

Report of the Harvard Forest

1930 - 1931

To the President of the University:

Applied biology is concerned more and more with the interactions of organic life and its environment. For twenty-three years the development of the Harvard Forest, both in experimental work and in management, has been essentially a process of altering or controlling the composition and succession of existing forests. There has thus resulted a series of contrasting or consecutive forest types of known history and origin and exhibiting significant differences in respect to soil, vegetation, and living organisms. This background of material is proving to be of unique value not only in the experimental development of forestry but to the solution of some biological questions, to which silviculture is intimately related.

During the current year Mr. Paul Miller of the United States Biological Survey has been studying the bird population on a number of special areas with a view to determining changes in numbers, species, and food habits on different types of forest. Dr. H. J. MacAloney of the United States Bureau of Entomology is continuing his observations of the white pine weevil on a large series of sample plots. Mr. A. B. Hatch, on furlough from the Allegheny Experiment Station of the United States Forest Service, is working at the Forest under Professor J. H. Faull of the Arnold Arboretum on the physiology of mycorrhiza, a fungus organism on tree roots which presumably plays an important part in nutrition. Dr. Gast is engaged in a study of the growth and development of Scotch pine seedlings as related to varying factors of light and soil nutri-

ents. This project, begun during his leave of absence for study under Dr. Hesselman in Stockholm, will be published in cooperation with the Swedish Forest Experiment Station. Additional projects conducted by students and staff in cooperation are: insect populations as related to certain contrasting soil types and their influence on the decomposition of humus; the effect of different types of mycorrhiza on the growth of pine seedlings under varying factors of soil nutrients and light; a study of the composition and potential value of hardwood reproduction on cut-over pine land in central New England; a summary and interpretation of the results of twenty years of coniferous planting on the Harvard Forest.

During the past year there have been published the following papers by students and members of the staff: A Method of Reclaiming Seriously Weeviled White Pine Plantations, by A. C. Cline, Assistant Director, and H. J. MacAloney (bulletin of the Massachusetts Forestry Association); Physical Properties of the Cove Soils on the Black Rock Forest, by H. F. Scholz (bulletin of the Black Rock Forest, Cornwall, N.Y.); The Harvard Forest as a Demonstration Tract, by R. T. Fisher (Quarterly Journal of Forestry (British), April 1931).

There is now in press European Larch in the Northeastern United States: A Study of Existing Plantations, by Stuart S. Hunt. The following bulletins are in manuscript: Norway Spruce in the Northeastern United States: A Study of Existing Plantations, by N. W. Hosley; and Factors Underlying Rate Making for Forest Fire Insurance in Massachusetts, by C. C. Averill and L. M. Frost.

Respectfully,

Director

Report of the Harvard Forest

1931 - 1932

To the President of the University,

Sir:

In spite of current difficulties, the Harvard Forest has had a productive year. The price of lumber as well as the demand has shrunk greatly since 1929. By rigid economy and change in the basis of sale, the Forest finished the fiscal year without a deficit. Taking the woods operation by itself, there was even a small profit.

The students now working at the Forest or under direction of its staff, six in number, are of exceptionally high quality. Three are candidates for the doctorate, now in their second year of residence, and three for the master's degree. They represent a very wide dispersal of residence: Denmark, Nova Scotia, New York, Utah, Idaho, and British Columbia. The general organization of research now provides the effective work in fundamental problems of tree physiology which we have long looked forward to as a necessary supplement to the practical and more broadly experimental handling of the Forest.

The program of experiments on the effects of environmental factors, particularly light and soil nutrients, on the growth of young trees, begun seven years ago by Dr. Gast, is beginning to bear fruit. The cooperation of the Black Rock Forest at Cornwall, New York, in a region of different climate, soil, and silvical conditions, which has provided the means for a parallel series of tests, has made possible an attack on several phases of the problem at once. Two large series of pine seedlings have been grown in pots under controlled conditions, one at Cornwall and the other at Petersham. These have

been treated with variations of soil nutrients, particularly nitrogen, solar radiation, and types of local soils. In addition, Mr. A. B. Hatch, working under the joint support and direction of the Arnold Arboretum, the Black Rock Forest, and the Harvard Forest, is continuing his study of the symbiotic association of fungi and trees (mycorrhiza), utilizing the plant material grown at Cornwall and Petersham as well as the pure cultures which form the basis of his method. Supplementing these studies as bearing on the derivation of soil nutrients is the continuing investigation of J. M. Johnston on the comparative insect populations for two types of humus layers in the Forest and their effect upon organic decomposition. One of the essentials for the interpretation of these studies is the accumulation of continuing meteorological records, particularly of solar radiation and temperature. An improvement in apparatus for recording light, developed by Dr. Gast, has been incorporated in the standard weather instrument. As regards temperature, the Blue Hill Observatory, which is also seeking local climatic data, has loaned the Harvard Forest a number of thermographs, which have been in use at various stations in the woods.

These related projects are yielding new knowledge which promises to be of great usefulness to forestry. There is evidence, for example, that the association of fungus and tree host is beneficial to the tree and that the association occurs under certain definite conditions of soil composition. It is likely that the seedling experiments will furnish an exact method of testing the comparative fertility of soils, which will be valuable in the choice of trees for reforestation and in indicating or measuring improvements accomplished by cutting methods in the forest. The value of such fundamental determinations as these used in connection with the application of particular experimental methods on a managed forest can hardly be overestimated.

The remaining studies under way this year at the Forest have a direct bearing upon the management and development of timber crops. One being conducted by Mr. T. Holsoe in collaboration with N. W. Hosley deals with the ascertainment of the most desirable form and growth for red oak and white ash and its relation to the handling of the forest. The other, conducted by A. V. Steed in collaboration with A. C. Cline, is a study of reproduction resulting from group selection cuttings in a white pine forest. Mr. H. J. MacAloney of the Northeastern Forest Experiment Station is continuing his use of selected areas on the Harvard Forest for a study of the white pine weevil, together with experiments in collaboration with Mr. Hosley on the control of mound-building ants in the Forest.

During the past year there has been published as Bulletin No. 17 of the Harvard Forest, European Larch in the Northeastern United States: A Study of Existing Plantations. A paper entitled A Method of Reclaiming Severely Weeviled White Pine Plantations by A. C. Cline and H. J. MacAloney has been published by the Massachusetts Forestry Association. Now in press and shortly to appear is Bulletin No. 19 of the Harvard Forest entitled Some Factors Underlying Forest Fire Insurance in Massachusetts by C. C. Averill and L. M. Frost. Another paper expected to appear in Ecology is entitled Growth of Scots Pine in Sand Cultures with Varying Radiation Intensity and Nitrogen Supply by H. L. Mitchell. There has appeared in the Journal of Forestry Wild Animal Damage to New England Forests by N. W. Hosley. Several other contributions substantially completed are awaiting final revision or funds for publication. These are The Occurrence and Value of Mixed Hardwoods on Cut-over White Pine Land; Cases in Forest Management; Life History of the Virgin Forest on the Pisgah Mountain Tract; Improved Technique in Controlling the White Pine Weevil by Direct Means.

The public relations of the Forest continue active. There have been a large number of visitors during the past season including several associations, such as the Worcester County Farm Bureau, Massachusetts Forestry Association, State Association of Tree Wardens, etc. During the past winter Mr. Cline supervised the expenditure of funds for unemployment/^{relief} on a nearby forest belonging to the Massachusetts Federation of Women's Clubs. Mr. Cline is also serving as President of the Alumni Association of the State College of Forestry of New York and as Chairman of the New England Section of the Society of American Foresters. In the latter organization Mr. Hosley is Chairman of the Committee on Wild Life Damage to Forests and a member of the Committee on Improvement in Composition of Stands.

THE HARVARD FOREST

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — The Harvard Forest is twenty-five years old. Acquired in 1907 and first put under management in the autumn of 1908, it has become by a number of years the oldest tract in America to be handled as a demonstration in forestry and an experiment station for research. At that time the profession of forestry in this country was barely ten years old, and almost the whole body of knowledge pertaining to the evolution of American silviculture was still to be obtained. In fact, up to comparatively recent times the main emphasis of forestry has been toward furthering public policies and public education rather than toward developing the scientific foundations of practice. With forests more than with any other form of vegetation the element of time is indispensable for the testing of cultural methods. It is the good fortune of greater age as well as favorable natural and market conditions that have enabled the Forest to perform a unique service.

The aim of an organized forest is to bring about such a distribution of age and develop such practicable methods of controlling growth and reproduction as will maintain a sustained and maximum yield. Toward this ideal the Forest has made substantial progress. Beginning with an estimated volume of ten million board feet of merchantable timber and an annual growth of two hundred fifty thousand, the growing stock has been built up to a volume of approximately twelve million board feet and an annual yield of nearly four hundred thousand. In the meanwhile more than seven million board feet of lumber have been harvested and something over three thousand cords of wood; and up to very recently the income from these operations has made the Forest, its buildings, and equipment self-supporting. The usefulness of such a development is indicated by the following extracts from an article in the "Yale Forest News," the alumni journal of the Yale School of Forestry:

This record of continuity in intensive silvicultural practice is probably unequalled in America. . . . The Harvard Forest gives to the profession that which is most needed now and which will continue to be our most urgent requirement for decades to come — a demonstration area where the actual working out of forestry practice as a successful business venture can be studied at first hand without having to visit a foreign country to convince ourselves that it can be done. . . .

Behind the evolution of the physical forest as a unit of production has been the slow accumulation of new knowledge about the life history, growth, and reproduction of the regional forest types: first, from the control and observation of varying methods of treatment; and second, through special research projects growing out of problems of management or of New England forestry. Since 1915, when elementary instruction was replaced by graduate research and specialization, these latter have been the subjects of theses by students, and with studies by members of the staff have taken form in seventeen bulletins of the Forest, shorter pamphlets, articles in technical journals, and coöperative publications with the State Department of Conservation, Massachusetts Forestry Association, Roosevelt Wild Life Experiment Station, and the U. S. Forest Service.

A number of fundamental facts or principles in forest ecology or silviculture have been developed at Petersham. It has been shown that many of our existing forest types, even some of those temporarily productive, are controlled not so much by natural factors as by the long operation of such human agencies as unregulated cutting, farming and farm abandonment, and increasing forest fires; and that many of these phases of forest cannot be considered as permanent or valuable. It has been shown that the succession from the original forest composition to the present predominance of inferior species and defective condition can be corrected by timely weeding of the young stands, and that this treatment is indispensable and generally profitable. It has been shown that the pure white pine forest, so common on abandoned farms, is generally productive of low grade timber, unduly susceptible to insects, disease, and climatic injury, and often detrimental to the soil. On the other hand, the conversion of pure stands of white pine into mixed stands of certain hardwoods or hardwoods with pine has been proved to result in the progressive conversion of infertile soil into soil with active fertility. Such stands also produce a higher quality of timber and are more resistant to damage by fire, insects, and disease. Experiments in the growth of pine seedlings under controlled conditions as related to soil nutrients and radiation promise more accurate and practicable methods of testing forest soil, and new light on the relation of fungus organisms to root absorption. These and other findings tested by practice have gone far toward resolving the complexity and degeneration brought about in our forests through two centuries of misuse and neglect, by defining the most favorable associations of species for regional soils and sites, and showing how

the reproduction, growth, and development of these may best and most profitably be controlled. The significance of such continuing combination of investigative work with practical experience may be inferred from the following comment by Colonel W. B. Greeley, then Chief Forester of the U. S. Forest Service:

The two days at Petersham last August stand out as red letter events for many reasons, among them that I felt closer on that occasion to native American silviculture than at any other time in my life.

Up to recently not only on the Harvard Forest but in the country at large the principal aim of forestry has been timber production; but the function of forests in the national economy is fast becoming much more inclusive. Not a few biological philosophers now believe that one of the critical problems of man is coming to be the effective control of his forest environment — in area, character, and location — and with it the indispensable benefits which flow therefrom: wood, water, soil stability, wild life, and recreation. Broader questions will demand broader attack and the need of more and more coöperation between foresters and specialists in other fields of biology and economics. This in fact is already developing most fruitfully in the joint conduct of investigative projects by the Harvard Forest, the Arnold Arboretum, and the Departments of Botany and Zoölogy. For such diversified purposes in research the Harvard Forest is bound to prove increasingly useful. From its wide variety of forest type, age, and origin, and long recorded history of controlled changes will come experimental material and interpretations impossible to get either from wild or unmanaged forests or from those but recently under observation.

The work of the Forest during the past year has been hampered by a sharp fall in income. Receipts from sales of lumber and wood dropped off nearly a half, and the return from invested funds has also dwindled. Notwithstanding a reduction of nearly forty per cent in total expenditure the Forest finished the year with a deficit. It is hoped to make this good from current gifts and economies.

The following publications have been issued: Bulletin 17, entitled "Some Factors Underlying Forest Fire Insurance in Massachusetts," by C. C. Averill and L. M. Frost; "New England Forests: Biological Factors," by R. T. Fisher, a chapter in the volume published by the American Geographical Society and entitled "New England's Prospect"; "The Improvement of Weeviled White Pine Plantations," by A. C. Cline and H. J. MacAloney of the U. S. Bureau of Entomology, a bulletin of the Connecticut

Forest and Park Association. Several other bulletins and papers are substantially completed and will be in print as soon as necessary funds can be secured.

Owing to the current demand for men with forestry training in the Civilian Conservation Camps, several students who would ordinarily have returned to finish their academic work have remained in the employment of the Government. Five men, about the number usually admitted, are registered as research students. Two are in part under the supervision of the Arnold Arboretum and one under that of the Department of Zoölogy. Dr. H. M. Raup of the Arnold Arboretum is carrying on a study of the distribution of trees and plants on the Harvard Forest. It is expected that this survey, being interpreted in relation to known successions of forest type and conversions carried out in management, may yield some new conclusions as to how far certain associations of species indicate variations in soil and site.

During the summer there have been more than the usual number of visitors to the Forest, in the neighborhood of three hundred, many of who have been connected with New England Conservation Camps. A two-day field demonstration was held for the superintendents and foremen of the New Hampshire camps, and several delegations of men from the Massachusetts organizations were instructed in methods of forest practice. This instruction was conducted by Mr. A. C. Cline, who has also served during the summer and autumn as supervisor of silvicultural work in camps in central Massachusetts for the State and the Federal Forest Service.

R. T. FISHER, *Director*.

THE HARVARD FOREST

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — On June 9th the Harvard Forest suffered a severe loss in the death of Professor Richard T. Fisher, who had served continuously as director since the acquisition of the Forest in 1907. The outstanding accomplishments of his time are contained in his report to the President for the academic year of 1932-33, the twenty-fifth anniversary of the Forest's establishment.

A continuation of the period of reduced income from invested funds and sales of forest products caused some further increase in the Forest's accumulated deficit of the past few years. Cultural work on the Forest went forward in accordance with the general plan of management. The annual cut of sawtimber amounted to 375,000 board feet, or slightly less than the estimated mean annual growth. New stands were established on sawtimber production areas from which mature stands recently had been harvested, and on approximately ten acres of abandoned pasture. The first thinnings were undertaken in certain young hardwood stands which originated on cuttings made soon after the Forest was placed under management. The excellent form and composition of these cultivated stands and the methods employed in directing the course of their development have attracted wide attention. In this connection the establishment of the Civilian Conservation Corps camps and the efforts on the part of the Federal Government to develop regional forest practice codes applicable to cuttings on private holdings have afforded many opportunities for the Forest to be of service through the demonstration of silvicultural methods.

A sudden increase in the destructiveness of the gipsy moth caused much concern during the year and prompted contacts between members of the Forest staff and officials of the U. S. Bureau of Entomology and the Gipsy Moth Laboratory at Melrose Highlands. As a result of several conferences, it now appears that a method of indirect control through the alteration of stand composition will prove more effective and less costly than the better known methods of spraying and creosoting, and that the demonstrable results of such a method applied to parts of the Forest eventually will be of value to other woodland owners in controlling this serious pest.

An unusually large program of work was carried out during the winter months at the Forest's Black Brook Plantations in Hamilton. Various systems of thinning were employed in both pure and mixed coniferous stands of high density. At the same time several permanent sample plots were established for purposes of comparing, through detailed initial records and periodic remeasurements, resultant growth and development under the several systems. Since these plantations are a decade or more older than any at Petersham and contain mixtures of conifers not found elsewhere in the region, the projected studies at Hamilton will provide information not otherwise obtainable and supplement the work being done at Petersham.

Studies in which students have participated were in varied fields. Mr. R. K. Ziebarth investigated with Mr. N. W. Hosley some winter relations of the white-tailed deer to the forests of central Massachusetts, a study which included an analysis of the contents of twenty-four deer stomachs. This is the first research project to be undertaken by the Forest in the new field of fish and game management, which currently is attracting much public interest.

Mr. J. D. Curtis in association with Mr. A. C. Cline investigated the rate of healing of artificially pruned white pine branches in relation to size and condition of branch, and method and season of cutting. This study is one of several aimed to provide further knowledge of the silvicultural methods which may be employed in producing timber of high quality on comparatively short rotations.

Further progress was made in the problems centered about the nutrition of forest trees. Professor P. R. Gast investigated methods for the determination of small amounts of potassium and phosphorus in resinous materials. Preliminary investigations were made in the formation and properties of base exchange compounds, artificial and natural, for use in controlled cultural experiments with seedling trees. Mr. W. H. Cummings in association with Professor Gast investigated the nitrogen, potassium, and phosphorus contents of white pines in plantations.

As in the past there has been cordial coöperation with other departments of the University in the joint conduct of research problems. Mr. C. M. Whelden, in association with Director R. T. Fisher and Dr. Edgar Anderson of the Arnold Arboretum, investigated the taxonomy of a number of species of *Fraxinus*. By hand pollination he hybridized certain of these and attempted to perpetuate certain desirable growth forms. Mr. R. W. Ward in association with Professor J. H. Faull investigated the nutrition of apple

clones of known variety, using in part information gained in the course of the continued project in tree nutrition at the Forest. In the investigation of mycorrhizae and related nutritional problems, Mr. A. B. Hatch, also working in association with Professor Faull, has drawn upon the experience of the Forest staff.

Dr. Hugh M. Raup of the Arnold Arboretum continued his ecological study of the distribution of plants in relation to forest cover types and stand histories on the Forest. As a basis for comparison with the secondary types, the Forest's old growth stand on Pisgah Mountain is serving a most useful purpose.

Investigative work in association with outside agencies has been continued. The program of nutritional experiments at the Black Rock Forest, prosecuted by Mr. H. L. Mitchell, is closely correlated with that at the Forest. From the experimental material thus grown, samples have been forwarded to Professor R. H. Wetmore for morphological examination. A many-sided study of such plants for both the chemical and structural qualities may be expected to yield important new knowledge.

Dr. H. J. MacAloney, Federal Government entomologist assigned to the Northeastern Forest Experiment Station, in collaboration with Mr. A. C. Cline continued his investigation of methods of controlling the white pine weevil.

A. C. CLINE, *Assistant Director.*

Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — With the beginning of the academic year, the four hundred-odd stands which constitute the growing stock of the Forest entered the second quarter century of their intensive cultural treatment under a policy of continuous production. Many of the techniques in silviculture applied in earlier years and outrightly experimental in character have by now more clearly demonstrated their worth and adaptability, thereby greatly enhancing the educational value of the Forest. Especially fruitful have been the methods developed in the culture of volunteer stands of hardwood following the cutting of second growth white pine, the latter a predominating cover type at the time the Forest was acquired. Also, the course of development of early plantations of coniferous species has now reached the stage where the habits and rates of growth of various species in relation to soil and other environmental factors, and the interaction of species growing together in mixtures, may be studied and observed with growing certainty of significant responses and relationships.

At the same time it is recognized that a large number of young, cultivated stands are approaching a critical stage in their development, when excessive competition between closely spaced stems must be relieved in order to avoid the serious consequences of arrested growth. From the standpoint of continued growing stock maintenance and the furtherance of silvicultural practice and experimentation, the arrival of the time for carefully planned and executed thinnings places an increased responsibility on the Forest staff and furnishes a broadened field for research in silviculture.

On the anniversary of the death of Professor Richard T. Fisher, June 9th, the President of the University and the alumni of the Harvard Forest dedicated a boulder and tablet in his memory. The spot chosen for the memorial was a great boulder in the old growth forest situated along the eastern shore of Tom Swamp Pond. At noonday a group of relatives, colleagues, and alumni gathered at the site to witness the dedicatory ceremony. John S.

Ames, '01, President of the Harvard Forest Alumni Association, presented the memorial to the University in behalf of the alumni, and President James B. Conant accepted it for the University. The simple and impressive ceremony marked an historical event of deep significance to the Forest.

During the year the alumni of the Forest, represented by a committee in charge of H. H. Tryon, '13, prepared and published a seventy-page, illustrated bulletin in memory of Professor Fisher, entitled *The Harvard Forest, 1907-1934: A Memorial to its First Director, Richard Thornton Fisher*.

Several gifts of great value are to be recorded. A generous friend has given the Forest ten completed forest stand models, which form part of a series of twenty-four to be housed eventually in a museum at Petersham, to be known as the Fisher Memorial Museum. It is believed that they represent the highest degree of fidelity yet attained in the small scale modeling of forest stands and the activities incident to their culture, and that in their final repository they will serve both as an eminently fitting memorial to Professor Fisher and as an enduring source of public education in central New England forestry. Another generous friend, who also wishes to remain anonymous, has given a 34-acre tract of woodland so situated as to safeguard the headquarters building site from undesirable occupancy or use of the land immediately adjoining on the west. Through the generosity of Mrs. Richard T. Fisher, essentially the entire personal forestry library of the late Professor Fisher has been added to the Forest's collection. By virtue of another gift by an anonymous donor, it was possible to publish Harvard Forest Bulletin No. 18, *Cutover Old Field Pine Lands in Central New England: A Regional Study of the Composition and Stocking of the Ensuing Volunteer Stands* by F. S. McKinnon, G. R. Hyde, and A. C. Cline.

In the field of research Professor P. R. Gast has continued the series of experiments dealing with the nutrition of forest trees. A further development was realized in the use of base exchange compounds in controlled cultural experiments with tree seedlings, and in the adaptation of the photronic cell and pyrliometer to the needs of this series of experiments.

Mr. N. W. Hosley was granted sabbatical leave for the academic year to undertake advanced research work in biology at the University of Michigan, receiving credit therefor towards the doctorate.

Research projects undertaken by students in collaboration with the Forest staff or other members of the faculty of the Division of Biology were chiefly in the fields of silviculture and forest soil biology. Messrs. J. W. Duffield and J. Hugo Kraemer in collaboration with Mr. A. C. Cline studied the results of the application of the shelterwood method of reproduction to white pine and hemlock stands on light soils. The findings will contribute much towards a working knowledge of partial cutting systems under American conditions.

Mr. James W. Johnston, Jr., working under the supervision of Professor C. T. Brues, with collaboration by the Forest staff, continued his thesis problem on the macrofauna of forest soils as affected by certain coniferous and hardwood cover types on the Harvard Forest. This is among the very first quantitative analyses of forest soil populations to be undertaken in this country and promises to yield highly valuable information on the control of soil fertility through forest stand composition.

Coöperation has been extended to other departments in the University and to outside agencies. The recently completed study by Dr. A. B. Hatch of the physical basis of mycotrophy in *Pinus*, pursued under the direction of Professor J. H. Faull, has engaged the interest and coöperation of the Forest for several years. For a two-week period during the past summer, the Forest was pleased to offer its facilities to Mr. Lorus J. Milne, a student in entomology under Professor C. T. Brues, for the purpose of collecting insects of the order *Trichoptera*.

As in the past, the nutritional experiments being conducted by Mr. H. L. Mitchell at the Black Rock Forest are closely correlated with those being undertaken at Petersham. Mr. A. C. Cline, in collaboration with officials of the Gipsy Moth Laboratory of the United States Bureau of Entomology and Plant Quarantine, conducted an investigation of the feeding habits of the gipsy moth on the Forest and surrounding areas in the town of Petersham. It was observed that complete defoliation of forest stands was strictly limited to areas supporting concentrations of one or more of a certain few hardwood species. This work has served as a basis for a policy of gipsy moth control recently adopted by the Forest, namely, to reduce defoliation to a tolerable degree through altering stand composition in favor of resistant species. The Forest is indebted to Dr. Perley Spaulding, Mr. J. R. Hansbrough, and Dr. Bailey Sleeth, forest pathologists associated with the United States

Bureau of Plant Industry, for their helpful coöperation in connection with silvicultural problems involving wood-rotting fungi.

The demonstrational value of the Forest has grown rapidly within the past two years, chiefly because of the unusually large programs of silvicultural work being undertaken on the national and state forests. Somewhat over three hundred visitors were entertained during the year, the majority of them students, teachers, or practitioners of forestry who spent a full day of observation under the guidance of a staff member. Special field trips through the Forest were arranged for organized groups from the White Mountain National Forest and from several state forestry departments and forestry schools. On several occasions within the year the Forest staff has been consulted in the drafting of codes of forest practice for use by public forestry agencies. It is evident that the results of the past quarter century of work at Petersham are becoming of ever increasing usefulness to others.

A. C. CLINE, *Assistant Director.*

Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — A generous gift by an anonymous donor for the three-year period 1936-39 has given the University a breathing spell in which to determine the future of the Harvard Forest and the nature and scope of the University's possible further contribution to forest conservation. The purpose of the gift was two-fold: to bring up to date the records, experiments, and management of the Forest both as a scientific laboratory and as a demonstration of practical and profitable forestry; and to permit the working out of a plan of permanently financing the Forest and possibly allied fields of instruction in Cambridge. The latter problem is being studied in the light both of the notable past history of the Forest and of the rapidly growing public interest and effort in the whole broad range of conservation of natural resources.

The crucial problem of the Forest remains the problem of finance. Continuing low prices of forest products have cut heavily into the current income from timber sales; and even were that not the case, the inadequate endowment of the Forest would continue to hamper the full development of its scientific, instructional, and public usefulness. Only the generous assistance of the University in making up the deficit has enabled the Forest to carry on during the lean years.

Pursuant to the terms of the above-mentioned gift, substantial progress has been made in reorganizing the work of the Forest. A beginning has been made in organizing a system of permanent roads and trails — an essential for a continuously managed forest property. Numerous experimental "sample plots" — covering various cultural methods — have been remeasured. A good start has been made on a complete "re-inventory" of the timber and young growth, in order to make an accurate forecast of the annual growth and of the allowable annual cut and to determine the cultural treatments needed by all the different age-classes and timber types of the Forest. This work, to be completed the ensuing year,

will afford the necessary factual basis for a written plan of management — an essential instrument for the handling of a complex forest containing upwards of 600 separate timber stands.

A beginning has been made also in extending cultural treatments to the entire Forest of 2,400 acres, including 100 acres of diversified plantations at Hamilton, Mass. Hitherto the emphasis has been laid on harvesting mature timber and on establishing artificial and natural regrowth. Extensive areas of intermediate age-classes are in need of cultural treatment in the way of thinnings and improvement cuttings both to assure an ultimate higher financial return and to demonstrate the methods of improving wild stands of timber. Experimentation is also underway in the greatly neglected field of planting valuable hardwood species to replace inferior cordwood stands.

One of the most valuable scientific and instructional assets of the Forest is the continuous record of silvicultural treatments of the various stands over a period of 30 years. Owing to shortage of personnel these records are now somewhat in arrears, but their early completion is being pushed.

A summary of all research work conducted at the Forest during the past 30 years has been made and will be used as a guide in formulating the general scope and objectives of a long-range future program. In this connection, numerous manuscript reports of past research projects are being studied with a view to their possible publication.

During the year, publication of *Harvard Forest Bulletin* No. 19, "Norway Spruce in the Northeastern United States," by Mr. Neil W. Hosley, of the Forest staff, was made possible by an anonymous gift. This bulletin presents the results of several years intensive field study of the numerous plantations of this highly important tree species for commercial timber production.

Also during the year, the Massachusetts Forestry Association published "Silvicultural Control of the Gypsy Moth," of which Assistant Director Cline is a co-author. This modest-appearing bulletin — likewise based on intensive field study — is likely to produce important consequences in that, by implication, it takes the Government to task for the seemingly fruitless expenditure of many millions of dollars in attempting to exterminate the gypsy moth by direct attack instead of seeking to control it by reducing the proportion of favorite tree species on which it feeds.

During the year, a study was made by Herbert William Turber-

ville, assisted by Mr. Hosley, of the food and cover requirements of the grouse.

Dr. Gast, in addition to continuing his fundamental studies on radiation and soil nutrients in relation to the growth of tree seedlings, inaugurated an extensive practical experiment in seedling fertilization in coöperation with the Metropolitan District Water Commission at its forest nursery at Enfield in the Quabbin Reservoir project. A large number of plots were established, on which accurately measured quantities of various mixtures of tree nutrients were placed to determine their effect on growth, hardiness, and survival of tree seedlings of various species. Striking differences developed early, and it is anticipated the experiments will improve the technique of forest nursery practice as well as add to our fundamental knowledge of the nutrition of trees.

A number of coöperative research projects have been inaugurated or continued.

In coöperation with Dr. H. J. MacAloney, of the United States Bureau of Entomology and Plant Quarantine, Mr. Cline continued studies on reclaiming severely weeviled white pine plantations and published a progress report in the *Journal of Forestry*.

Dr. MacAloney, Mr. W. L. Baker, and Mr. Cline established sample plots on the Forest for the intensive study of the feeding habits of the gypsy moth in mixed hardwood stands of varying composition. Messrs. Baker and Cline published in the *Journal of Forestry* a report on the gypsy moth in the town of Petersham.

Dr. J. R. Hansbrough, of the United States Bureau of Plant Industry, coöperated with Dr. Gast in starting a study of a newly identified fungus disease in a valuable Norway spruce plantation of merchantable age. Drs. Hansbrough and MacAloney completed their study of dying back of young oak twigs and determined that frost was the primary cause. This study indicates an important problem in protecting stands of young oak, one of the most abundant and valuable species in the forest.

Dr. Perley Spaulding and Dr. A. M. Waterman, of the United States Bureau of Plant Industry, have continued studies of tree diseases at the Hamilton plantations.

In the field of extending its influence beyond its immediate confines, the Forest has had a notable year. In addition to some 300 visitors coming singly or in small groups, the Forest was the scene of a two-day meeting by 150 members of the New England Section of the Society of American Foresters, in honor of the Harvard

Tercentenary. The Forest has also taken an active part in the movement to extend the farm-benefit payments of the Agricultural Conservation Program to farm woodland improvement.

Most notable in the field of public educational influence was the installation in the University Museum, as a part of the Tercentenary exhibit, of 16 completed models of the Harvard Forest. These models, presented to the University by an anonymous donor and ultimately to be housed at Petersham, are the joint work of the artist-firm of Guernsey & Pitman and of the late Director Richard Thornton Fisher, Assistant Director Albert C. Cline, and the donor. As works of art, they represent an extraordinary perfection in model-making; as a presentation of the science and practice of American silviculture as evolved through 30 years at the Harvard Forest, they achieve a truly amazing perfection of realistic detail and mass effect. Thousands of people have viewed them during the summer, and as a result the Harvard Forest has emerged from its long isolation "on the periphery of the University."

Substantial progress has been made in working out detailed plans to be presented to the University authorities for the future development and financing of the Forest and of allied fields of instruction at the University. A Visiting Committee to the Harvard Forest has been organized under the Chairmanship of Mr. Henry S. Morgan and is taking an active interest in the formulation of plans.

WARD SHEPARD, *Director.*

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CAMBRIDGE, MASSACHUSETTS
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Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — The continuance by an anonymous friend of the Forest of the special Gift Fund of \$15,000 a year has permitted further progress in improving the Forest and its records. A careful reinventory of the timber and young growing stock has been practically completed, and will afford the basis of a carefully coördinated written plan of management. Such a plan is essential to the systematic improvement of the silvicultural condition of the forest as a whole and is also an important tool of instruction in the art of forest management. The Gift Fund has also permitted the remeasurement and computation of the permanent experimental sample plots in silvicultural research, and has made possible substantial progress in bringing the written research and operation records up to date, in classifying and cataloguing the library, and in various physical improvements, such as roads and trails, pruning, thinning, weeding, and other cultural operations.

The Harvard Forest is participating in the long-range research in tree-breeding initiated by the creation of the Maria Moors Cabot Foundation for Botanical Research. In addition to fundamental work on nutrition and radiation in relation to tree growth, that part of the program to be done at the Harvard Forest in the immediate future will consist in the selection and breeding of the better individual strains of white pine and white ash, two of the most valuable trees of the region. Certain tree species have been found to vary greatly in form and vigor, and this clue will be followed to determine if similar variations occur in white pine and white ash, and if so, to use the better strains for further breeding and propagation.

In collaboration with the Department of Economics, a coöperative plan has been worked out with a number of Bureaus of the Federal Department of Agriculture and with the Massachusetts State College for a comprehensive study of the land resources of Worcester County with a view to determining the public and private action needed for a long-range program of agricultural and forest improvement. The purposes of the study, however, go beyond fact-finding and planning. They seek a better coördination of methods and objectives of the numerous agencies concerned with the agricultural problem and a better understanding of the kinds

of public and quasi-public institutions needed for the guidance of a coördinated agricultural program.

The Worcester County project is typical of the efforts now being made to broaden the educational and demonstration value of the Harvard Forest. With its limited resources, its principal past contribution — and a highly valuable one — has been in the biological aspects of forestry. The wide extent of destructive exploitation of our natural resources, however, indicates that a pressing problem of the future will be in the broad application of the social sciences — particularly those relative to legislation, planning, and institutional adjustment — to make possible the wide application of biological and engineering techniques to prevent the wasteful use of the soil. This need of widening the attack is strikingly shown by the fact that in an extensive region surrounding Petersham, in spite of thirty years of intensive work by the Harvard Forest in silviculture and forest management, there has been a constant deterioration of the forest resources to the point where they have little social and economic value. This deterioration of a once highly valuable and productive resource is closely linked with the general agricultural and social decline of the region during the past 75 years. It is hoped, through further and continuing collaboration between the Harvard Forest, the Department of Economics, and the Graduate School of Public Administration, to strengthen the University's work in the conservation of natural resources.

Fruitful coöperative studies with scientists of the federal government were continued and enlarged. The Division of Forest Insects of the Bureau of Entomology and Plant Quarantine established in the Forest a series of sample plots for the study of feeding habits of the gypsy moth, to be kept under continuous observation during the feeding period for a number of years. In addition, the year by year survey of gypsy moth defoliation in the Town of Petersham, begun in 1935, was continued. These coöperative studies have been of great value in bringing to light the possibilities of controlling the gypsy moth by altering the composition of the forests by reducing the proportion of favorite food trees, a process which happens to be in harmony with forest improvement from the silvicultural standpoint, sorely needed throughout the region to rebuild depleted and deteriorated growing stocks.

The Forest coöperated with the Division of Forest Pathology of the Bureau of Plant Industry in a study of decay hazards in sprouts of several important species, including white ash, paper birch, and

red maple. Because of the sprout origin of many hardwood stands and the need for improving their form and quality through various kinds of weeding and thinning, a knowledge of decay in relation to the parent stump and stubs left in thinning sprout clumps is of the utmost importance. The findings of the past season were of such character as to be immediately useful. The same Division continued its studies of the Cytospora canker of Norway spruce in the Forest, the work consisting of various degrees of thinning and fertilization in order to learn whether the disease was influenced by tree vigor.

Plans for the development of the Schwarz Tract, given to the Forest for the purpose of demonstrating the combined application of silviculture and landscape architecture to woodlands, were begun by the Forest staff aided by Mr. D. N. Glick, a graduate student in the Department of Landscape Architecture in the University. This is pioneer work which gives promise of contributing to the development and management of public forests and parks, private estates, country roadsides, and the like.

A fund of approximately \$4,000 will become available to the Forest beginning with the academic year 1937-38 for the publication of bulletins and short papers. A considerable number of valuable manuscripts has been accumulated, partly the work of members of the faculty and partly the result of research projects by graduate students. Progress has been made in putting these manuscripts in form for publication, including "The Life History of the Climax Forest on the Pisgah Mountain Tract," "A Study of Artificial Pruning in White Pine Plantations," "The Uniform Shelterwood Method in Mixed Pine and Hemlock," and "The Management of Red Oak and White Ash."

Among other gifts to the Forest are the following: from an anonymous donor, \$363.10 for the publication of Mr. N. W. Hosley's bulletin, "Norway Spruce in the Northeastern United States"; from the Charles Lathrop Pack Forest Education Board for the academic years 1937-38 and 1938-39, a fellowship with an annual stipend of \$3000 for a mature worker in land use planning; from Mr. John W. Blodgett, Jr. of Grand Rapids, Mich., a five-year fellowship with a stipend of \$500 for a graduate student at the Harvest Forest.

During the past year, a number of new models have been completed for the Harvard Forest group now on exhibition in the University Museum. The models continue to attract many visitors.

WARD SHEPARD, *Director*.

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Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — In the practical management of the forest property, substantial progress was made. Continuing from the previous year, most of the field work in the physical re-inventory of the timber was completed as well as a more accurate resurvey of the entire Forest and its numerous subdivisions. Much of the work also of organizing the inventory data into a revised management plan for the Forest was done. This work is of basic importance in managing a forest property of any size and complexity, in that it gives a systematic schedule of the time, place, and amount of timber-cutting from year to year, as well as of cultural operation in the younger stands.

Pursuant to the policy of improving the timber "growing stock" of the whole Forest as rapidly as possible by thinnings and other forms of partial cutting, about 70 acres were cut, yielding some 350,000 board feet of merchantable lumber and leaving the better trees for further and more rapid growth.

In the field of forest investigations, a notable occurrence was the initiation of a long-time project under the Maria Moors Cabot Foundation for Botanical Research looking to the possible discovery of superior strains of eastern white pine. It is well known that certain tree species, such as Scotch pine and western yellow pine, have evolved numerous geographical races of varying quality as timber trees, and in the belief that the same may be true of eastern white pine, seed was collected from a considerable number of individual trees in the neighborhood of Petersham and planted in a nursery. At the end of three years in the nursery, the young trees will be planted on near-by lands of the Metropolitan District Water Commission for long-time observation. Arrangements were made also to collect eastern white pine seed in the autumn of 1938 in various parts of its wide range as a broader approach to the same experiment. After some years this work should reveal whether white pine has races of superior vigor and quality — a possibility important both in relation to the source of seed for plantations and to the selection of stock for tree-breeding experiments through hybridization.

Dr. Hugh Raup, of the Arnold Arboretum, with the assistance of Reynold E. Carlson, a graduate student of the Department of

Economics, started work on a study of the land-use history of the properties now included in the main body of the Harvard Forest at Petersham. The purpose of this study is to trace, through county land records, historical documents and the evidence on the ground, the cultural history of each separate parcel of land in the Forest. If the study is successful, one of its most important results will be to determine what was the original forest type on each parcel. With such knowledge, the development of silvicultural systems for the different parts of the Forest can be undertaken with greater assurance, since it would be a logical assumption that the original forest type evolved by nature for each site would be the best. (This work was partly financed by the Committee on Research in the Social Sciences.)

An important and comprehensive project was initiated this year to bring together and analyze the records and results of all the diverse silvicultural operations of the Harvard Forest during the previous thirty years of its existence. The method followed is first to compile all the historical data on each of the many stands that have been given one or more cultural treatments, showing previous composition and condition, methods of treatment, costs, purposes, and results. Then the stand is studied on the ground as to its present composition, quality, and condition. As many stands have had several treatments in the course of thirty years, the compilation and interpretation of all the data is arduous and requires critical skill. This "case study" of a multitude of forestry experiments will, it is felt, be a unique contribution to American silviculture, as well as a scientific memorial to the late Director, Richard Thornton Fisher, as practically all the work covered by the study was initiated and supervised by him.

The federal Bureau of Entomology, in coöperation with the Forest, began a several years' study of the feeding habits, population changes, and enemies of the destructive gypsy moth. This is the most intensive study ever undertaken of this forest pest and will, it is expected, throw light on practical methods for its control.

The Forest continued coöperation with the Department of Economics and with several governmental agencies in the study of land use and management in Worcester County. The Forest was especially concerned with the analysis of forest conditions and the preparation of forest management plans in the town of Hardwick.

The Director collaborated with Professors Black and Friedrich in organizing and conducting the Land Use Seminar in the Graduate School of Public Administration.

Through the generosity of an anonymous donor, a handsome fireproof brick garage was constructed, with a capacity for fourteen cars, a small workshop, and housing for the well, pump, and pressure tank.

Three more models in the series of Harvard Forest Models — the gift of the same donor — were finished. These are the models on Shelterwood Method of Reproduction, Wild Life Management, and Phases of Soil Erosion and Its Amelioration by Forest Practices and will ultimately be housed in the proposed forest museum at Petersham.

WARD SHEPARD, *Director*

Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — Just thirty years after the Harvard Forest was first put under management it was visited by the most destructive hurricane of which there is any record in this part of New England. This is attested by the fact that the Forest's stand of old growth timber, situated on top of a mountain some twenty-five miles north of Petersham and exposed to every gale, was composed chiefly of veteran white pines which had attained an age of over 300 years. In the recent hurricane many less-exposed pine stands no older than 30 years were completely blown down, and thus one may confidently say that no storm of equal violence could have swept through this part of the region for at least upwards of 300 years.

Immediately following the disaster of September 21, 1938, the Forest concentrated its every energy on the task of timber salvage. A reconnaissance of conditions revealed that a large part of the merchantable-sized timber had been uprooted or broken by the wind. Through the generosity of a friend, who wishes to remain anonymous, the sum of \$20,000 was made available as a revolving fund for rehabilitation purposes. This permitted the start of logging operations with a minimum of delay, an urgent necessity in view of the limited time before the timber would spoil.

Director Ward Shepard was appointed by Governor Charles F. Hurley as chairman of a committee to negotiate with the authorities in Washington upon the matter of assistance to New England in coping with the emergency. The committee played a leading part in the drafting of a plan for setting up a federal timber-purchasing and fire-protection agency, known as the Northeastern Timber Salvage Administration and under the jurisdiction of the United States Forest Service. Throughout the region this Administration undertook the buying of hurricane-felled timber in the form of logs delivered at designated receiving points, and directed the work of thousands of Works Progress Administration employees assigned to fire hazard reduction. Because of a shortage in saw-mills and the advantages of spreading the manufacture and sale of such a large quantity of material over a period of years, the Administration leased ponds for the storage of logs. The College was the first owner in Massachusetts to lease a pond for such purposes.

The Forest was instrumental in the formation of a local timber salvage corporation, the Petersham Forest Coöperative Association, and contributed the sum of \$1,500 to this organization to assist it in getting under way. Because of the corporate status of Harvard College, the Forest itself could not become a member of the Association, but worked in close coöperation with it. The Association engaged a competent manager, built a logging camp, and brought in contractors and lumberjacks from several eastern states where surpluses of such labor existed. The total number of woodsmen and foresters working in the town at times exceeded three hundred, and the usual slow pace of winter life in the community gave way to feverish activity.

With such a large portion of its total area in timber forests, the town of Petersham was outstanding both in the amount of damage sustained and the amount of labor required to reduce the fire hazard to a point of reasonable safety. Shortly after the hurricane the Forest temporarily enlarged its woods crew to approximately twenty men, for the purpose of supplementing the efforts of Federal Works Progress Administration crews, town employees, and others in opening the roads and constructing firebreaks. The Forest at the same time organized a fire patrol to prevent fires from starting on its property along the state highway. Heavy traffic and deep piles of pine tops close to the roadside created an unusually hazardous condition. To assist Petersham in more effectively meeting the emergency, the Forest made a gift of \$3,000 to the Town to be used principally in reducing the fire hazard in the most publicly dangerous areas of the Harvard Forest and other properties. Most fortunately, it happened that weather conditions during both the fall and spring seasons generally were unfavorable for the start of forest fires; otherwise great losses in property might have been experienced.

Timber salvage operations have been carried on continuously since the hurricane. The Forest engaged several logging contractors to supplement the work of its regular employees, and as many as sixty-five men were working at one time in cutting the trees into logs and transporting them to Government receiving points. Nearly 4,500,000 board feet have been sold to the Government in the form of logs, and approximately another 1,000,000 to a private lumber concern in the form of stumpage, the combined amount representing at least 90 per cent of the total merchantable timber blown down, and the equivalent of nearly fifteen years' cuttings

in normal times. Under the unusually difficult conditions of logging and high overhead costs it was impossible to show more than a very slight profit on the salvage operations.

No other heavily wooded town in the region salvaged such a large proportion of its fallen timber as did Petersham, or provided such a convenient and businesslike way in which numerous individual owners might arrange to sell their timber. Near the end of salvage operations, in the fall of 1939, the Federal Government had purchased 15,000,000 board feet of timber in Petersham, 6,600,000 board feet of which were stored in Harvard Pond in the form of logs. The large measure of success realized by the Petersham Forest Coöperative Association has encouraged the Association to consider continuing beyond the period of the emergency and undertaking the sale of such forest products as fuelwood.

The disposal of hurricane slash, both on private and on public lands, has been carried on without interruption by the Works Progress Administration, the Civilian Conservation Corps, and special hazard reduction camps established by the U. S. Forest Service. From 200 to 400 men have been steadily engaged in this work in the town of Petersham for the past twelve months. Much valuable work already has been done in the Harvard Forest by these public agencies, and the fire hazard substantially reduced thereby.

On the basis of four degrees of damage, ranging from none or very slight to complete blowdown, the growing stock remaining in the forest after the hurricane may be classified as follows:

Degree of Damage	Area in Acres
Undamaged or Very Slightly Damaged	477.9
Moderately Damaged	625.9
Severely Damaged	504.4
Completely Blown Down	333.9

Losses in merchantable timber were greatest by far in the older pure white pine stands, which owed their origin to volunteer seeding on old fields and pastures abandoned for farm use some fifty to eighty years ago. In general, hardwoods suffered less severely than conifers. All of the young hardwood stands developed since the Forest was acquired in 1908, including the 30-year-old stand on the area first logged under the University's management, escaped with no more than slight injury. It was in these

young stands that most of the experiments in silviculture were being conducted. Young coniferous stands proved to be less resistant, and heavy losses were sustained in certain exposed plantations not over 25 years of age. In the case of young mixed stands, the conifers not infrequently were uprooted while the hardwoods remained standing. An analysis of the relationships between the composition and age of the stand and its susceptibility to wind-throw is being undertaken by Mr. Willett Rowlands, a student at the Forest.

There has been a heavy loss in merchantable and near-merchantable growing stock, and a severe setback in progress towards a uniform distribution of stand ages, upon which a plan of sustained yield management is largely dependent. The long succession of annual lumber harvests now comes abruptly to an end, and resumption at a level comparable with that attained in the past cannot be expected for two decades or more. The loss in future income from the sale of forest products adds to the problem of adequately financing the activities of the Forest.

On the other hand, the essential needs of field instruction and research in forestry may be met as well now as before the hurricane. Old problems may have been replaced to some extent by new; but, by and large, the general course of research in silviculture and allied subjects has not been affected. In many respects the excessive felling caused by the wind is fairly comparable to the overcutting associated with a good lumber market, a condition which existed in New England at the time of the World War. Thirty years of experience in dealing with the volunteer stands which follow clear cutting places the Forest in a position to be helpful in formulating policies of forest restoration in the hurricane area.

Heavy losses were also suffered by two of the Forest's outlying properties. The 20-acre tract of virgin timber on Pisgah Mountain in Winchester, New Hampshire, was blown down, with the exception of a few scattered trees. Since the purpose of acquiring this remnant of old forest was to study the course of nature when undisturbed by human influences, no salvage was undertaken. Even in their prostrate form these veteran trees, with their huge upturned roots and boles nearly 150 feet long, make an impressive scene seldom witnessed before in this section of New England. The usefulness of this tract for the purposes intended has by no means been destroyed.

The Schwarz Tract of 45 acres, situated in the western part of Petersham and given to the Forest for demonstrating adaptations of forestry to landscape architecture, met a similar fate. The entire growing stock of timber was of rather poor quality, having originated on an abandoned farm, and only a part of it proved worth salvaging. The income from an endowment established by the late G. F. Schwarz will permit the gradual re-establishment of a forest on the area and the resumption of work provided for by the donor.

Good progress was made in the preparation of the report on the first thirty years of forest experiments at the Forest. An appeal for contributions toward a fund of \$2,500 to carry forward this work was sent out during the year. To date approximately one-third of the amount sought has been provided in the form of small gifts from numerous friends of the Forest. Sixty representative cases in the silvicultural treatment of stands have now been analyzed and made ready for incorporation in the report. Mr. Russell J. Lutz of the Forest staff and Mr. E. Arnold Hanson, a student at the Forest, are chiefly responsible for the recent progress. At the same time, records of current logging operations were kept up despite the fact that salvage was carried on in 170 different stands.

In continuation of work under the Maria Moors Cabot Foundation for Botanical Research, Professor P. R. Gast started a second nursery test of white pine. The seeds for these tests were gathered over a wide range. The first nursery contains plants from an intensive sampling of pine trees in the vicinity of Petersham. Growth data at the end of the first summer indicated that stands of trees in this area do not vary in the average growth-rate transmitted to their offspring. Individual trees within a stand, however, differ markedly in departures from the average. Continued observation will be necessary to demonstrate reliably the existence of individuals from which superior strains can be bred. Of the parent trees one-quarter survived the hurricane in two out of five stands. Although the plan of work will have to be changed in detail, the general program will not be seriously impaired.

Dr. Hugh M. Raup, of the Arnold Arboretum, and his assistant, Mr. Reynold E. Carlson, a graduate student in the Department of Economics, brought to completion the study of the land-use history of the Petersham properties of the Forest. This knowledge of the character of the original forests and of successive plant

communities as influenced by various kinds of land occupancy and use will be helpful in guiding the development of the new stands replacing those destroyed by the hurricane.

The Forest has continued its participation in the Seminar in Agricultural Forestry and Land-Use Policy, conducted by Professor John D. Black as a part of the Graduate School of Public Administration, and two of the candidates for the Master of Forestry degree, Messrs. K. E. Barraclough and John M. Chandler, undertook specialization in the field of forest economics. It has also continued the contribution of time of its staff members towards the completion of the Worcester County Land-Use Planning Project, begun in the fall of 1937 by the University in coöperation with several public agencies. The woodlands of 113 selected farms distributed throughout ten sample towns have now been analyzed.

Another fruitful development which grew out of the Forest's participation in the Land-Use Seminar was a Forest and Soils Conference convened at Petersham in June. Earlier in the year Professor Black had sponsored a seminar session in which soils workers and foresters took part. The interest thus stimulated was used by Professor Gast to arrange for a larger group meeting. Definite suggestions for correlative studies were made, and work has started at several experimental forests in the Northeast, including the Harvard Forest. The joint study of the results by foresters and soil surveyors will lead to a better appreciation of the other's technical methods and a distinct advance in the planning of forest management.

Studies undertaken by students at the Forest and not already referred to were "A Study of White Ash with Particular Reference to the Habit of Branching" by Jonathan W. Wright and "The Effect of Frost on the Establishment of White Ash" by Lewis C. Swain.

The oak and poplar sample plots used by members of the Division of Forest Insects of the U. S. Bureau of Entomology and Plant Quarantine in studies of the feeding habits of the gypsy moth were destroyed by the hurricane, but it has since been possible to find suitable new locations in the forest and to continue the experiments without loss of time. New coöperative studies between the Division and the Forest were initiated during the year. A recently developed concentrated spray has been applied on an experimental basis to test its effectiveness in controlling the white pine weevil (*Pissodes strobi* Peck) and the Pales weevil (*Hylobius pales* Herbst).

Portions of young pine stands in the forest were devoted to this test. The Division of Forest Insects, the Northeastern Timber Salvage Administration and the Forest jointly undertook an experiment in spraying logs to determine the effectiveness of various chemicals in preventing attack by bark beetles and wood borers. Some 1650 logs from the forest were used in making the tests. Final results have not been determined, but the indications are that none of the sprays was more than moderately effective in preventing the entrance of insects.

Two more of the Harvard Forest Models were finished during the year. The entire series is now approaching completion, and the Forest staff is looking forward eagerly to the time when the donor's plan to house them in a forest museum at Petersham will be consummated.

The financial situation has been rendered more critical as a result of losses sustained through the hurricane. During the year efforts were made through a general appeal for funds to increase the Forest's endowment and to supplement the resources available for current use. The final portion of the generous gift by an anonymous donor for a three-year period, 1936-39, was available for use in helping meet the extraordinarily heavy expenditures of the emergency. In the coming year the lack of such a substantial sum and of further income from timber sales will force drastic economies and a sharp curtailment in the activities of the Forest. Efforts to raise the needed additional funds are being continued. The total amount received as gifts not already referred to, except the response to the general appeal, was \$3,935.

Changes in the staff during the year were the retirement of Mr. Ward Shepard as Director as of September 1, 1939, the appointment of Mr. A. C. Cline as Director as of December 1, and the appointment of Mr. Russell J. Lutz as Instructor in Forestry and Assistant to the Director.

A. C. CLINE, *Director*

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Harvard Forest

TO THE PRESIDENT OF THE UNIVERSITY:

SIR, — As regards work in the Forest itself, the year was devoted chiefly to a continuation of the laborious task of removing trees felled by the hurricane of 1938 and in other ways putting the forest growing stock and land in satisfactory condition for resuming the program of experimentation in silviculture which now has been under way for thirty-two years.

Additional deliveries of logs to the Northeastern Timber Salvage Administration brought the total income from salvage sales, of logs and stumpage, to \$55,458.21. This represents a total volume of approximately 5,500,000 board feet, or roughly three-fourths of the merchantable timber in the Forest before the hurricane. Of all the logs sold to the Administration, which comprise four-fifths of the entire volume salvaged, 90 per cent were white pine, 6 per cent hemlock, and 4 per cent hardwood. The profit on the salvage operations, based on the income from the sale of logs and on those expenses for labor, machinery, and supervision involved in actual logging operations, was \$4,268.70. Stumpage sales netted an additional \$2,094.10. However, when other expenses connected with the hurricane are included, such as slash burning, forest fire patrol, and that portion of staff salaries and transportation chargeable to the hurricane emergency, the outcome is a loss rather than a profit.

With the completion of logging operations, in the fall of 1939, concentration of effort was shifted to salvaging part of the large quantity of wind-thrown hardwoods of below sawtimber size and quality. Over 500 cords of fuelwood were cut by our woods crew, and numerous small sales of cordwood stumpage were made to local people. In a few instances, wood was given away in return for clearing the ground. At the same time, the woods crew piled and burned slash in those portions of the Forest where especially valuable young stands were surrounded by highly inflammable material. Particular attention was given that section lying between Harvard Pond and Petersham Village, which contains a large share of the young stands in which the most interesting and significant experiments in silviculture have been conducted. Most fortunately, these young stands, developed from the start under scientific treatment, escaped without appreciable loss. As a further means

of reducing the fire hazard in the Forest, the continued work of the local Civilian Conservation Corps camp and the special D.A. (Department of Agriculture) camps has been very effective and greatly appreciated. Crews of young men from these organizations disposed of slash in many parts of the Forest where fire hazard was high. These crews also were readily available for assistance in suppressing forest fires. The Commonwealth has erected a new steel fire tower on Prospect Hill, a part of the Forest, to replace the one blown down by the hurricane. Fortunately, there have been no serious fires as yet, and every effort is being made to prevent future losses from this cause.

Another task in forest rehabilitation, recently begun, is the felling of leaning trees in our young coniferous plantations. Outwardly, the plantations appear to have escaped damage by the hurricane, but in most instances more or less blow-down occurred in the interior portions. By cutting partially uprooted trees and lopping their branches, the neighboring trees supporting them are relieved, fire hazard is reduced, and decay of the damaged trees hastened.

Another effect of the hurricane was the dislocation of iron pipes, set along all the compartment boundaries and used as reference points in the establishment of experimental plots. They have been reestablished, where necessary, throughout the Tom Swamp Block.

On the whole, conditions in the Forest at the end of the year were vastly better than could be foreseen in the days immediately following the hurricane. While most of the merchantable timber was lost, thus forcing the temporary abandonment of sustained yield cuttings, the bulk of the stands of greatest usefulness from an experimental standpoint were spared. Furthermore, the blow-down areas are rapidly restocking with satisfactory volunteer reproduction, which will provide us with abundant opportunities for advancing the art of forest weeding, in which the Forest has for many years taken the leadership. Because natural regeneration on these areas is so promising and because the Forest already contains so many cases of clear cutting followed by the planting of conifers, the raising of coniferous planting stock in the nursery has been discontinued.

The impossibility of harvesting any major products for a number of years to come has lessened interest in growing timber, per se, under a plan of sustained yield management, and has served to

lend more weight to experimentation in the methodology of silviculture. The latter, in the opinion of the writer, promises to be of greater value than a demonstration of sustained yield management, which unavoidably comes to depend more and more upon routine cultural treatments, with a corresponding reduction in outright experimentation.

The destruction or disturbance by the hurricane of many experimental plots and stands of special interest, for which detailed records of treatment were being kept, necessitated field inspections and the preparation of reports on present conditions. This task is well under way and will be completed in the fall of 1940.

During the year an important memorandum was prepared for the Committee appointed by the Board of Overseers to visit the Forest. Its title was "The Harvard Forest: Its Present Status and a Proposed Plan of Work Thereunder." The following paragraphs, concerning instruction and research, are taken from the Introduction to this memorandum.

Since instruction in forestry was first offered at Harvard in 1903, the work has taken several different forms. Over these thirty-six years continuous readjustments have been made to accommodate the program to the rapid development of forestry education and the ever increasing activities of public forestry agencies.

In the early years of forestry in this country the Harvard Forest was able to do effective pioneering in a number of fields, and the results of research by staff and students contributed to the understanding of many problems which were receiving little or no attention elsewhere. These contributions were the result of insight and imagination, and a flexible research program which permitted following promising leads and required facilities which were relatively crude. But with the enormous increase in the body of knowledge pertaining to forestry which had taken place within the past fifteen years, research is becoming increasingly refined and specialized. It is no longer possible for the small group of workers at Petersham effectively to undertake as diversified a program of research as was once the case.

The time again has come to readjust the work plan of the Forest with a view toward fixing more definitely upon those activities in which the greatest contributions can be made. The decision to concentrate in silviculture and a certain few of the underlying sciences arises only in part from a traditional interest and special fitness in those branches of the field of forestry. It arises also and gains strength from the conviction that there is a need in the forestry profession for more effective training in biology. Throughout the vast network of forestry activities in this country, there are marked weaknesses attributable to inadequate groundings in biology. There evidently is only partial recognition of the fact that, although forestry may need more able administrators and is impeded by economic

factors, yet there can be no sound forestry practice without the biological base. It is this element in the structure which the Forest staff aims to provide in the training of students coming to Petersham.

The Harvard Forest can assist in the development of forest administrators and specialists in land use planning through continued participation in the agricultural economics and land use work of the Graduate School of Public Administration. It can provide students who contemplate a career in such fields with a better understanding of the laws of biology as they relate to forests and thus help develop within our public forestry agencies a more realistic comprehension of the nature of the living material with which they are dealing. Those with a forestry training background can in turn acquaint themselves with the economic relationships conditioning practical forest operations, either private or public.

Thus, it is expected that more definite concentration in those subjects which the present Forest staff is most competent to deal with will assure more satisfactory results from the standpoint of both student and teacher and strengthen the position of the Forest in many ways.

On account of the extra burden imposed upon the staff by the hurricane, no new students were accepted for residence at Petersham for the year. Mr. Willett Rowlands completed his study of the relationship of wind-throw to the age and composition of the stand. Mr. K. E. Barraclough, whose major work was taken in the Department of Economics, completed his thesis dealing with forestry coöperative organizations.

Under the genetics program of the Maria Moors Cabot Foundation for Botanical Research, two important timber species, white pine and white ash, are being cultivated. In two nurseries there are now growing about 80,000 white pine seedlings. These represent two sorts of seed collections: an intensive series of samples from the vicinity of Petersham and an extensive series from the full range of white pine. By a method found valid for Scots pine, the white pines have been examined for differences in cold weather hardiness. This is a factor of great importance in a practical breeding program. In Scots pine there occur strains which exhibit increasing cold hardiness according to the latitude and the altitude of the parent trees. No evidence of equally narrow discrimination could be found in white pine. Observations on nutrition, mycorrhizae, and such correlative studies were continued as necessary adjuncts to the breeding program. In all these tasks Dr. Gast was assisted by Mr. E. A. Snow and Mr. P. F. Faunce. Through the kindness of numerous coöperators, a collection of samples of seeds

from ash trees over a wide range of sites was obtained. As in the case of Scots pine, ash is apparently quite sensitive to climatic influences, and the identification of races hardy in a given locality is important. The study of the taxonomy of this collection was undertaken by Mr. Jonathan Wright, a graduate student.

As a complementary investigation on white pine, a project was undertaken in coöperation with the Metropolitan (Boston) District Water Supply Commission. It is planned to choose the fastest growing from among the seedlings being raised by the Commission for planting on the Quabbin Reservoir watershed. This requires a periodic sorting of the plants, in order to correct for variation in plant size — the capital — at the beginning of the next period of growth. In this way the plants showing the greatest relative growth can be selected easily. An initial sorting of seeds according to weight is helpful; and sixty pounds were sorted for the Quabbin nursery by equipment devised at the Forest. Should the program succeed, there will result a final collection of élite white pine stock invaluable for propagation, as well as a verification of theses fundamental to a planned program of breeding.

The Forest continued its participation in the Worcester County Land Use Planning Project, a joint undertaking by several federal agencies, Massachusetts State College, and the University. Mr. Gordon L. Chute, representing the U. S. Forest Service, was stationed at the Forest during the year. Field work has been completed, and the data are being analyzed with a view towards publication of the findings.

Through coöperation with the Division of Soil Survey of the U. S. Bureau of Plant Industry, intensive mapping of the soils of the three main tracts of the Forest was begun. A map and report for the Tom Swamp Block will be completed by the end of the 1940 field season. Information already made available has been of great value in determining the stand composition to favor on certain of the blow-down areas.

Coöperative research projects shared with the Division of Forest Insects of the U. S. Bureau of Entomology and Plant Quarantine and the Division of Forest Pathology of the Bureau of Plant Industry were continued. These include a long-term study of the food habits of the gypsy moth in relation to environmental factors, the testing of a highly concentrated poison spray for use in controlling the white pine weevil and the Pales weevil, observations on the life history of certain wood borers attacking white pine logs,

and a study of the occurrence and damage caused by a canker (*Cytospora* sp.) found on Norway spruce.

The entire record system is being improved and brought up to date. This has been facilitated by the use of new forms. To the Stand Treatment file, which contains separate records of treatment for each stand in the Forest, is being added a "Cumulative Stand Record" sheet, and a "Stand Inspection" sheet showing the condition of the stand after hurricane clean-up has been completed. The Research file is being reorganized, and all old sample plots are being abandoned or continued, as conditions dictate. In the case of forced abandonment, as much information as possible is secured through observations and measurements of the fallen trees. A complete duplicate record file is being made up for the use of students and others who desire to take records into the field for reference.

As time permitted, work was continued on the report of the first thirty years of experimentation in silviculture in the Forest. The number of cases to be published has now been reduced to fifty. These represent the full range of silvicultural treatments applied since the Forest was acquired, and great care has been taken in the interpretation of the results of treatment thus far obtained.

Of outstanding importance to the future of the Forest was the receipt during the year of a most munificent gift from a generous friend. It provides for the construction of two new buildings at Petersham. One, to be known as Shaler Hall, will take the place of the present headquarters building and will contain offices, laboratories, library, and living quarters for students. The other will be known as Fisher Museum, and it is especially designed for the display of the twenty-three Harvard Forest models. A third building, a sixteen-car garage, was provided by the same donor in the previous year and already is in use. The construction of Shaler Hall and Fisher Museum was begun on June 11.

Other gifts received during the year amounted in all to \$3,093.29. In several instances these were from friends of long standing who have been most generous and faithful in their support of the Forest. The Forest is especially indebted to Mr. T. Catesby Jones, a summer resident of Petersham, for his invaluable assistance in raising funds to help meet urgent current needs.

The Forest also was favored by the construction of a much-needed new state highway through the Slab City Tract, better known as the Barre Woods. Despite the loss of trees by the hurri-

cane, this will remain one of the most attractive drives in this part of the state; furthermore, such an improved highway will greatly increase the number of visitors to Petersham and the Forest. Large sales of gravel to the contractor have been agreed upon, and the income from these will substantially aid the Forest in meeting its expenses during the coming fiscal year.

A. C. CLINE, *Director*