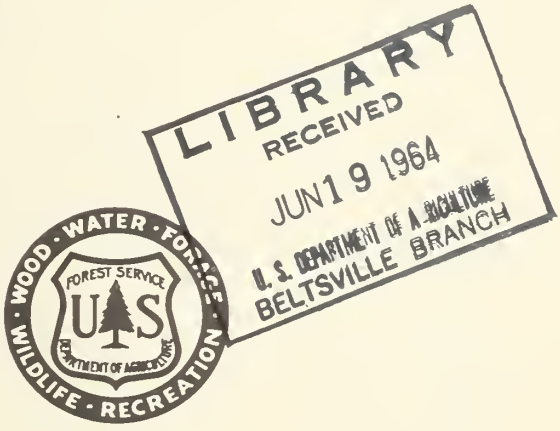
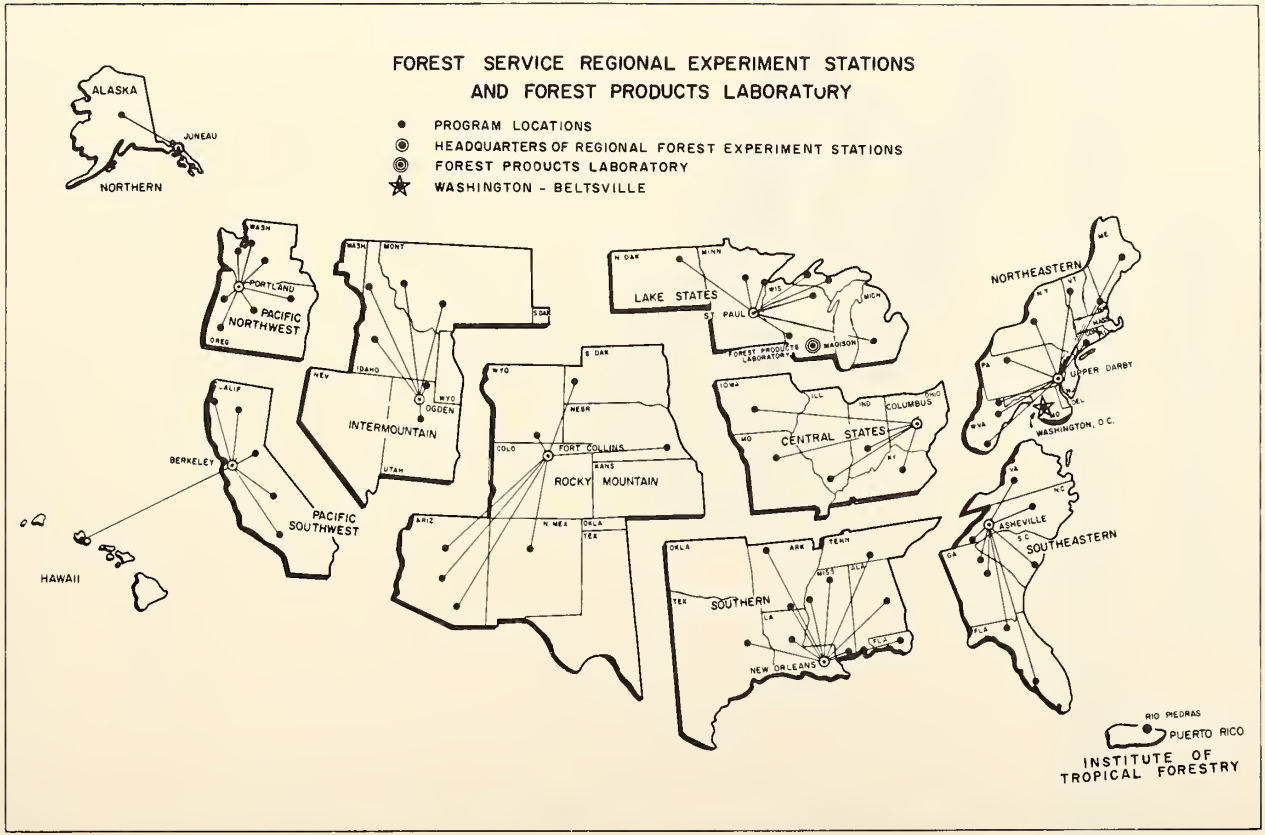
A NATIONAL FORESTRY RESEARCH PROGRAM



Miscellaneous Publication No. 965

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE MAY 1964

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 Price 20 cents



Forest Service regional experiment stations and Forest Products Laboratory

Following is the text of a letter from the Secretary of the Department of Agriculture to the President of the Senate and the Speaker of the House transmitting a national forestry research program.

U.S. Department of Agriculture,
Washington, D.C., April 15, 1964.

Dear Mr. Speaker: (Dear Mr. President:)

Enclosed for information of the Congress and appropriate reference is a report entitled "A National Forestry Research Program."

This report outlines a balanced program of research in the major forest resource problems facing the Nation. The program covers research in the management of timber, forest soil and water, range forage, wildlife and fish habitat, and forest recreation; research in protection of the forest from fire, insects, and disease; forest products and engineering research: and forest resource economics and marketing research.

This is the second report concerning the programs of the Department of Agriculture relating to forestry activities. The first one, "A Development Program for the National Forests," was sent to you by the President on September 21, 1961.

The purpose of this forestry research program is to develop a firm scientific base and technical support for the rapid and efficient advancement of programs aimed at increased forest resource management, protection, and utilization. It is a cooperative undertaking aimed at forestry problems of all categories of ownership—Federal, State, and private.

The specific proposals cover an initial 10-year period with long range objectives related to the forest development programs that will be necessary to produce the wealth of renewable forest resources needed by the year 2000. The proposals have been developed with careful consideration of forestry research to be done by other organizations and institutions and full recognition of the need for a strong cooperative program.

President Kennedy in his 1961 special messages to Congress on American Agriculture and Natural Resources called for certain measures needed to insure adequate forest resources in the future by sound, effective programs relating to privately owned woodlands, as well as our National Forests and other public lands. Included among these measures are expansion of forestry research and acceleration and expansion of the Forest Service's long-range program for the development and improvement of our National Forests.

Pursuant to that message, I directed a review of the requirements relating to research in the Department's forest resource program and, where they fall short of the needs, the development of a program to fill the gaps.

In 1959, the Department of Agriculture sent to the Congress a "Program for the National Forests." In that program there were included forestry research needs for the National Forests as viewed at that time. Since then there has been a further intensive appraisal of Forest Service research activities. The results of this appraisal are included in the enclosed program, which presents the research needed to adequately support all forestry activities, whether on National Forests, other public forest lands, or private forests and woodlands and the laboratory facilities required to implement an effective research program. The appraisal includes all research for which the Forest Service has responsibility. Other major changes from the research needs previously recommended are listed in the preface of the enclosed report.

Presentation of this forestry research program is timely because on January 31, 1964, President Johnson, in his message on Agriculture outlined to the Congress his views on better use of forest lands and resources as a means of strengthening the Nation's economy. He directed the Department of Agriculture "to accelerate forest research to find new methods of wood utilization, better timber management techniques, improved fire protection, and more effective use of forest ranges." The forestry research program which has been developed will provide the knowledge needed for more efficient and abundant production of products and services from the Nation's forest and related resources. These include 773 million acres of forest land plus additional extensive areas of intermingled and related ranges.

A sound program of forestry research is essential to full achievement of the long-range program for development and improvement of the National Forests. Research is likewise a key factor in the forestry program needed to develop the resources on some 4½ million private forest ownerships. In many rural areas, development of the forest resources represents the major long-range hope for permanent relief of underemployment problems.

The enclosed report should not be regarded as a request for the appropriation of funds, or as a proposed rate at which the program will be implemented with fund requests. The Department intends to carry out this program in an orderly and balanced manner at a practicable rate within the overall budgetary requirements and financial resources of the Government. The need for funds will be considered each year in the customary way through budget processes.

Sincerely yours,

ORVILLE L. FREEMAN,
Secretary.

CONTENTS

PREFACE

"One of our most important natural resources, and one of our most neglected is our forest land." With these words, President Kennedy in March 1961 introduced his comments on Forest Resources in his special message to the Congress on American Agriculture. He called for rejuvenation, expansion, and new emphasis on all forestry programs to insure adequate forest resources in the future. He observed that forestry research should be expanded to meet the needs of accelerated forest development programs.

As presented here, the National Forestry Research Program outlines the research needed to adequately support forestry activities, whether on the National Forests and other public lands or on private lands, including especially the farms and other small private woodlands. It will supply the knowledge required to put the forestry programs on a sound technological basis in a period when natural resource production, protection, and utilization must move forward rapidly.

This forestry research program is a revision of the research outlined in the "Program for the National Forests" submitted to the Congress in March 1959. The new program includes the research required on forestry problems of all categories of ownership—Federal, State, and private. The earlier report was confined to research needed on National Forest problems. Several major problems that were not previously recognized in full are included in this report. The latter were revealed by recent problem analyses which pointed to the accelerated progress required in the protection and management of forests and the fuller utilization of their resources. The major changes are:

1. Inclusion of the research required on problems of private lands, especially those concerned with increasing the productivity of farm and other small ownerships and with increasing the utilization outlets and markets for poor-quality and little-used species of timber.
2. Extension and strengthening of the support given to cooperative programs with colleges and universities to stimulate forestry research by these institutions.
3. Increasing estimates to update the program in keeping with recent trends in forest resource use that introduce new problems or require greater emphasis or speed in solving older ones.
4. Adjustment of all other cost estimates to 1962 levels.

This program includes the research for which the Forest Service of the U.S. Department of Agriculture has responsibility. It embraces most aspects of all major problems of forests and associated range lands but does not include the related research that is the assigned responsibility of other Federal agencies. The program will be carried out as rapidly as possible within the overall budgetary requirements and financial resources of the Federal Government.

A National Forestry Research Program

INTRODUCTION

The program of forestry research presented herein outlines a balanced attack by the U.S. Department of Agriculture on the major forest resource problems facing the Nation. The long-range objectives of the research are related to the forest development programs that will be necessary to produce the wealth of renewable forest resources needed by the year 2000. This report outlines a carefully developed research program to be done in an initial 10-year period to provide a firm scientific underpinning and technical support for the rapid and efficient advancement of programs aimed at increased forest resource protection, management, and utilization. The research program, like the "Development Program for the National Forests," is for fiscal years 1963 through 1972.

This research program has been developed after much study. The Department of Agriculture completed in 1958 an exhaustive review of the timber situation of the Nation entitled "Timber Resources for America's Future." This, together with a more recent reappraisal of the timber situation as of 1962 and other studies dealing with the various forest resources, has provided a basis for long-range development objectives related to the year 2000. In 1956, the Department of Agriculture made a searching review of all Department research to clarify objectives, to determine program emphasis for the immediate years ahead, and to provide for improved Department-wide coordination of research. In 1958, the forestry research which related directly to the problems of the National Forests was incorporated in the "Program for the National Forests" sent to Congress by the Secretary of Agriculture in 1959. Subsequently, an intensive field study of all Forest Service research has been completed, project by project and location by location, as a basis for further planning. These and other studies provide much of the background for the program presented here.

The programs of the non-Federal agencies now engaged in forestry research and their probable contributions in the future were also taken into account in drafting the national program. It is not only the responsibility of the Department of Agriculture but of the State agricultural experiment stations, forestry schools, and certain other public institutions, to acquire and disseminate information concerning forestry. These agencies are responsible for research on forestry problems, whether local, State, or national, and have, together with industry, a mutual interest in their solution.

Private industry performs a valuable and substantial amount of forestry research. Currently about two-thirds of all forestry research

is done by the forest products industry. Their research emphasizes primarily problems of forest product development and utilization. Some studies of timber production are also underway.

The colleges and universities have gradually strengthened their forestry research programs in recent years, particularly the institutions with agricultural experiment stations and forestry schools. This research is supported mostly by State and other non-Federal funds. Some Federal support to forestry research, however, is derived from Department of Agriculture grant funds made available to the States through cooperative programs administered through the Cooperative State Research Service. The Forest Service also provides cooperative financing of selected projects at universities to stimulate additional research on projects of joint interest.

In the colleges and universities lie substantial opportunities for future expanded forestry research. Their research potential has as yet barely been realized and they could and should be doing more. The national program recognizes the importance of institutional research. It proposes as a part of the Federal program a strengthening of cooperative research at the colleges and universities.

The coordination of research has also been carefully considered as a necessary part of the national program. Coordination is achieved in a number of ways. The Department of Agriculture maintains a uniform project system under which all project proposals by research agencies of the Department are reviewed and coordinated. Technical advisory committees composed of university, industry, and Federal scientists meet regularly to discuss research plans and projects underway. Formally constituted regional research committees plan and do joint research on problems of interest to several States. Special panels of industry representatives are organized periodically to review and coordinate research in a special problem field such as seasoning of wood or glues and gluing. Other committees are frequently formed to coordinate research on special problems such as pole blight disease research or brush control studies. This type of coordinating machinery has been effective in the past. It should continue as an essential part of future expanded programs of the industries, colleges and universities, and the Department of Agriculture.

Within the Federal Government, the Department of Agriculture has since its origin had the primary responsibility for forestry research, and the Forest Service for many years has been assigned the task of planning and carrying out forestry research programs. These programs provide the technical basis for protecting, managing, and utilizing all of the renewable resources of the 186 million acres of National Forests and National Grasslands administered by the Department of Agriculture. They provide the technical forestry information needed by the U.S. Department of the Interior in protecting and managing millions of acres of forests and ranges on the public domain, National Parks and Monuments, Indian Lands, and other areas. The forestry research program of the Department of Agriculture also provides information used by other Federal agencies on lands in their custody or of direct interest to them.

In addition to problems on these public lands, the Federal Government is vitally concerned with solving the forestry problems arising on the 4½ million privately owned properties which aggregate 358 million acres. About three-fourths of these forest land holdings are

on farms, mostly in small parcels. Generally the level of production from small private ownerships is low. Improvement of the management of these lands and the marketing of forest products from them is the key to the success of many aspects of the Nation's future resource program and to an increased and stable rural employment.

Forest Service research is performed at the national headquarters in Washington, D.C.; at the Forest Products Laboratory, Madison, Wis.; at 10 regional forest experiment stations which carry out programs at other locations throughout the various States; and at an Institute of Tropical Forestry in Puerto Rico. These research activities, located close to the problems on the ground and for the most part close to colleges and universities which are also engaged in forestry research, are effectively coordinated to represent a strong and balanced attack on all of the problems of forest resource production, protection, and utilization.

Basic authority for the development of the research work of the Department of Agriculture is the McSweeney-McNary Forest Research Act of 1928. This act authorizes and directs the Secretary of Agriculture to conduct a forestry research program of broad scope and to cooperate with individual agencies and organizations in carrying it out. The Whitten Act (Public Law 473 of Apr. 6, 1956) authorizes cooperative aid financing at research institutions for work on selected projects. These laws and other statutory authorities are adequate for carrying out most of the program planned for the 10-year period. Other legislation will be recommended as needed.

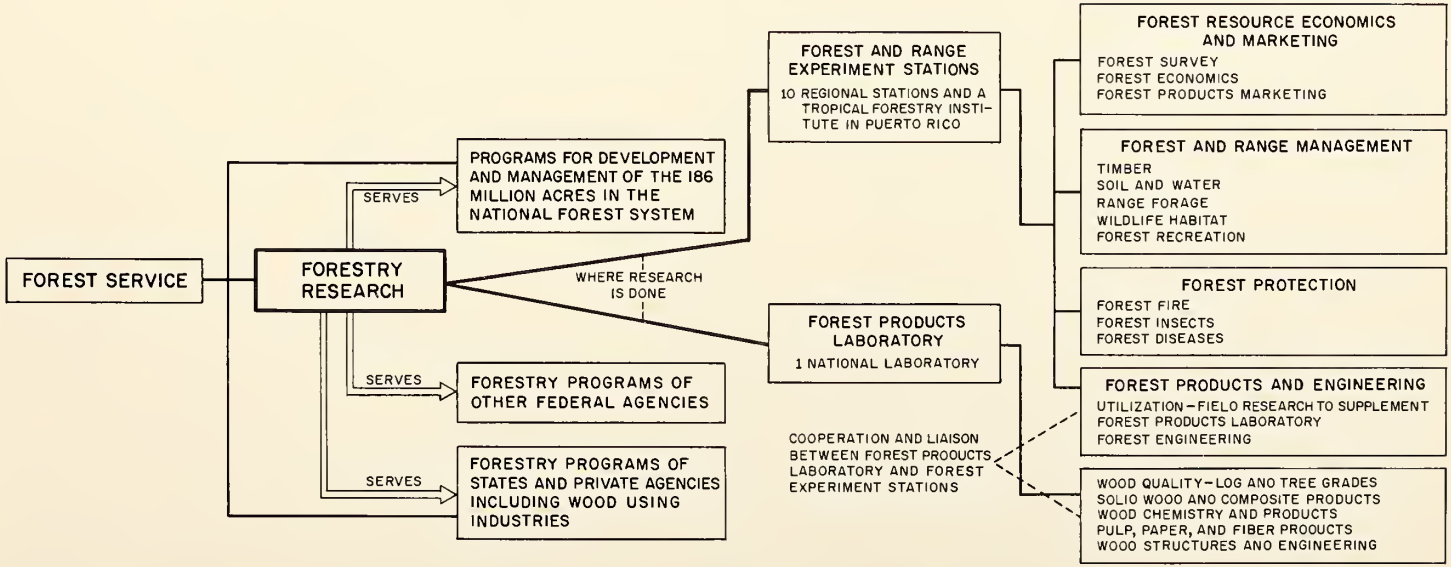
RESEARCH IS ESSENTIAL TO FOREST DEVELOPMENT PROGRAMS

In recent years, every knowledgeable citizen has been impressed with reports of scientific breakthroughs and he is aware of the importance of research as the driving force behind progress. He has seen evidence on every hand of research that has been responsible for rapid technological achievements. Research is an equally essential key to progress in forestry. In fact, research is necessary to the achievement of the major objectives of forestry: to manage and utilize the renewable forest resources on a permanent and highly efficient basis with the maximum benefits to landowners, to forest industry employment, and to the forest resource users. Some forestry research is underway today and the accomplishments of past efforts have been of significant value to forestry activities. Such accomplishments will be even more important to the future development of sound forestry programs everywhere.

Past Accomplishments of Forestry Research

Past progress in forestry has been due in large measure to achievements based on systematic research. The body of silvicultural knowledge on which successful timber harvesting and forest regenerating practices are now based is the product of research. Techniques for airplane seeding of some species of pines are now being applied in the South and are saving half the costs incurred in planting seedlings by ordinary methods. Devised by research, a technique of terracing and planting severely eroding "sore spots" has successfully stopped destructive mud-rock floodflows in the Wasatch Mountains of Utah.

731-988 O—64——2



Forestry research in the Forest Service, U.S. Department of Agriculture

The method is being applied on many critical watershed areas of the West. Experiments to determine the effects of fire and herbicides on various individual species and plant communities are making it possible to control sagebrush, chaparral, woodland brush, mesquite, and other low-value plants on vast range areas and to replace them with desirable species.

Achievements in forest fire control, based on research, are widely recognized. Methods of measuring and rating forest fire danger are now used by all protection agencies to gage the level of forces and distribution of equipment needed to meet fluctuating fire weather conditions. Much greater efficiency in control of fire results. Research has produced new fire retardants, equipment, and methods of aerial attack, now widely used.

Insect and disease research has contributed to the prevention of losses caused by forest pests with the saving of huge volumes of timber. In the ponderosa pine region of the West, methods of identifying high insect-risk trees to be removed have been widely adopted and are effective in reducing losses to residual healthy pines. Research established the relation between nematode injury to the roots of tree seedlings in nurseries and subsequent disease losses. A system of soil fumigation was developed that returned several forest nurseries to production and greatly increased production of healthy, high-quality trees for planting programs.

Research on forest products has stimulated utilization and improved the efficiency—hence the profitability—of closer utilization of wood. The development of the semichemical and cold-soda pulping processes has made practical the use of low-grade hardwood as a raw material. Sixty mills now use these processes in producing more than 2.5 million tons of pulp annually. Basic research on wood-moisture relations led to the development of a basic type of dry kiln for seasoning lumber, 12,000 of which are now being used by the lumber industry. Studies of the feasibility of salvaging woods and mill residues for the production of woodpulp in the South have stimulated fuller utilization of this material, and the quantity used has jumped from 0.1 million cords in 1953 to 3.8 million cords in 1962. The nationwide Forest Survey has provided basic information on timber supplies and demands for timber products required for the evaluation of forestry problems and the determination of needed forestry programs. Research in the economics of timber production has provided a measure of the profitability of forestry investments under varying forest conditions.

These examples clearly show the importance of forestry research. They could be multiplied many times in a complete review of past accomplishments. Yet, productive as past forestry research has been, it has not probed deeply enough into the more complex problems of forestry. Substantial gaps in knowledge exist. Unless these gaps are plugged, they will prevent orderly positive progress toward the intensive forestry practices that future resource development and utilization demand.

Research as an Element in Future Progress

As indicated above, the complex nature of producing, protecting, and utilizing the Nation's five basic forest resources—wood, water,

forage, fish and wildlife, and recreation—emphasizes the need for a strong supporting research program in the years ahead. The steady and rapid upswing in the need for resources and services from the forests and the growing pressures and conflicts in use cannot be met and solved without reliable information produced by systematic study. The current and anticipated changes in forest resource use are very great, as the following brief summarization shows.

The estimated 350 million people in the United States in the year 2000 will need at least twice as much timber as is now being produced.

Forest fires, insects, diseases, and other destructive agents continue to take a heavy toll of forest growth. They constitute a serious drain on timber resources and growth potential. Newly discovered destructive diseases and insect pests are a serious threat to expanding tree-planting activities and intensified forest management programs.

Forest recreational use is climbing rapidly. The estimated 400 million annual visits on publicly owned forests represents only part of the current use on all forest lands, expected conservatively to increase fourfold by the year 2000.

The country's 940 million acres of grazed range, more than one-fourth forested and one-half intermingled with forests, support about one-half of our beef cattle and more than three-fourths of our sheep for at least 6 months of the year. Many of these grazing lands are vital watershed areas as well.

Forests and related rangelands provide the main habitat for 10 million big-game animals and countless other forms of wildlife. Thousands of miles of forest streams provide habitat for fish. Today a hunter or fisherman lives in every third home and the numbers are increasing and adding to the demands for increased fish and wildlife resources.

The needs for water will increase from the present use of 270 billion gallons per day to 600 billion gallons by the year 1980. Since more than half of the Nation's streamflow originates on forest lands, the future protection and management of these watersheds to maintain and increase good-quality water supplies is an absolute necessity.

The expanding needs of the Nation's future economy can best be met with a rich and abundant natural resources base. Wood, the most versatile of raw materials, occupies a key place in providing the needed structural materials, fiber, extractives, and chemicals. But improved and more efficient utilization of forest products must be achieved in the face of general lowering of quality and size of timber trees and stiffer competition from substitute materials.

Needs for all forest and range resources are mounting rapidly. These pressures against the forest resource base give sharp emphasis to conflicts in use that are occurring now and could greatly increase in the future. They stress the need for harmonious management of forest and range lands to get maximum benefits under the principles of multiple use.

The growth in the need for and the use of the five basic forest resources can be met by greatly intensified forest development and management along with an increase in utilization proficiency. Greater skill must be brought to bear on intensive measures of pro-

F—490255

Research has helped develop better methods of aerial fire control using improved chemical fire retardants.

ducing forests and protecting them from fire, insects, diseases, and animal pests. Special emphasis must be given to increasing the supply of water, forest recreation, and fish and wildlife. Utilization of wood can be improved by greater efficiency in processing, development of better products that will give superior service, and the discovery of many new uses that will capture the natural advantages of wood's versatility as a raw material.

The pattern of rapidly increasing use and the need for greatly intensified management brings into focus sharply the need for broad supporting research programs. The Nation cannot tolerate inefficient forest management practices fostered by lack of knowledge. It cannot much longer suffer annual destruction of timber and growth losses that almost equal yearly sawtimber utilization because more effective measures of protection have not yet been developed. It cannot see forest and range watersheds deteriorate further because of the absence of practical corrective techniques or effective preventive measures to stabilize soil and prevent erosion and sedimentation. In areas of critical water supply it cannot forgo the increased water yields from forests that could come from proper management of forest vegetation. It cannot continue to accept only partial utilization of all the forest resources because of a lack of knowledge and the technology that would stimulate use. It cannot continue to see conflicts in resource use become more and more complex when systematic study would help materially to relieve such problems. In short, the Nation's future

requirements for forest resources can be met only if production, protection, and utilization programs are developed and accelerated with the full support of a complete and far-sighted research program.

THE RESEARCH PROGRAM

The program presented here is geared to meeting the most urgent forestry research needs of the next 10 years. It is designed to keep the National Forests and all other forest and related range lands moving ahead on an efficient, effective, and economical basis to play their proper role in the progress and development of the Nation.

Resource managers, administrators, owners of small woodland properties, and all others charged with forestry responsibilities need answers to their everyday problems. They also have the additional need for new knowledge, and organized research has a further objective to achieve significant breakthroughs that will show the way to new methods and new horizons in the management, protection, and utilization of forest resources. The short-term research program is needed to yield quick results, applicable during the initial period, and information of high value in attaining long-range objectives.

The program will be carried out by the Forest Service of the Department of Agriculture in cooperation with other agencies, public and private.

Forest and Range Management Research

The basic renewable natural resources of the forest and ranges upon which the Nation will rely to an increasing extent in the years to come are timber, soil and water, forage, wildlife and fish habitat, and recreation. Their greatly intensified development is necessary during the next few years to meet both near- and long-term objectives. This will require a substantial step-up in the research to support and guide the accelerated resource production and management programs.

Timber.—The overriding objectives of timber management research will be to provide the improved forest trees and the intensive cultural practices needed to double the Nation's production of wood and related tree products by the year 2000. There are more than 130 commercially important forest tree species in the United States, each differing in its quality and product value and each varying in the requirements for crop production. Natural forests, moreover, are usually made up of mixtures of species and have strong responses to and interactions with environmental changes.

Accomplishment of timber management research objectives will require increased emphasis on the fundamentals of genetics, growth, and other vital life processes of the tree itself, areas of study that have heretofore been largely neglected. Also required will be expanded efforts to provide answers to many practical operating problems to increase the efficiency of establishing, growing, and harvesting of timber on a sustained yield basis under a wide variety of conditions.

The research proposed, emphasizing both basic and applied aspects, will:

1. Accelerate, through work in forest genetics, the production of trees superior to present ones—in growth rate, wood quality, resistance to insects and diseases, and other special qualities—for use in planting programs on public and private forest lands.

F—474697

Research will play a prominent role in the future intensive production, protection, and utilization of all the basic forest and range resources.

2. Intensify research on site requirements, reproductive habits, growth characteristics, and other life processes of forest trees to provide the basis for more intensive silvicultural practices.
3. Develop new cultural practices to increase the production of high-quality seed through establishment and management of seed orchards; better methods of harvesting, storing, and processing seed; and more efficient and faster planting practices, including direct seeding with aircraft. Intensify plantation management research.
4. Find cheaper and more effective methods for converting brushfields and other low-value vegetation on potential timber sites to profitable timber stands.
5. Improve the silvicultural techniques for stand culture, such as weeding to control composition, thinning to regulate spacing and growth rate, pruning to improve quality, and other practices to increase the health, vigor, and quality of the forest. Especially emphasize methods suitable for use by the owners of small forest properties.
6. Perfect methods for correcting soil deficiencies or improving the productive capacity of forest soils through use of soil amendments and other measures such as silvicultural control to favor soil-improving tree species that promote the decomposition of forest humus.
7. Find ways to control animal damage to tree crops, including loss of seed and newly planted seedlings to birds and rodents, and loss of older trees to porcupines, bears, and browsing animals.
8. Develop better timber harvesting systems to maintain productive amounts of growing timber in logged areas for sustained

yield and to insure natural regeneration of preferred timber species.

9. Improve volume and yield tables, rotation age data, and other information for regulating timber growing-stock densities in managed forests, including methods to estimate growth rate, yield, allowable cut, and quality of forests as affected by environment and silvicultural treatment.
10. Improve the techniques for the profitable production of crops of gum naval stores, maple sap, Christmas trees, and other nontimber crops from forest trees.

Forest Soil and Water.—The basis for effective and efficient watershed management practices is an understanding of the fundamental relationships involving soil, climate, vegetation, and water. These factors and their interactions are varied and complex over the wide span of forest and related range lands. A more complete understanding of them is required to speed the development of applicable techniques and measures to insure good protection and management of the vital watersheds of the National Forests and National Grasslands and other forest and range lands.

The research proposed will include:

1. Studying soil erosion processes as related to chemical, physical, and biotic characteristics of soils, and developing effective and efficient measures to stabilize eroding slopes.
2. Developing better information and guides for logging and road location, construction, and maintenance under various soil and topographic conditions so as to prevent accelerated erosion and sedimentation.
3. Through ecological and physiological studies of forest phreatophytes (water-loving plants), determining how much water these plants use and how they spread, to provide a basis for controlling them and thus increasing water yields.
4. Studying snow deposition, melt, evaporation, and metamorphism as related to possible alterations of forest types and timber harvest patterns so as to increase water yields or prolong streamflow into the summer.
5. Determining, by basic research, the processes controlling the formation of forest soils, including the chemical, physical, and biological elements involved, and how these processes are affected by different environments and forest practices.
6. For wetland forest areas, developing methods for control of water to increase forest regeneration and growth, giving attention to the basic hydrologic relations involved.
7. Improving the use of forest soil surveys in land management planning and action programs.

Range Forage.—Major long-range objectives—for the rangelands in the National Forests and Grasslands and for other public and private forested and related open rangelands—are proper intensities of animal use along with resource improvements to achieve desirable watershed conditions and sustained high-level production of forage. Production of forage on these lands is far below their potential capacity, and much of the area is in watersheds that are in deteriorated condition.

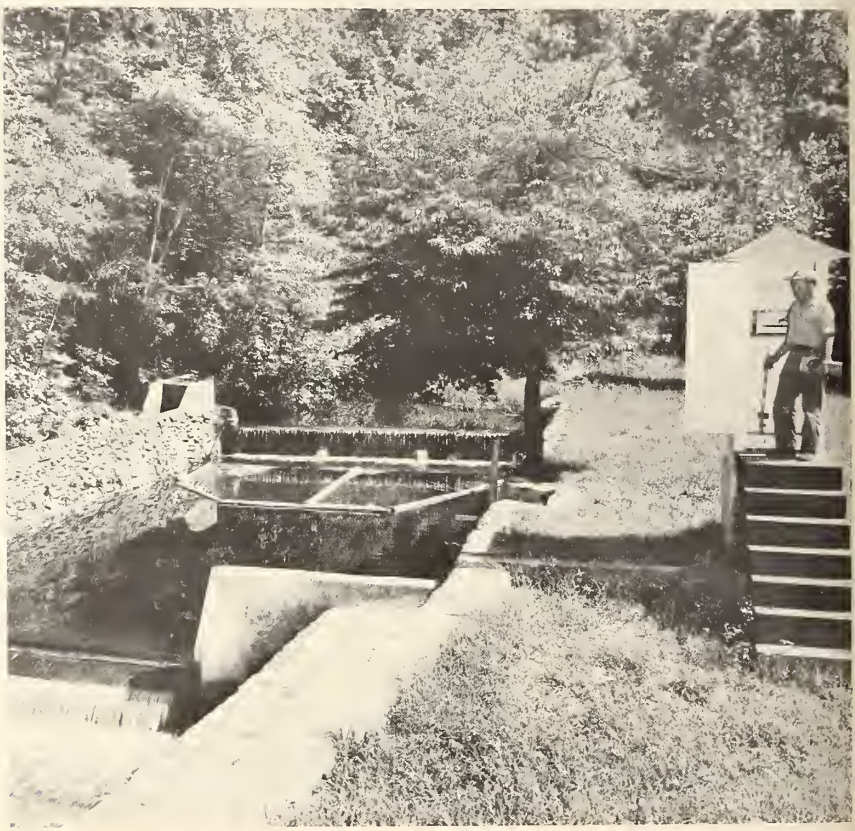
F—494196—7

Forest tree improvement research has developed these 15-year-old progenies of high-gum-yielding pines, which are now going through another selection and breeding cycle to produce still better trees for future plantations.

731-988 O—64——3

Providing an improved basis for the programs needed to achieve range management objectives will require a strong research program. The range research proposed includes:

1. Developing management methods that will maintain forage yield and good watershed conditions on forest ranges restored through seeding, fertilization, prescribed burning, control of undesirable plants, and other measures.
2. Devising more effective and efficient range improvement practices, including the use of fire alone and in combination with chemical and mechanical measures for the conversion of low-value trees and brush such as post and blackjack oak in Missouri and Arkansas; mesquite and juniper in the Southwest; sagebrush in Utah, Idaho, and elsewhere; and chaparral in Arizona and California.
3. Developing better systems of managing western high-mountain watersheds and handling livestock on them, particularly those areas with extremely erodible soils, so as to maintain or increase forage yields and protect and improve watershed values.



F—469734

Watershed management studies point to practices that improve timing and quantity of water yield from forest and range lands.

4. For western commercial timberlands, developing range management systems that will best harmonize grazing with timber production, wildlife, recreation, and other land uses.
5. In the South and Southeast, finding better methods for (a) coordinating livestock grazing and softwood timber production in plantations and other forests; and (b) use of forest ranges in conjunction with improved pastures, forage firebreaks, prescribed burning, and supplemental feeding—to increase the financial returns of small forest-land owners.
6. Evolving effective management methods and improvement practices to make best economic grazing use of the annual grasslands of California, Idaho, and other areas in the West.
7. Determining the identity and ecological relationships of rodents, insects, and diseases and the effects of forest range conditions and grazing management on pest populations and damage.
8. Through basic and applied ecologic research, devising adequate standards for appraisals of forest and related ranges in terms of

F—475854

Range management research requires detailed analysis of composition and trends in range-plant communities as affected by season and intensity of grazing.

current and potential forage production, related grazing capacities, and effectiveness of range improvement practices.

9. For forest range vegetation, developing improved measurement techniques and inventory procedures—rapid, accurate, and readily adaptable for administrative as well as research use in measuring plant and soil responses to grazing, fire, logging, and other disturbance factors.

Wildlife and Fish Habitat.—The use of the wildlife and fish resources of the Nation is being continually increased by a growing army of hunters and fishermen. Serious conflicts have developed between wildlife habitat needs on one side and augmented requirements for production of water, timber, and forage for livestock on the other. The research planned will determine the food and cover requirements of various wildlife species. It will point out the way the forest and related range lands could be managed and improved to better meet the increased requirements for forest resources while supporting maximum game and fish populations.

The proposed research will:

1. Determine the wildlife populations that can be supported by the various vegetation types; develop practices that improve wildlife destribution and allow more uniform and efficient utilization of available forage and cover.
2. Develop methods for improving depleted and naturally unproductive big-game habitats by seeding and planting browse, controlling undesirable vegetation, manipulating desirable plant cover, or other measures to alter or regulate environment.
3. Work out ways to improve wildlife habitat through modified timber cutting and stand improvement practices so that wildlife production will be encouraged, while watershed values are maintained or enhanced.
4. Devise techniques of seeding and planting to create improved habitat for small upland game in forest openings and permanently cleared powerline and pipeline rights-of-way, particularly in the eastern forests.
5. For various types of range, determine the nature and degree of animal competition for forage, and suitable management practices to harmonize use by livestock and wildlife, especially by big game.
6. Accelerate work on problems of improving game fish habitat and food supplies by regulating shade and water temperatures through management of streamside vegetation, by stabilization of channels, and other measures.

Forest Recreation.—Research on forest recreation problems is basic to the development of sound administrative policies and the formulation of programs to meet skyrocketing future recreational needs on public forests and private forest lands. The research planned gives emphasis to National Forest problems, but the problems of other forests will not be neglected. Hence, research results are expected to have broad application to both public and private forest lands.

Examples of the research proposed are:

1. Determining the most efficient physical layouts for forest campgrounds and other recreational installations to provide for opti-

mum use and recreation enjoyment with minimum adverse effect on the forest environment.

2. Developing facilities and organization of the use of recreation areas to eliminate dangers to recreationists from forest fires, avalanches, and other natural hazards, and to maintain safe, sanitary conditions.
3. Determining ways of administering forest recreation business efficiently and at minimum cost. This will include the development, maintenance, and operation of recreation areas and the use of self-help devices and other procedures for reducing litter cleanup and similar maintenance costs on mass recreation areas.
4. Developing guides for measuring recreational carrying capacity of various forest types, based on water, soil, and vegetation conditions and users' sense of satisfaction.
5. Obtaining information needed to plan and administer the special use of wild-land resources as wilderness, including data on the use wilderness areas receive: what kind and how much, when it occurs, and how it is distributed. Defining the key features of wilderness environment as a basis of inventory, evaluation, and allocation of resources as wilderness.
6. Determining how timber harvesting can be modified to enhance forest recreation, with particular attention to road, stream, trail, and lakeside zones and commercial stands of old-growth timber.
7. Developing biologically sound measures to rehabilitate recreational areas depleted by overuse.
8. Devising ways to measure and evaluate current recreational use and future requirements, determine preferences of use and response of recreationists to various types and qualities of improvements, administrative policies governing use, and other factors influencing use.
9. Determining to what extent natural, geological, archeological, historical, and other such special areas may be adapted to recreational uses without conflicting with the basic intent of their establishment.

Forest Protection Research

Some of the possibilities of greatest gains in extending the supply of forest resources and maintaining forests and ranges at highly productive levels lie in prevention and control of fire, insects, and disease. Acceptable progress will require strong fundamental research programs to establish the basis for new methods of attack. A thorough understanding of physical principles in the case of fire, and biological and physiological relationships in the case of insects and diseases, will be necessary for continuing significant progress in the control of destructive agents. On the other hand, practitioners will want many detailed answers to special problems; these will require a strong program of applied-science studies. Destructive forces such as fire, insects, and diseases do not halt at property lines and hence are of direct concern to all types of forest-land owners. All will benefit from a balanced research attack on fire and pests.

Forest Fire.—Abolition of forest fires as an obstacle to profitable long-term investment in intensive forestry is a major objective for organized research. For a number of years 90 percent of the costs and damages suffered from fires has resulted from less than 5 percent of the

F–478277

Big game and other wildlife constitute important resources of forest and related range land. Management methods that will insure adequate food ond habitat for wildlife in harmony with other uses of such lands must be developed.

total number of fires. Yet we lack the knowledge that will enable the fire control specialist to identify the potential runaway fire early in its life. Since the heaviest losses occur from unpredictable and erratic fire behavior, scientists must look deeply into the fundamentals of the combustion process, as influenced by an ever-changing environment, for an understanding of runaway fires, their prevention and control. Moreover, Federal, State, and local fire control agencies have many development-type problems in preventing and suppressing fires. These deal with improving aerial fire attack, more effective planning for use of forces and facilities, and techniques and programs for reducing numbers of man-caused fires.

The forest fire research proposed will:

1. Speed basic research on the chemical and physical processes of ignition and combustion, and development of techniques for pre-

F—486578

Skyrocketing recreational use of forests creates problems of protecting the soil and vegetation against damage that would reduce future values for camping and picnicking.

dicting fire behavior as influenced by weather, fuel, and topographic factors.

2. For each important forest region, develop improved methods of measuring and rating fluctuating forest fire danger through studies of microclimate and the integration of these systems into a national fire danger rating procedure.
3. Improve fire control systems and organization through operations research techniques, leading to more efficient, faster, and safer fire suppression.
4. Develop new and more effective systems of aerial fire control, including the improvement of chemicals to retard and extinguish fires and better methods of application.
5. Expand knowledge relating to the prevention of man-caused fires and effective methods of minimizing careless, thoughtless, or malicious fire-starting activities of man.

6. Intensify basic research on atmospheric factors leading to the formation of fire-starting lightning storms, and develop methods for reducing the lightning potential by cloud seeding or other means.
7. Improve the techniques for using fire effectively and safely as a silvicultural or a hazard-reduction device to eliminate unwanted vegetation, litter, or accumulations of logging slash.
8. Develop, test, and evaluate measures to speed the application of new knowledge in fire control operations to improve efficiency and reduce danger to human lives.

Forest Insects.—Although provisional measures of direct chemical control are available for suppressing outbreaks of many forest insects, the greatest promise for the future lies in breakthroughs in preventive control through the use of biological control factors or in improved forest management measures. Accelerated research on the use of insect enemies, or on utilization of radiation techniques to control insect reproduction cycles, offers great promise. Many practical questions also need continuing research attention to provide for modern solutions to special insect problems. Of particular concern are problems that arise from sudden buildups in endemic populations of pests in areas where forest management is most advanced and where investments are highest. In such instances, strong programs of basic research on insect life histories, their biology and physiology, and relations of insect populations to environments are extremely important to future control.

The balanced program of proposed investigation will embrace studies illustrated by the following examples:

1. Research on parasites, predators, and diseases of insects that damage forests and related ranges and the development of techniques for using these biological agents effectively in varied natural environments.
2. Intensified research on factors associated with or responsible for insect outbreaks and development of silvicultural practices designed to prevent outbreaks.
3. Research to develop safer and more effective and economical chemicals for direct control, with special emphasis on systemics for use against such pests as the bark beetle vector of Dutch elm disease.
4. Increased understanding of insects that damage wood by boring into the trunks of living trees or attack and destroy wood products used in structures or for other purposes; and development of improved methods for preventing or controlling damage caused by these insects.
5. Accelerated research on insects that damage or destroy the flowers, seeds, and cones of forest trees and jeopardize the success of forest regeneration and tree planting programs.
6. Beginning research on the biologies and ecologies of insects attacking important species of browse plants on forest-related ranges.
7. Accelerated research on the physiology of the most destructive forest insects with emphasis on nutrition, genetics, and the development of sterilization techniques.
8. Expansion of knowledge concerning prevention or control of destructive populations of forest insects, through acceleration of

fundamental studies of insect habits and behavior and of environmental factors affecting insect abundance.

Forest Diseases.—Before effective measures can be devised to substantially reduce the annual loss of billions of board feet of sawtimber from diseases, the nature and extent of this damage needs much more intensive study. Of special concern are the mounting problems caused by the introduction of new diseases or the sudden flareup of previously innocuous ones that are favored by more intensive management practices, such as one-species plantation culture, thinning, and pruning. These problems are costly to cope with and they cannot be quickly solved without more basic information on the identity and life processes of pathogens, which can be obtained only through study of their taxonomy, ecology, physiology, and genetics. Similarly, there is need for a great deal more knowledge of the toxic principles associated with the damage caused by noninfectious diseases due, for example, to air pollution, severe weather, or unfavorable soil conditions. Control measures utilizing direct chemical or biological or indirect silvicultural approaches must be developed. Once control measures are applied, continuing study is needed to evaluate their effectiveness under a variety of conditions and to better adapt and adjust them to meet many different situations.

The research program proposed will:

1. Provide information on the life processes and reproductive requirements of destructive forest pathogens (fungi, bacteria, viruses, nematodes, and mistletoes) and on the edaphic and climatic factors that influence their spread and intensification.
2. Create an understanding of relationships between tree roots and micro-organisms in various soils to develop preventive and control methods for annosus root rot of southern pines and poria root rot of Douglas-fir.
3. Select and breed trees genetically resistant to epidemic diseases such as fusiform rust and little leaf of southern pines, blister rust of white pines, dwarfmistletoes on western conifers, and heart rots of all important species.
4. Determine the physiological and biochemical action of systemic antibiotic compounds for the direct control of forest diseases such as the rusts and dwarfmistletoes of conifers, stem cankers of hardwood, and oak wilt.
5. Determine the toxic components in noxious industrial fumes and how they interfere with normal tree growth and health, emphasizing the effects on trees of prolonged discontinuous fumigation with low concentrations of air pollutants.
6. Determine the nutritional and environmental requirements for healthy tree growth as the basis for the formulation of practical, effective biological and silvicultural controls for forest diseases.
7. Formulate and improve measures to lessen or prevent the intercontinental spread of dangerous forest pathogens and thereby avoid introduction of additional catastrophic diseases such as chestnut blight and white pine blister rust.

Forest Products and Engineering Research

A strong program of basic and applied research on forest products utilization problems is vital to achievement of the Nation's future tim-

ber production and utilization objectives for three main reasons: (1) Ways must be found to remove and utilize at reasonable cost large volumes of poor-quality timber that now occupy extensive and valuable growing space; (2) logging and mill residues and bark and wood extractives, now wasted or little used, must be used more extensively to increase processing efficiency and the income from forest products; and (3) ways must be found to realize the full potential of wood as a versatile raw material base for industries that will expand markets for timber and create industrial employment opportunities, especially in rural areas. Much valuable research has been done in forest prod-

F—506456

Through use of model fires, physicists goin a knowledge of the principles of fire behavior, leading to improved methods for the control of disostrous wildfires and for the proper use of fire as o tool in forest monagement.

F—506457

Biological control of forest insects, illustrated here by virus-killed larvae of the pine sawfly, promises to replace more hazardous and less permanent chemical control methods.

ucts to expand the basis for increased utilization. However, many important problems need more intensive study. Research to utilize wood in unmodified forms through better engineering design and fabrication techniques will contribute to increased utility. Basic studies of how wood substance may be modified and converted into new or improved fiber and chemical products hold great promise.

The engineering aspects of establishing forests, tending them, and harvesting crops systematically and with the benefits of mechanization have received far too little research effort up to the present. Future forest management efforts must be well engineered and appropriately mechanized to keep costs at acceptably low levels.

Forest Products.—Research on forest products utilization will be aimed at new and improved processes and uses of wood from all the various timber crops. Special attention will be paid to extending outlets for little-used species and low-quality materials. Profitable disposition of this type of forest growth is especially important to the improvement of the 257 million acres of small woodlands where lack of markets is a serious obstacle to forest management. Finding new uses for wood as well as improving the entire technology of wood utilization will benefit many consumers and forest-land owners. It will enhance the future contribution to the Nation's economy made by

timber products utilization which today generates more than $25 billion a year of the gross national product. It will directly benefit the National Forest timber management and sales program, under which the annual harvest from these Federal lands will reach 13 billion board feet, with $200 million income by fiscal year 1972.

The proposed program will:

1. Accelerate basic research on the chemical composition of wood and the development of conversion processes to yield a wide array of industrial chemicals, especially from low-quality or little-used species.
2. Develop better processes for making usable pulp from timber, especially the species not now used commercially, and from residues of harvesting and milling operations. Develop new uses for fiber and fiber products in structural materials and packaging.
3. Intensify research on the chemistry of lignin (which makes up about one-third of wood substance), its separation from wood in unmodified form, and its utilization in plastics and other products.
4. Accelerate basic research on properties of wood such as its density and the length and angle of fibers, and on their relation to environment and heredity to guide the production of timber having desirable qualities.
5. Expand knowledge of the structural and related properties of commercial timber species to establish working stresses as the basis for further improvements in design criteria needed for beams, laminated arches, rigid frames, stressed shapes, and stressed-skin units.
6. Develop improved methods for converting trees and logs into lumber, veneer, plywood, and other solid wood products, with emphasis on little-used species and small trees from thinnings; develop new composite products of wood combined with metals, plastics, fiberboards, or other materials.
7. Devise log and tree quality grades and standards as the basis for improved utilization and marketing of timber.
8. Improve the processes for extending the life and usefulness of wood and wood products by means of preservative applications or other techniques that eliminate or reduce attack by fungi, insects, and marine borers. Expand research on fire retardants and finishes for wood.
9. Intensify basic research on bark and wood extractions, including wood resins for naval stores products.

Forest Engineering.—The application of sound engineering principles to timber production will require research into organizing the flow of operational steps required in managing, harvesting, and renewing forests and the mechanization of each phase. General objectives will be to reduce costs and increase the efficiency of timber growing. Research on problems of concern to the small timberland owner will be accelerated substantially by emphasizing studies of logging equipment designed for small operations, logging methods, log handling processes, and methods of processing to upgrade the quality of products. Research will:

1. Develop well-engineered systems of timber production leading to efficient organization and ready mechanization of seed collection

F—502225

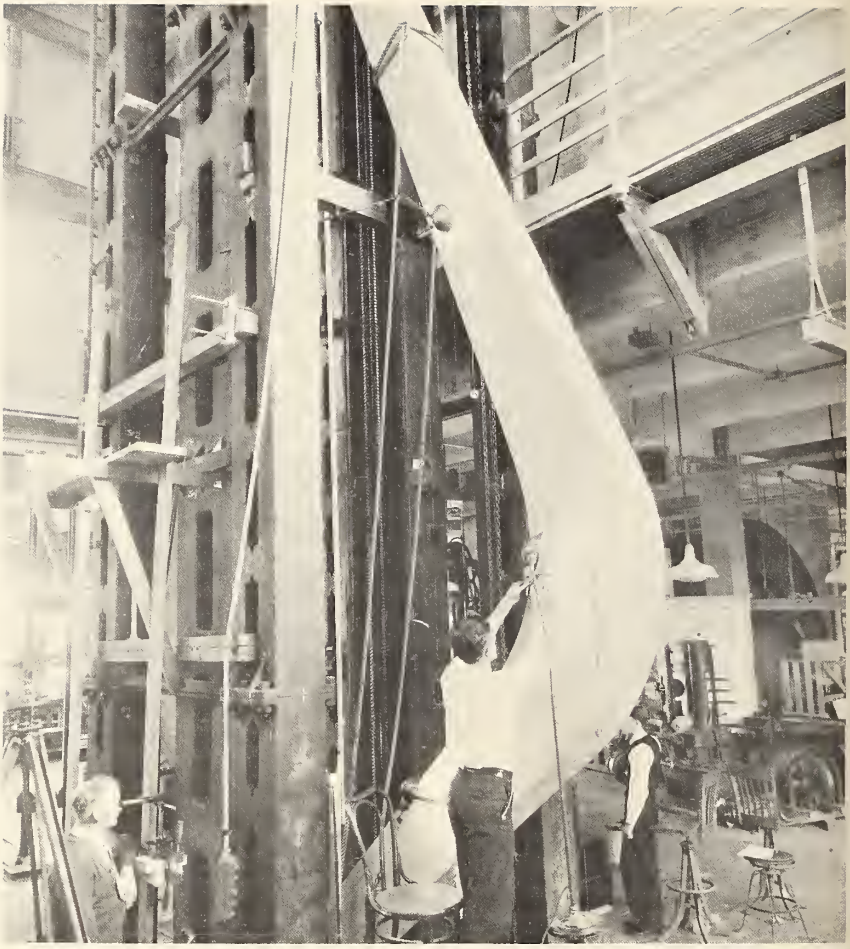
Accelerated research to determine how and why a root rot fungus destroys an otherwise thrifty young stand of Douglas-fir will provide measures to prevent losses like this.

and handling; tree nursery operations; planting, thinning, and pruning; and final harvesting, sorting, and transporting a variety of timber products. Problems of the small woodland owner will receive emphasis.

2. Design and evaluate new and improved logging equipment especially adapted to protecting watershed values, such as overhead cable systems that will permit extension of harvesting operations into steep mountainous country where soils may be highly erodible.
3. Develop and evaluate unique systems such as logging, pest control, or fire suppression by helicopter or other new principles and devices that may benefit future timber production and utilization.

Forest Resource Economics and Marketing Research

At every step in the complex process of producing, protecting, and utilizing forest resources, the landowner or manager must consider the costs and economic advantages of alternate methods of organizing and operating his resource program. Administrators of public forests must develop economically sound management policies. They must have a sound basis for selecting alternative combinations of resource uses that are necessarily based on sound biological principles but also on favorable economic returns. Industrial foresters must base their recommendations and practices on cost and return deter-



M–25188–F

Maintaining the usefulness of wood in modern architecture requires research on design and construction of laminated structural members built up from many pieces.

minations within the framework of company policies and objectives. The 4½ million farmers, businessmen, professional people, or other occupational groups who own in small parcels 53 percent of the Nation's commercial forest land make decisions on timber growing that are influenced to a large degree by economic considerations. Thus, a comprehensive program of forest resource data collection and analysis and of research on the economics of production, harvesting, and the processing and marketing of forest products occupies a key place in future forest development.

Forest Survey.—The Forest Survey provides basic inventory information on the area and condition of forest lands by various classes of ownership; the volume, quality, and location of standing timber; trends in timber growth and mortality; amount and kind of timber cut for industrial products; and the prospective availability of future timber supplies. Such facts on timber supplies, together with ap-

M–100877–F

Electron microscope enables Forest Products Laboratory scientists to probe secrets of wood cells and may lead to new knowledge of potentialities of lignin as a raw material for industry.

praisals of the outlook for timber demands, provide bases for forest policies and programs of Federal, State, and private agencies and for plant locations and timber supply situations of direct concern to forest industries.

The Forest Survey program proposed will provide for reinventories of forest resources in each State at intervals of 8 to 10 years, depending upon the rate of change in forest conditions and wood supply. It includes analyses of timber supply situations in each important timber type and periodic comprehensive analyses of timber supplies and demands for the Nation as a whole. The program proposals are:

1. Acceleration and intensification of the Forest Survey to provide current appraisals of the Nation's timber supplies, information on opportunities for forest industrial development, and a basis for determining the public and private forestry measures required to meet rising needs for timber products.

F—460717

Logging steep, unstable mountain slopes without causing erosion and sedimentation will require better methods of timber harvesting.

2. Improvement of techniques for inventories of forest land and timber resources to provide better guideposts for forest management planning and evaluation of forestry programs.
3. Intensification of Forest Surveys to provide localized timber resource information needed by forestry organizations in carrying ing out programs of forest industrial development and improvement of forest practices on small ownerships.

Forest Economics.—Research in forest economics will have as one of its major objectives the determination of the costs and returns that may be expected from timber growing and harvesting activities. Another aim will be to develop concepts and principles for economic evaluation of combinations of forest land uses, and guides for decisions on coordinated management of timber production, grazing, recreation, wildlife, and water uses. The problems of the small owner will receive special emphasis.

Projects that illustrate the research contemplated are:

1. Determining the opportunities for profitable timber growing for different combinations of site, forest type, class of ownership, and market location, and the potential returns from investments in planting, thinning, pruning, or other cultural measures.
2. Developing procedures and guides for evaluation of multiple uses of forest lands for timber, water, recreation, forage, and wildlife and fish habitat—aimed especially at optimum use and management of National Forests and other public forest lands.
3. Evaluating opportunities and methods for profitable combination of timber growing, recreation, and other uses of small forest ownerships.
4. Providing criteria for evaluating relative benefits from capital investments in forest development and road construction on the National Forests and on private holdings, and for investment of private capital in industrial facilities for timber production.
5. Evaluating forestry programs for small ownerships aimed at improving forestry practices on the major part of the Nation's forest land that is in such holdings, including pilot area studies of owner associations and other devices for stimulating timber production.

Forest Products Marketing.—The forest products marketing research planned will provide especially for studies of the marketing problems of small forest owners and processors, including the development of more efficient arrangements for harvesting, marketing, and processing timber crops produced on small properties. Investigations of timber resources and markets in problem areas to appraise potential opportunities for expansion of existing forest industries or the feasibility of new ones will be scheduled.

The amount and kind of wood products used in housing, farm construction, manufactured products, shipping, and other industries will be determined. Potential timber demands will be related to projections of timber supplies in comprehensive appraisals of the Nation's timber situation and outlook.

Planned research will:

1. Develop and evaluate more efficient arrangements for harvesting and marketing timber crops produced on small ownerships. These embrace various forms of leases, management and marketing cooperatives, price and market reports, and promising modifications of marketing practices, which will be pilot tested.
2. Determine possibilities for increasing efficiency in the processing and marketing of lumber and other wood products, with the aim of reducing costs and improving the competitive position of timber products.
3. Evaluate potential markets for wood products and opportunities for new or expanded forest industries, particularly in areas needing economic development and relief from chronic underemployment.
4. Analyze trends in consumption and study the potential future demands for forest products to provide bases for determining the adequacy of timber supplies and of forestry programs.

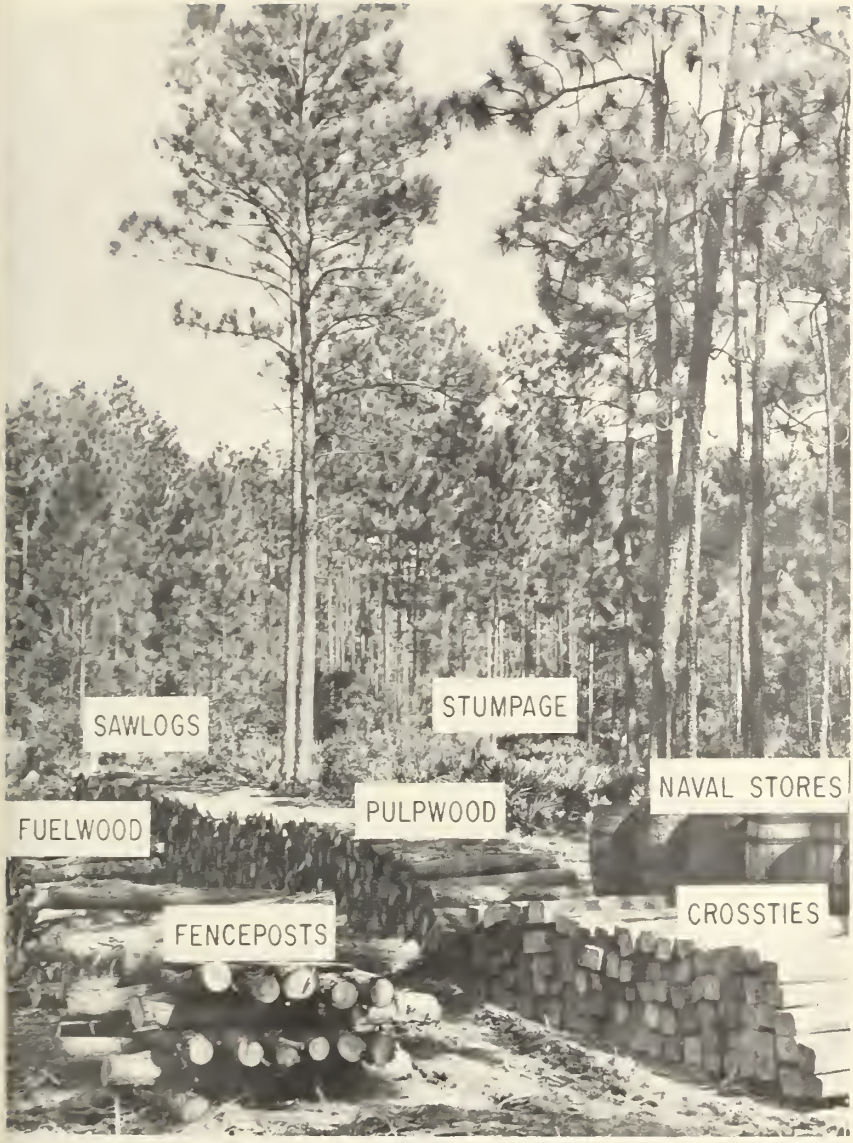
F—498733

Conversion of streamside timber types to grass increases water yields, but economic evaluation is needed to weigh this gain against loss of timber growth and changes in wildlife habitat values.

Cooperative Programs With Colleges and Universities

The forestry problems defined above will form the basis not only for the Department of Agriculture's forestry research program at its own research units but also should provide a useful background against which to plan for the cooperative programs at colleges and universities. Many of these forestry problems, particularly those concerned with the numerous farm and other small forest holdings, can be studied effectively at the forestry schools, the agricultural experiment stations, and other units of the colleges and universities in cooperation with the Department of Agriculture. These institutions have skills that need to be brought to bear on forestry-oriented research. Moreover, the further strengthening of research programs at educational institutions would facilitate training of graduate students and provide broader opportunities for developing specialists needed in the expanding forestry programs of all agencies.

The forestry research programs of the land-grant colleges and other universities having forestry schools and advanced graduate programs need to be greatly extended. Both State and Federal Governments have a stake in their further expansion in the research area. The States will profit from research that leads to better management on the private lands where many of the problems arise that are of intense local and statewide significance. The Federal Government will bene-



F–498805

Marketing studies are needed to help woodland owners and timber processors achieve full use and value from varied timber crops.

fit from a greater sharing of responsibility with the States for acquiring and disseminating information concerning forestry.

The National Forestry Research Program provides for stepped-up support of cooperative forestry research with colleges and universities. Greater use of the Whitten Act as a basis for cooperative aid projects is anticipated. Authority to make project grants for basic research is available and will be used to stimulate cooperative research

at educational institutions. Also, the recently authorized cooperative program of grants to the States for forestry research under the McIntire-Stennis Act (Public Law 87–788 of Oct. 10, 1962) will be developed and expanded. This program, administered by the Cooperative State Research Service of the Department of Agriculture, will further strengthen the forestry research at participating colleges and universities. It will be fully coordinated with the National Forestry Research Program through a national advisory committee, the uniform project system, and other procedures available to the Department of Agriculture which have been previously mentioned.

These cooperative programs would include research of mutual interest on problems or areas of investigation outlined in the previous pages. Experience has shown that cooperative programs of the kind proposed lead to greatly stimulated research by the colleges and universities, several times larger than the Federal cooperative support. It is this kind of growth that is needed if the educational and research institutions are to fulfill their potential in a broad forestry research program for the future. Emphasis by the colleges and universities on forestry-oriented research is an essential ingredient in meeting future needs for new knowledge.

Research Construction and Equipment

To implement properly the forestry research work planned in the National Forestry Research Program, more adequate laboratory facilities and modern scientific equipment will be provided during the short-term period. Some of the construction will house work underway where no laboratories presently are available. Other laboratories will be expanded or remodeled where present facilities are overcrowded, outmoded, or not properly equipped for the use of new, time-saving techniques.

There are 22 research locations where existing laboratories are adequate (or have been provided for in fiscal year 1962, 1963, and 1964 appropriations) and no further construction is needed. At 58 other locations, however, some construction will be necessary. At some locations facility needs are minor and consist of greenhouse-headhouse structures to implement research housed in an adequate laboratory nearby.

Plans have been phased to fit the development and the gradual strengthening of research activities. Buildings not immediately needed are scheduled for the later years of the program. Others are to be built in stages if the entire facility, including auxiliary structures and equipment, is not necessary to performance of the work at an early date.

Eighty-five percent of the sites required for the construction projects are already in Federal ownership or are likely to be available on no-cost leases from colleges and universities. Others probably will be donated to the Federal Government. A few will have to be purchased.

Program Benefits

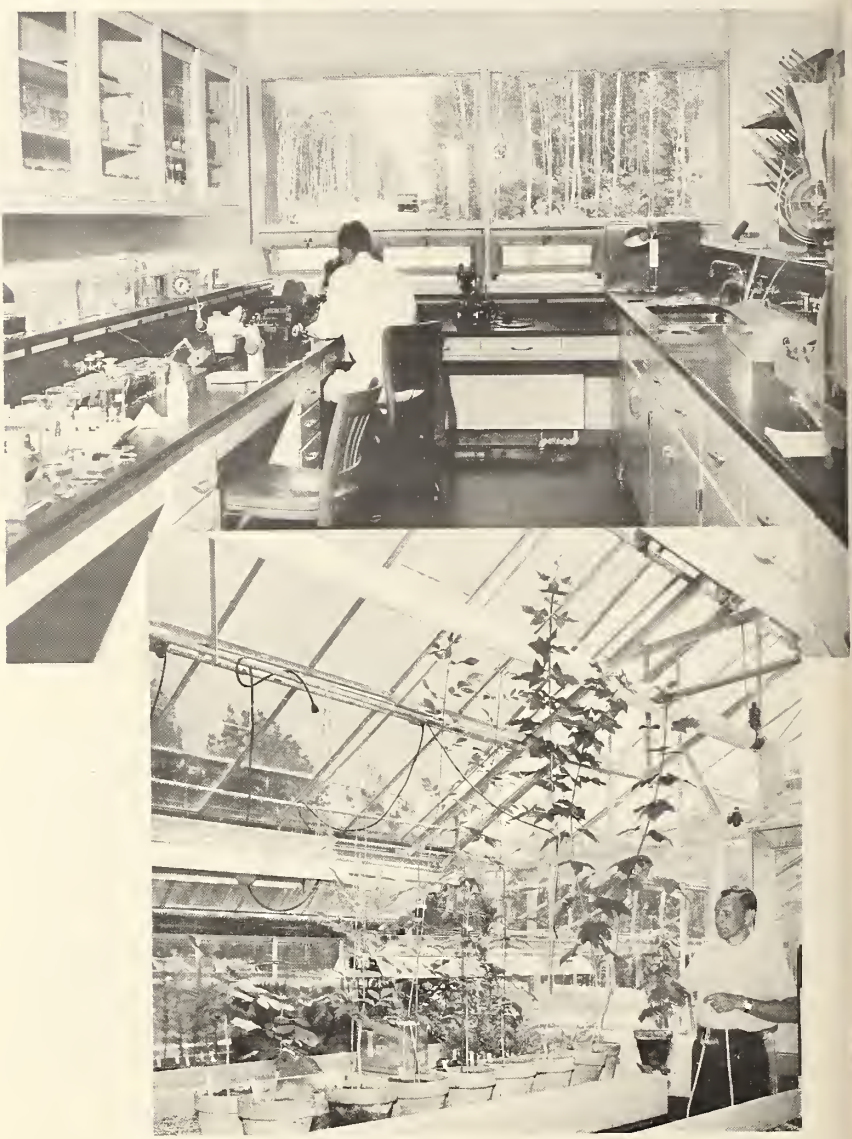
The proposed forestry research program will provide the knowledge needed for more efficient and abundant production of goods and services from the Nation's forest and related resources. These include

F—498852, 499272, 498857

Well-trained scientists need modern forestry research laboratories to do effective research.

773 million acres of forest land plus additional extensive areas of intermingled and related ranges and wildlife habitat.

A strong program of forestry research is essential to full achievement of the goals set forth in the Development Program for the National Forests. Research is likewise a key factor in the forestry programs needed to develop and make fully productive the resources on some 4½ million private forest ownerships. In many rural areas, develop-



F—498863—4

Facilities such as these allow scientists to probe more deeply into the genetics and physiology of forest trees.

ment of the forest resources represents the only hope for permanent relief of underemployment problems.

These forest conservation programs apply to a portion of the Nation's economy that is of basic and growing importance. The capital values of forest land and timber alone amount to an estimated $30 billion. The 100,000 establishments primarily engaged in the manufacture and merchandising of forest products have an invested capital of at least $20 billion. Substantial and increasing investments in water development, in forest recreation enterprises, in sporting goods firms, and in livestock production, for example, likewise rest upon continued management and development of forest resources.

In the years ahead, expanded development and use of all natural resources will be necessary to match the steady growth of population and consumer demands, and this will greatly increase both the capital values and the flow of national income and employment related to forestry. Thus the program for the National Forests and National Grasslands, covering 186 million acres, will produce cash receipts of some $230 million annually within a few years, plus much larger but intangible benefits from the various multiple uses of these public lands. Similar benefits will accrue to forest owners and consumers from development of other Federal, State, and private forest lands.

In the timber economy alone the values now produced amount to more than $25 billion annually, or about 5 percent of the Nation's gross national product. More than 3¼ million workers are employed in the growing, manufacturing, distribution, and marketing of forest products. With the help of research, this large and growing timber business can be expanded to far higher levels to meet the rising requirements of the 350 million people expected in the United States by the year 2000.

Research on regeneration and management of timberlands will help restore to productive condition the 110 million acres of commercial forest land that is now idle or of limited productivity in the United States, exclusive of Alaska. Breakthroughs in protecting forests from fire, insects, and diseases will make available to our expanding economy billions of board feet of sawtimber that is now lost annually to destructive agents. Development of new consumer products, new uses of wood, and better utilization of timber will support higher living standards for all consumer groups in the Nation. Thus, as in other segments of our economy, investments in timber production and utilization research will pay off in expanded national income and higher levels of employment for a growing labor force.

Forest and related ranges provide a substantial part, and in the West often a critical part, of the economic base for the domestic livestock industry. Research on ways of improving and managing these forest and related ranges will aid directly in meeting the future needs of the Nation for livestock products.

In addition to these direct contributions to national income and employment based on commercial enterprises, more productive forest resources will also provide far-reaching intangible benefits.

Water, for example, already is of immeasurable value to agriculture, industry, and consumers in every part of the Nation. Yet by the year 2000 water requirements are expected to be three times those of today. Research to develop improved watershed management practices will help conserve and build up soil productivity, extend and

improve water supplies, and reduce flood losses. All these will be increasingly of critical importance in future years.

Problems related to forest recreation also are multiplying along with the spectacular increases in the needs for all forms of outdoor recreation. On National Forests alone, recreation use by the year 2000 is expected to increase sevenfold to more than 600 million visits annually. Research will help provide both public administrators and private landowners with guiding principles for meeting these new and unprecedented pressures for forest recreation.

Research on fish and wildlife habitat will show the way to greater production of big game and other wildlife resources for the enjoyment of more and more millions of hunters, fishermen, and outdoor recreationists.

Much progress has been made in all phases of forestry research. The proposed National Forestry Research Program builds upon this foundation. A continued and much larger investment in forestry research will provide the basis for more effective multiple use of all the resources on all Federal, State, and private forest lands. It will guide the greatly expanded production and utilization programs for timber, water, recreation, and other forest resources needed in a growing and prosperous America. It will result in substantial and varied benefits to all our citizens.

Program Costs

The National Forestry Research Program will require reaching a level of expenditure of $76 million annually by the end of the 10th year. Implementation of the research at the Forest Service's 10 regional experiment stations, Forest Products Laboratory, and Institute of Tropical Forestry will move ahead in orderly stages over the 10-year period.

The construction of laboratories and related facilities at those locations throughout the country where additional structures are needed will require an estimated $50 million during the period.

The $76 million Federal program described is practical and feasible in relation to the needs and the level of research expenditures that experience has shown to be sound. This sum is about three times the 1962 appropriation for Federal forestry research. The 1962 estimate for forestry research by public and private agencies combined was about $92 million. If this were increased three times, the total expenditures by all agencies would be $275 million, or slightly more than 1 percent of the total consumer expenditures for forest products. The percentage would be much lower if it were possible to assign market values to water, recreation, fish and wildlife, and all of the other material and intangible benefits that come from the forests.

The National Science Foundation reported that in 1961–62 approximately $14.7 billion was spent on all research and development activities nationwide. This is about 2.7 percent of the gross national product. Forestry research expenditures, in comparison, are currently about 0.35 percent of the gross national product contributed by forest products. Funds for forestry research today are at one-eighth of the average level for all research.

Forestry research by the colleges and universities and the forest products industry should increase proportionately with the Federal programs in the years ahead.

U.S. GOVERNMENT PRINTING OFFICE : 1964 O—731–988