



THE HARVARD FOREST, 1967-68

Harvard University



Frontispiece: Cross section from the basal part of a 98-foot-tall white pine which commenced growth at the Harvard Pisgah Tract shortly after 1665 and was blown down in the hurricane of 1938.

Magnification x 4.5

H A R V A R D F O R E S T

H A R V A R D B L A C K R O C K F O R E S T

Annual Report.....1967-1968

STAFF

The staff of the Harvard Forest during the year of 1967-68 consisted of the following persons:

Hugh M. Raup, Director (until September 1967)
Ernest M. Gould, Jr., Forest Economist
Walter H. Lyford, Soil Scientist
J. Mark A. Swan, Research Fellow (Harvard and Black Rock Forest)
Richard A. Howard, Research Fellow (until September 1967)
Jack J. Karnig, Forest Manager (Harvard and Black Rock Forest)
Charles F. Upham, Woods Superintendent
Barbara M. Kelley, Business Secretary and Librarian
Julia W. Savage, Secretarial Assistant
Vibeke Holm, Assistant to the Librarian

The staff of the Cabot Foundation, working at the Harvard Forest, during the year of 1967-68 consisted of the following:

Martin H. Zimmermann, Forest Physiologist
Brayton F. Wilson, Forest Botanist (until September 1967)
Philip R. Morey, Forest Botanist
P. B. Tomlinson, Forest Anatomist (Joint Appointment with
Fairchild Tropical Garden, Miami, Florida)
A. Malcolm Gill, Research Fellow
Barbara M. McCurda, Secretary

The most important of the changes in staff during the past year has been the retirement of Dr. Hugh M. Raup as Charles Bullard Professor of Forestry and Director of the Harvard Forest, on September 1, 1967. He moved to Baltimore, Maryland, where he is now Visiting Professor

at the Isaiah Bowman Department of Geography at The Johns Hopkins University. Dr. Raup has been associated with Harvard University for 35 years, and has been Director of the Harvard Forest since 1946. This is perhaps a good place to express the appreciation of us all, present as well as past members of staff and students. We all treasure the memories of the past years when Dr. Raup was with us in Petersham and miss both him and Mrs. Raup very much. A search committee to find a new director has been formed by Dr. Franklin L. Ford, Dean of the Faculty of Arts & Sciences, under the Chairmanship of Professor John G. Torrey of the Department of Biology (the Director of the Cabot Foundation). The administrative duties are being carried out during the interim period by myself until October 1, and by Dr. Ernest M. Gould, Jr. from October 1, 1968, while I am taking a sabbatical leave for 10 months in Zürich, Switzerland.

Mr. Richard A. Howard left us in September 1967 to take up graduate work leading toward a Ph.D. at the University of Massachusetts. Changes in staff also include the departure of Dr. Brayton F. Wilson, who left the staff of the Cabot Foundation to take up a new position at the University of Massachusetts in Amherst. He has been replaced by Dr. Philip R. Morey who arrived in the early summer of 1967.

GRADUATE STUDENTS

Three graduate students were in residence during the period covered by this report: Mr. J. David Henry spent the summer of 1967 and two semesters here to obtain his Master's degree in Forest Science, which was awarded to him in June 1968. Mr. A. Jon Cassista continued his work (under the auspices of the Cabot Foundation) towards a Ph.D. in Biology. Mr. Melvin T. Tyree arrived here on June 8, 1968 after having received his B.S. degree from Pomona College in California, to spend the summer doing research under Cabot Foundation auspices. He will leave in September to begin a Ph.D. program with Professor Jack Dainty at the University of East Anglia in Norwich, England, with a Fulbright Fellowship.

BULLARD FELLOWS

Dr. Vera Gregorič, Assistant in the Biotechnical Faculty of the University of Ljubljana, Yugoslavia, arrived here on June 12, 1967 and left on September 14, 1967. During her stay here she was studying geology and soils of the northeastern United States with Mr. Lyford.

Dr. Bertram Husch, Chief of the Resource Surveys Section, Forestry and Forest Industries Division of F.A.O., arrived here on July 8, 1967 from Rome, Italy, and left again on June 11, 1968. He wrote to Professor J. D. Montgomery, Secretary to the Bullard Fellowship Committee, on July 1, 1968, "I believe this year has been one of the most satisfying and intellectually profitable of my professional career. It represented a rejuvenation of spirit as well as providing time for reflection, catching up on technical advances and writing. I was able to achieve the goals which I had set for the year; namely, a revision and modernization, with my collaborators, of my textbook on forest measurements, an understanding of the recent advances in linear and dynamic programming, simulation, model building and operations research and attendance at a course in economic development at Cambridge."

Mr. John Naysmith from the Canadian Department of Indian Affairs and Northern Development is a Bullard Fellow who worked in Cambridge, but spent a good deal of time with Dr. Gould at the Harvard Forest. He is the first one to use the year to work for a Master of Forest Science degree at the Forest.

Dr. Søren Ødum, Dendrologist of the Royal Veterinary & Agricultural College of Copenhagen, arrived here on July 1, 1967 to study the distribution of native woody species in eastern North America. He left here on June 2, 1968 to collect tree seeds and herbarium specimens in the western United States, including Alaska. He departed from Anchorage, Alaska on August 7, 1968 for Denmark.

Dr. Thomas O. Perry, Associate Professor of the School of Forestry at North Carolina State University, Raleigh, North Carolina, arrived here on September 1, 1967 and left in August 1968. While here, he worked on a manuscript for a textbook of forestry for college juniors. The book will be concerned with methods foresters can use to increase productivity, e.g. selection of genotypes and the manipulation of the environment. In addition to completing about 150 pages of text and illustration for this book, Dr. Perry wrote four papers, including a review article on "Dormancy in Trees."

Mr. T. Bruce A. Yerke, Station Librarian at the U.S. Forest Service Experiment Station in Berkeley, California, spent most of his time at the Widener Library in Cambridge. However, he made several visits at the Harvard Forest to discuss information storage and retrieval problems with members of the staff.

Dr. Robert C. Zimmermann was a Bullard Fellow jointly supported by the Cabot Foundation and the Harvard Black Rock Forest. He finished an extensive piece of work, begun many years ago by the late Dr. John C. Goodlett, to accurately map the ranges of key hardwood species in New England.

VISITORS

A great number of scientists from all over the world have again visited the Harvard Forest for shorter or longer periods, to discuss research with staff members. To list all of them would take too much space. We might, however, mention Dr. Edwin W. Mogren, Professor of Forest Science from the Colorado State University in Fort Collins, who used the Harvard Forest as a base of operations for his study of forest research and management in the northeastern United States during the summer of 1968.

The meeting of the northeastern forest economists again brought about 16 men to the Forest for two days in the fall. This annual event is becoming well known throughout the region and eastern Canada. The Canadian Chief of the Division of Economics attended, and this year has asked the group to visit Canada for its meeting.

As in preceding years, the Forest was host to many students. A group of graduate students of landscape architecture from the Harvard Graduate School of Design spent a few days at the Forest in September studying natural environments in the Forest and its vicinity, working with Dr. Gould. Many groups from neighboring forestry schools spent a day or two at the Forest.

The museum had numerous visitors, individuals as well as groups, many of which were taken on field trips by members of the staff.

RESEARCH

Dr. Gould's main activities for the year centered on the concluding phases of his project on planning the production of timber and landscape amenity. The grant supporting this work expired on January 1, and the final report to the U. S. Forest Service should be ready for publication sometime during the fall or winter 1968. Several interesting areas of research suggested by this report will hopefully be followed later. Mr. Richard A. Howard who collaborated with Dr. Gould in this project as a computer programmer, still gives him a few days of assistance while working in Amherst. The presence of Mr. John Naysmith offered an opportunity to test the new planning procedures on the real problem of initiating steps to develop the Yukon Territory. Dr. Gould also received several invitations for lectures and consultation visits. Cooperative research on the use of computers in forest planning has continued with

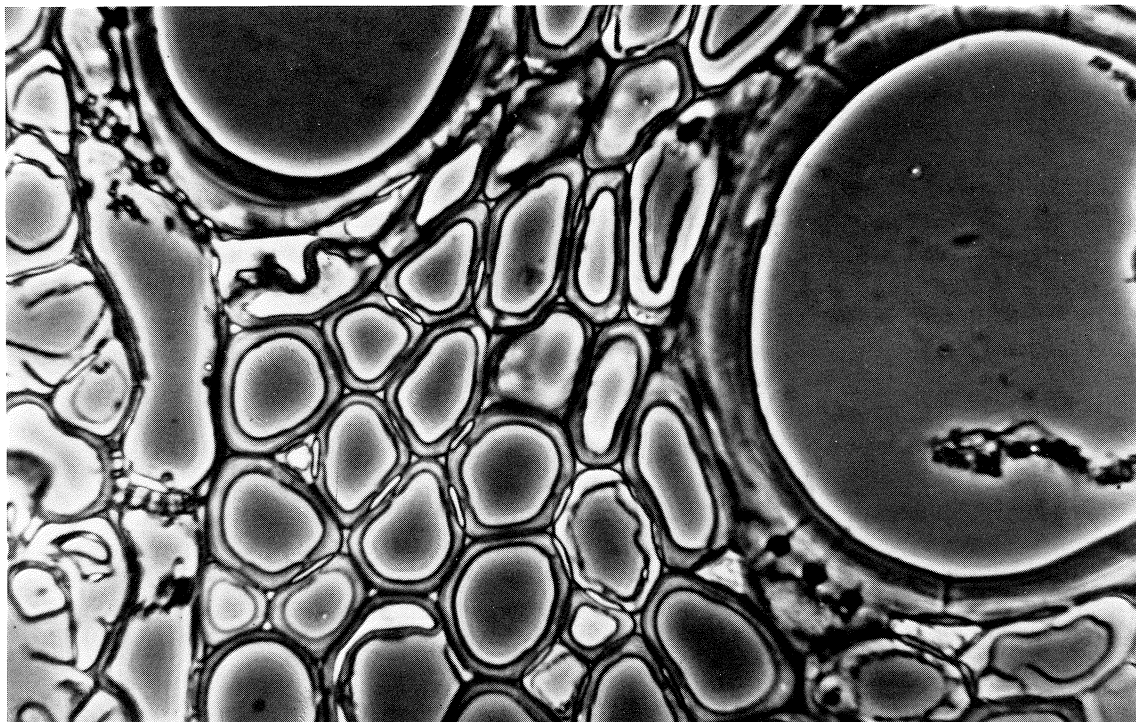
Dr. William G. O'Regan at the U. S. Forest Service Experiment Station in Berkeley, California.

For several years, Mr. Lyford has grown red maple roots on mature trees in root cellars ("rhizotrons"). During the past year red oak, sugar maple, yellow birch, trembling aspen, and white ash roots were also grown successfully. Detailed measurements of some of the roots were made to determine the parameters most useful for evaluating health. Preliminary work was started on three rather long-term projects: (1), soil morphology-root distribution at the Harvard Forest; (2), mortality and decay of forest trees, a joint study with Dr. D. W. MacLean, Canadian Department of Forestry and Rural Development, centered mostly in Canada; (3), weathering of surficial deposits in New England with special attention to transformation and translocation of iron and manganese by biological agencies, a joint study with F. Pessl of the U. S. Geological Survey.

Few direct ecological studies of vegetational change over long periods of time have been conducted because of obvious practical difficulties of measurement. Mr. J. David Henry has reconstructed forest growth and change over the last 300 years on a one-tenth acre plot of the Pisgah Tract in southern New Hampshire. He pieced this story together from a detailed examination of wood fragments, microtopography and stem locations on the plot, a method first used by Dr. Earl Stephens at the Harvard Forest in 1952. From the analysis of wood fragments buried in the forest floor, he and Dr. Swan are presently identifying the species of the larger stems that were in the forest before 1650.

Dr. Swan is conducting another study of vegetational change over time. He aims to find out how an extensive floating mat, largely composed of ericaceous shrubs and sphagnum moss, has formed at the northern margin of the Harvard Pond since the time the pond was made in the latter part of the 19th century. Dr. Swan is also currently working on methods of analyzing vegetational patterns in the field to search for consistent and therefore predictable relationships between species behaviours and their environment.

The primary purpose of the Maria Moors Cabot Foundation for Botanical Research is "to increase the capacity of the Earth to produce fuel by the growth of trees and other plants." In order to improve the growth of trees one has to learn how trees grow. Cabot Foundation activities, therefore, all center around the physiology of tree growth. Dr. Morey's research concerns the effect of plant growth regulators on the development of woody tissues in hardwood seedlings. Another of his projects is the study of the structure and microchemical nature of woody tissue preserved in fossil material. He found that lignin and cellulose are present in a lignite of Oligocene derivation.



Well-preserved hardwood specimen from Griffin Hill peat, about 10,000 years old. Magnification x 930

Photomicrograph by P.R. Morey

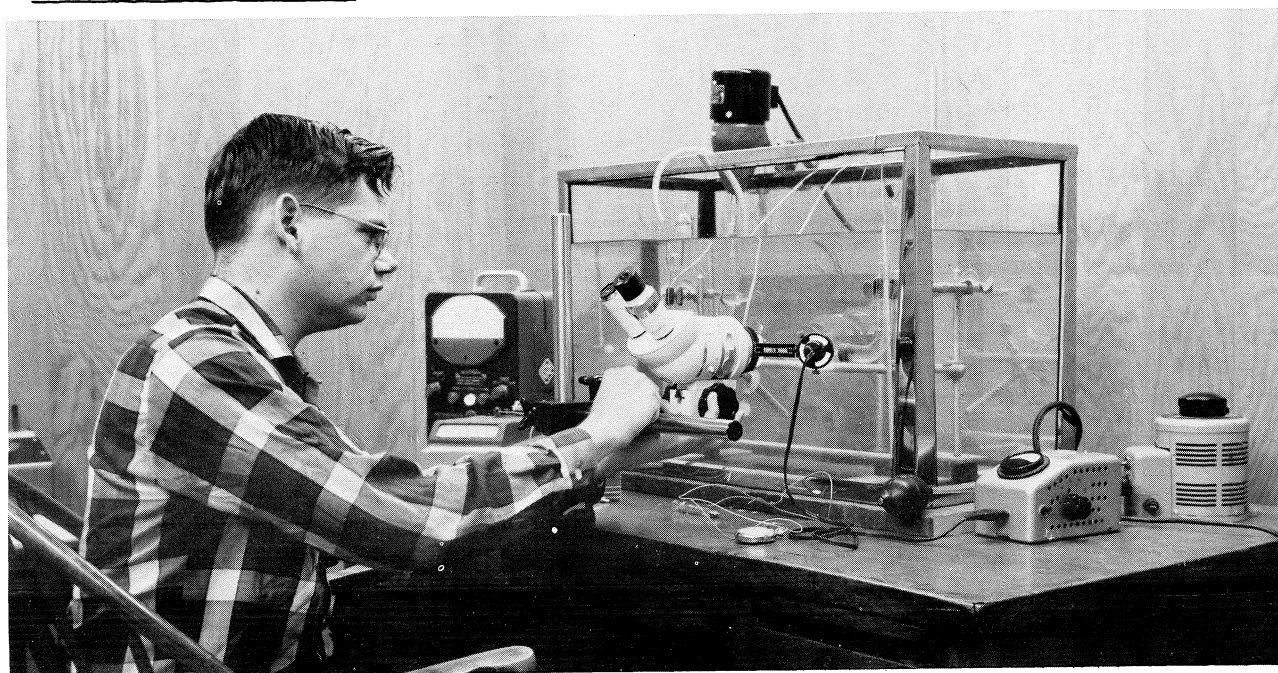
Dr. Gill continued his studies of the growth, morphology and development of shoot and root systems of white ash (Fraxinus americana L.). Root system studies have been extended to the aerial roots of trees of a Puerto Rican elfin woodland and of the Florida mangroves. A survey of patterns of bud distribution and shoot growth of the woody plants of the Forest is also under way.

Mr. Cassista's thesis project concerns the initiation and regulation of cambial activity. Few investigators attempt to attack this problem with fully grown trees. Seedlings are mostly used for ease of handling and uniformity of experimental material. Mr. Cassista approaches the problem mostly by girdling tall trees and sampling the cambium below the girdle for anatomical growth analysis and chemical analysis of growth regulators in various positions so that places of different intensities of growth can be compared.

Dr. Tomlinson's research, carried out in collaboration with myself, concerns the vascular anatomy of monocotyledonous trees. This turned out to be a badly neglected field of endeavor, for quite obvious reasons: it is a microscopic problem on an enormous scale. Special methods of investigation had to be developed specifically for the problem, and the results obtained

during the past four years have been quite remarkable. The basic principle of vascularization in palms and its development have been discovered. The extension of the work to other monocotyledons suggests that these principles apply to monocotyledons in general. One of the devices we developed for this study, the shuttle microscope, is now used in many other fields in botany, zoology, paleontology and medicine (neuroanatomy in particular) (see the paper by Zimmermann & Tomlinson in Science 152: 72-73. 1966). Another device, a continuous-advance microtome clamp, has been perfected during the past year. It permits continuous photography of sequentially cut surfaces of the specimen. This method has already yielded valuable information not only about palms, but also on the three-dimensional distribution of vessels in wood, an aspect of wood anatomy about which very little is known. Dr. Tomlinson spends a few weeks at the Harvard Forest every year.

Problems of translocation of water and nutrients are of crucial importance for tree growth. We have to visualize that all the carbohydrates making up the tree trunk are produced in the leaves and have to be transported to the stem before they can be used for growth. Two translocation problems are under investigation at the Harvard Forest. Mr. Tyree continues a study on which he worked with Prof. David Fensom of Mt. Allison University in Sackville, New Brunswick, for several summers. He is testing the Onsager equations for steady state thermodynamics. With these it is possible to describe for the first time the inter-relation of the various forces (hydrodynamic, electric, etc.) acting upon the flow of solutes through a tree. Another project is a clever application of these equations: when a D.C.



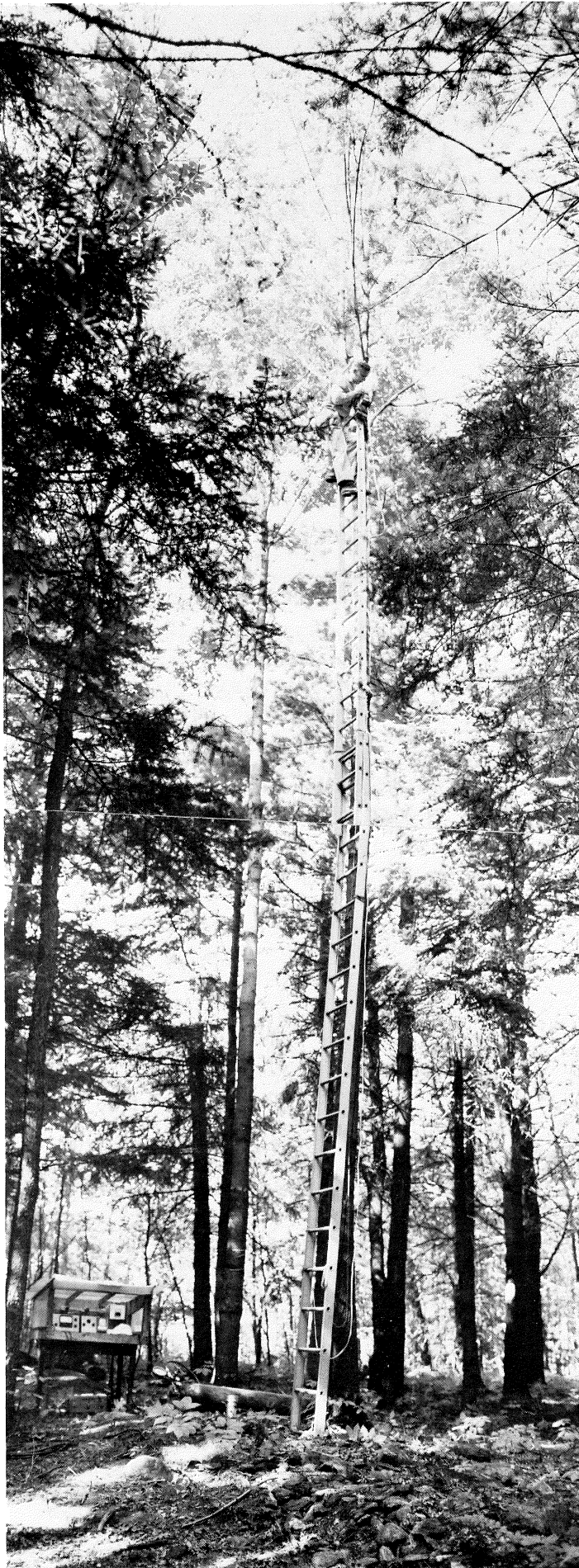
Mel Tyree measuring cross coefficients of Onsager equation with a piece of red maple in his electro-osmometer.

voltage is applied at two points to the xylem of a tree alternately in two directions, a difference in electrical currents can be found if the tree is transpiring, i.e. if the current alternately has to go against and with the flow of water. The current difference is proportional to the water flux and to the pressure gradient. His present aim is to calibrate this electrical measurement of water flux with cut stems.

My main research project has, for many years, centered around the translocation of carbohydrates from leaves to stem and roots. In most trees the bulk of carbohydrate is transported in the form of sucrose. In white ash (*Fraxinus americana* L.) there are three major translocation sugars, sucrose, raffinose and stachyose, and even a sugar alcohol, D-mannitol. This makes many interesting experiments possible. The ratio of the various sugars changes slightly throughout each 24-hour period. The resulting "ratio wave" (for example conc. sucrose/conc. stachyose) can be tracked on its way down along the trunk, thus yielding a figure of the translocation velocity as well as the quantity of sugar moved.

At the Black Rock Forest, Mr. Karnig and Mr. Lyford completed a study on oak mortality in the Hudson Highlands caused by drought. Another study, by Mr. Karnig and Prof. B. B. Stout of the School of Forestry at Rutgers (the former manager of the Black Rock Forest), on the growth of northern red oak following understory control has also been finished. Data and photographs are being accumulated on all aesthetic thinnings installed since 1964 in an attempt to document this phase of cutting at the Black Rock Forest.

A "ratio-wave" experiment



FOREST OPERATIONS

Harvard Forest in Petersham. Experimental cutting activities have been concentrated on one 15-acre area in Compartment IV of the Tom Swamp Tract. Two degrees of thinning-and-improvement-cutting were made, leaving the best trees to grow into sawtimber. On the north half of the area 40 percent of the volume was cut, and on the south portion 60 percent was removed. Both cuttings greatly increased visibility through the residual stand and on the advice of our landscape architect friends we have set out to preserve this attraction by spraying sprouts with herbicides. Without some such control the view is likely to be obscured in a year or two. An unsprayed plot has been set out as a check. Total fuelwood production from this area during the past year was 220.75 cords.

A small number of logs were cut and sawed in the Forest mill during the year to produce slightly more than three thousand board feet. Some large sales of lumber reduced our inventory from 26 to 12 thousand board feet.

Forest operations for aesthetic purposes. Opening a "window" onto Brooks Pond, Tom Swamp Tract. Left before, right after cutting.





The new office building at the Harvard Black Rock Forest with living quarters on the upper level.

Black Rock Forest. General maintenance included building improvement work as well as road and trail clearing throughout the property. Road work has been made necessary particularly by a storm in April, 1968, during which 5 inches of rain fell and caused considerable damage to roads. Because of budget limitations, some of the repair work will have to be spread over the next two or three years.

Two aesthetic thinnings were installed and a new scenic trail was improved. Recreational use of the forest is on the increase and guided tours have become quite popular. Hunting and fishing rights are enjoyed exclusively by the Black Rock Fish and Game Club of Cornwall. This club does not pay for these privileges, but its large membership serves as a reserve force in the case of forest fires. This past April a forest fire did break out on our property and burned about ten acres before it could be stopped by the local fire departments, Conservation Department personnel and members of the above-mentioned club.

Contract logging has been carried out at three different locations during the past year. Ten cords of fuelwood were cut in Compartments XVI and XV. Another oak stand is marked for thinning in Compartment VII adjacent to the White Oak Road. The wood is being stockpiled in our shed for fall delivery to local customers.



1913

We recently obtained from Mr. Jesse Dennison a number of photographs taken by him in 1913 within the Harvard Black Rock Forest. The view above shows maneuvers by U.S. Military Academy cadets from West Point. The picture below shows the same view of Continental Road today.



1968

SWIFT RIVER VALLEY TRUST

During the last year the four landowners of contiguous areas in the Swift River Valley in Petersham formed the Swift River Valley Trust. The trust was signed by a representative from each of the following organizations: the James W. Brook Wildlife Sanctuary, Harvard University (the Harvard Forest), the Massachusetts Audubon Society and the Worcester Natural History Society. The land includes about 1000 acres of forest and fields along five miles of stream and is a good example of such attractive undeveloped outdoor environments in Central Massachusetts. The purpose of the Trust is to promote use of this area for scientific research and public education in various fields of biology, geology, forestry, conservation, etc. Only the Slab City Tract of the Harvard Forest is involved and this agreement will in no way limit present or future research projects, on the contrary, it is likely that all will gain by closer cooperation. One immediate goal is to restore Connor's Pond by rebuilding the dam which was damaged by the 1938 hurricane and the 1952 tornado.

Petersham, Massachusetts
August, 1968

Martin H. Zimmermann
Acting Director

PUBLICATIONS

The following articles have appeared in print during the fiscal year of 1967-1968:

- Gould, E. M. Jr. 1967. Simulation and Forestry. Proc. 14th IUFRO Congr. (Section 25), Munich 1967. 6: 96-104.
- Raup, H. M. 1967. American forest biology. J. Forestry 65: 800-803.
- Tomlinson, P. B. and M. H. Zimmermann 1967. The "wood" of monocotyledons. Bull. Internat. Assoc. of Wood Anatomists 1967/2: 4-24.
- Tomlinson, P. B. and M. H. Zimmermann 1968. Anatomy of the palm Rhapis excelsa, V. Inflorescence. J. Arnold Arb. 49: 291-306.
- Tomlinson, P. B. and M. H. Zimmermann 1968. Anatomy of the palm Rhapis excelsa, VI. Root and branch insertion. J. Arnold Arb. 49: 307-316.
- Wilson, Brayton F. 1967. Root growth around barriers. Bot. Gaz. 128: 79-82.
- Wilson, Brayton F. 1968. Effect of girdling on cambial activity in white pine. Can. J. Bot. 46: 141-146.
- Wilson, Brayton F. and Richard A. Howard 1968. A computer model for cambial activity. Forest Science 14: 77-90.
- Wilson, Brayton F. 1968. Red maple stump sprouts: Development the first year. Harvard Forest Paper No. 18, 1-10.
- Zimmermann, M. H. and P. B. Tomlinson 1967. A method for the analysis of the course of vessels in wood. Bull. Internat. Assoc. of Wood Anatomists 1967/1: 2-6.
- Zimmermann, M. H. 1967. Translocation of sugars and amino acids in relation to flowering in trees. Proc. 14th IUFRO Congr. (Section 22), Munich 1967. 3: 31-37.
- Zimmermann, M. H., A. B. Wardrop and P. B. Tomlinson 1968. Tension wood in aerial roots of Ficus benjamina L. Wood Sci. & Technol. 2: 95-104.