land-Use Allocations	J. D. Brodie	103
Wyoming	880	Biotic Communities	H. G. Fisser	20
Univ. of	928	Diseases of Aspen	W. D. Ross	63
	940	Ecology of Aspen	A. A. Beetle	20
	31-70	Summer Elk Range	A. A. Beetle	34
	46-71	Park Areas	P. C. Singleton	48

Table II. Summary of McIntire-Stennis Forestry Research Project Activity During 1970

Institutions	Chapter I	Chapter II	Chapter III	Chapter IV	Chapter V	Chapter VI	Chapter VII	Chapter VIII	Chapter IX	Total Number of Projects	Scientists	Graduate Students	Publications
Alabama, Auburn Univ.	3	1	–	2	1	–	–	3	–	10	10	7	5
Alaska, Univ. of	3	–	–	–	–	–	–	2	–	5	4	2	2
Arizona, Univ. of	2	–	–	1	1	–	–	–	1	5	5	4	5
Arizona, Northern Univ.	–	2	–	–	3	–	–	1	1	7	7	5	2
Arkansas, Univ. of	1	–	–	4	–	–	–	–	–	5	7	7	3
California, Univ. of	1	1	–	2	3	2	2	4	1	16	14	31	13
California, Humboldt St.	3	3	–	–	3	–	–	–	1	10	8	16	2
Colorado State Univ.	3	1	–	–	–	–	–	2	1	7	8	1	5
Connecticut, Univ. of	2	–	–	–	–	–	–	–	1	3	2	3	5
Conn. Ag. Exp. Sta.	4	1	–	–	1	–	–	–	–	6	7	0	9
Delaware, Univ. of	–	1	–	–	–	–	–	–	1	2	2	0	3
Florida, Univ. of	5	–	–	1	–	–	–	–	–	6	9	0	1
Georgia, Univ. of	2	1	–	1	2	1	–	1	–	8	8	7	9
Hawaii, Univ. of	3	–	–	2	–	–	–	–	–	5	5	6	2
Idaho, Univ. of	4	4	–	2	1	–	–	3	1	15	11	12	6
Illinois, Univ. of	3	–	–	–	–	–	–	–	1	4	4	2	5
Illinois, S.I.U.	4	1	–	–	1	–	–	1	3	10	9	11	3
Indiana, Purdue Univ.	1	1	–	–	1	–	–	2	1	6	6	1	7
Iowa State	3	–	–	–	–	–	–	2	2	7	11	10	1
Kansas State Univ.	2	1	–	1	–	–	–	–	–	4	3	2	1
Kentucky, Univ. of	1	–	–	–	–	–	1	4	–	6	5	3	6
Louisiana State Univ.	3	4	1	–	–	–	–	2	1	11	8	21	4
Louisiana Tech.	1	–	–	3	1	–	–	–	1	6	9	5	5
Maine, Univ. of	4	–	–	1	1	–	–	2	1	9	15	10	7
Maryland, Univ. of	–	–	–	3	–	–	1	1	1	6	9	5	2
Massachusetts, Univ. of	6	–	1	1	–	–	–	2	–	10	13	13	13
Michigan, Univ. of	1	–	–	1	–	–	–	–	–	2	2	0	3
Michigan State Univ.	3	1	–	2	–	1	–	2	2	11	12	0	8
Michigan Tech.	1	–	1	2	2	–	–	2	2	10	9	7	2
Minnesota, Univ. of	4	2	–	2	1	–	–	3	2	14	15	15	18
Mississippi State Univ.	2	–	–	1	–	–	–	5	–	8	8	8	6
Missouri, Univ. of	7	–	–	1	1	3	1	2	1	16	12	16	7
Montana, Univ. of	4	2	–	1	1	–	1	1	2	12	12	16	6
Nebraska, Univ. of	1	1	–	–	–	–	–	–	–	2	2	0	0
Nevada, Univ. of	3	–	–	–	–	–	–	–	1	4	6	0	0
New Hampshire, Univ. of	–	1	–	1	1	1	–	1	1	6	5	6	1
New Jersey–Rutgers	3	–	–	2	–	–	–	–	1	6	6	3	2
New Mexico State Univ.	2	–	–	1	–	–	–	1	–	4	5	1	5
N. Y., Cornell Univ.	2	1	–	–	1	–	–	1	1	6	11	5	7
N. Y., SUNY, Syracuse	5	–	–	–	2	–	–	1	2	10	14	0	10
North Carolina St. Univ.	6	3	–	1	1	1	1	9	1	23	26	21	12
North Dakota St. Univ.	–	1	–	–	–	–	–	–	–	1	1	1	1
Ohio, OARDC, Wooster	4	1	–	2	–	–	–	–	–	7	7	4	8
Oklahoma State Univ.	7	2	–	1	1	–	–	1	–	12	8	6	8
Oregon State Univ.	7	–	–	3	2	1	–	5	–	18	19	14	6
Pennsylvania State Univ.	2	1	–	3	1	–	–	4	3	14	17	12	9
Puerto Rico, Univ. of	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhode Island, Univ. of	3	–	–	–	–	–	–	–	–	3	5	2	2
S. C., Clemson Univ.	8	1	–	1	1	1	–	2	–	14	10	2	0
South Dakota St. Univ.	1	1	–	–	2	–	–	–	–	4	6	0	0

Institutions	Chapter I	Chapter II	Chapter III	Chapter IV	Chapter V	Chapter VI	Chapter VII	Chapter VIII	Chapter IX	Total Number of Projects	Scientists	Graduate Students	Publications
Tennessee, Univ. of	5	3	–	1	–	1	–	1	2	13	8	13	3
Texas, SFA St. Univ.	–	–	–	–	–	–	–	–	1	1	1	0	0
Texas A&M Univ.	1	1	–	2	1	–	1	2	1	9	10	5	10
Utah State Univ.	3	2	–	–	1	–	–	–	2	8	7	4	3
Vermont, Univ. of	4	4	–	–	1	1	–	–	1	11	11	3	1
Virginia, V.P.I.	4	3	–	–	1	–	–	2	–	10	15	15	22
Washington, Univ. of	9	1	–	2	–	1	1	6	2	22	23	21	12
Wash. State Univ.	6	–	–	–	1	–	1	2	1	11	12	3	4
West Virginia Univ.	3	–	–	–	1	–	–	3	–	7	7	3	0
Wisconsin, Univ. of	2	–	–	3	1	1	1	1	1	10	9	8	17
Wyoming, Univ. of	3	1	–	1	–	–	–	–	–	5	5	3	3
Totals	180	55	3	58	44	15	11	90	47	503	525	401	317