

THE HARVARD FOREST, 1969-70

Harvard University



Frontispiece: Ice accumulations on branches of a red pine (<u>Pinus</u> <u>resinosa</u> Ait.) during the Christmas ice storms. Additional illustrations appear on pages 8 and 9.

HARVARD FOREST

HARVARD BLACK ROCK FOREST

Annual Report.....1969-1970

STAFF

The staff of the Harvard Forest during the year of 1969-70 consisted of the following persons:

Martin H. Zimmermann, Acting Director (Sept. 1969 through June 1970) Ernest M. Gould, Jr., Forest Economist, Acting Director (through August 1969) Walter H. Lyford, Soil Scientist Hugh M. Raup, Bullard Professor of Forestry, Emeritus J. Mark A. Swan, Forest Ecologist (Harvard and Black Rock Forest) Jack J. Karnig, Forest Manager (Harvard and Black Rock Forest) Supporting personnel included: Barbara M. Kelley, Business Secretary and Librarian Catherine M. Danahar, Secretarial Assistant Vibeke Holm, Assistant to the Librarian Charles F. Upham, Woods Superintendent Gordon B. Mitchell, Woods Crew George T. Kenney, Woods Crew Edward H. Hyde, Woods Crew Theodore S. Walkama, Custodian Donald Mitchell, Assistant to the Manager of the Black Rock Forest

The staff of the Cabot Foundation, working at the Harvard Forest, during the year 1969-70 consisted of the following:

Martin H. Zimmermann, Forest Physiologist
P. B. Tomlinson, Forest Anatomist (Joint Appointment with Fairchild Tropical Garden, Miami, Florida)
Werner A. Iten, Research Fellow (from September 1969)
Philip R. Morey, Forest Botanist (through June 1970)
Jörg J. Sauter, Research Fellow (from February 1970)
Donald S. Skene, Research Fellow (through June 1970)
Barbara M. McCurda, Secretary Two staff members of the Cabot Foundation left, and two new ones arrived. Dr. Philip Morey left the Forest in June 1970. He moved to the Texas Tech University in Lubbock where he holds the position of Associate Professor of Biology. Dr. Donald Skene left the Forest on July 25, 1970 to take up the duties of Plant Anatomist at the East Malling Research Station in England.

The new staff members of the Cabot Foundation are Dr. Werner Iten of the Swiss Federal Institut of Technology, who arrived in September 1969, and Dr. J&rg Sauter of the University of Freiburg i. Br. (Germany), who arrived on February 1, 1970. Both of them plan to stay at the Forest for a period of two years.

Dr. Raup received an honorary D.Sc. degree from Wittenberg University in 1968. He spent another year as Visiting Professor at the Isaiah Bowman Department of Geography at the Johns Hopkins University. At the end of the spring semester (June 1970) he and Mrs. Raup moved to Petersham.

As usual, members of the staff gave lectures at various outside institutions. One of the important events of the year in which some staff members participated was the XI International Botanical Congress which was held in Seattle, Washington, in late August and early September 1969.

In February 1970, Mr. Karnig was elected to the position of Chairman of the New York Section, Society of American Foresters, for a two-year term. He will be representing New York State foresters at the 1970 and 1971 national conventions to be held in Las Vegas and Cleveland.

STUDENTS

Mr. Melvin T. Tyree spent another summer (1969) at the Forest to study electrical effects of the flow of sap through xylem. He is now at the University of Cambridge (England) working towards his PhD degree. During the past winter he spent a considerable amount of time in England on improving instrumentation for his Harvard Forest project, which he intends to continue in the future.

Because Petersham is an hour and a half drive from Cambridge it has been impracticable to involve Harvard students in a regular course of

Opposite page: The woods crew splitting firewood in Tom Swamp Tract II. Left to right on top illustration: Gordon Mitchell, George Kenney, Edward Hyde, Charles Upham.







field studies at the Harvard Forest during the normal school year. This past fall an innovation was tried when Dr. Gould and Mr. Lyford gave a course (Biol. 298) in "Soil, Land and Human Environment" during four weekends in October. A 12-passenger car was purchased by the Forest and 10 students were picked up in Cambridge early Saturday morning and returned there Sunday evening. Travel to and from Petersham was designed to study the regional setting and land-use problems, while at the Forest case studies were pursued in depth. Thus students and instructors enjoyed over 90 contact hours during October. During the rest of the semester the class met only once at the Forest but each student worked in Cambridge on a topic of his choosing and wrote a paper. The course appeared to be highly successful and will be given again this year.

As in the past, a group of first-year Landscape Architecture students from the Harvard Graduate School of Design spent a few days at the Forest in September to become familiar with the area's landscape, history and ecology.

During the fall term an experiment in cooperation with the University of Massachusetts was carried out. The Senior Seminar of the Department of Forestry and Wildlife Management held its first five meetings at the Harvard Forest. During the balance of the semester Dr. Gould attended their meetings in Amherst. This joint venture with Dr. Carlozzi of the University of Massachusetts seems to have been successful, and we hope for further cooperation with nearby institutions.

Mr. Richard H. Rosen completed his thesis on the Mineral King controversy and was awarded an MFS degree. Mrs. Linda Seale moved to the Forest in June 1970. She will work on the translocation of nitrogen into and out of leaves.

Three students were hired to help in various phases of research during the summer of 1970. Miss Carla Bloedel (Radcliffe, 1972) is doing microtechnique work for the investigation of monocotyledons and Miss Jane Difley (Connecticut College, 1971) helps with the study of sugar mobilization in trees. Both work in the Cabot Foundation Laboratories. Mr. Kenneth Carlson (Graduate student, University of Massachusetts) assists Dr. Gould, Dr. Swan and Mr. Lyford.

BULLARD FELLOWS

Dr. William B. Critchfield, who had arrived in March 1969, left about mid-October 1969. His work has been described in last year's annual report. Dr. Charles H. W. Foster was engaged in a special research project supported by a grant from Resources for the Future, entitled "Site Preservation in New England". In connection with this, a small conference of landowners and local officials was held at the Forest on May 15, 1970. In addition, Dr. Foster completed a special report, entitled "The Northfield Mountain Pumped Storage Project - Counterpoint to Con Ed" which appeared as Harvard Forest Paper No. 19. -- Dr. Foster's primary object while a Bullard Fellow was to study the feasibility of a privately-supported New England Natural Resources Center. This study resulted in the signing of a formal trust instrument establishing the Center as a legal entity as of June 19, 1970. Though Dr. Foster spent most of his time in the Boston area, he made frequent trips to the Forest where he collaborated closely with Dr. Gould.

Dr. Earl L. Stone, Professor of Forest Soils of Cornell University, arrived here September 1, 1969. He worked on a compilation of literature for a critical review of the forest's influence on soil development, with special emphasis on short-term changes. He also used the time to write two technical papers, worked on a book outline, and continued to serve as Editor of the Journal of Forest Science. He left the Harvard Forest early in July 1970 to spend part of July and August in Indonesia as advisor on soils research in the lowland rain forest under the BIOTROPE Program sponsored by the Smithsonian Institution.

VISITORS

From May 8th to 10th, 1970, the Harvard Forest was host to the New England Fern Conference, an informal meeting organized by Drs. Rolla and Alice Tryon of the Gray Herbarium of Harvard University. Papers and discussions concerned various aspects of the biology of ferns, ranging from taxonomy to the physiology of development. One afternoon was devoted to a field trip, even though the ferns had only begun to emerge from the forest soil. Judging from the enthusiastic response of the various participants, the conference was quite successful and might be repeated in the future.

Groups from various Forestry Schools spent a day or two on their field trips at the Forest, as they have in previous years. The Fisher Museum was visited by about 60 organized student groups during the past year, ranging in numbers from 15 to 50, and in age from fourth graders to college level. Many of the visiting groups call us ahead of time and request guidance by a staff member. It has always been a problem for us to decide just how much of the staff's time we should invest in this kind of group education. To ease the pressure somewhat, a self-guiding natural history





Above and on left:

Two consecutive ice storms, one immediately before, the other after Christmas (1969) accumulated large amounts of ice on trees. Damage was quite localized and most extensive in the Prospect Hill area. The headquarters' building was without power for 60 hours. The entrance to the Fisher Museum is shown above, the area between the museum and the Community House on the opposite page. The pictures were taken on the morning after the second storm. trail was set up a year ago. This has been used by groups and many individual visitors. Judging from the number of descriptive trail leaflets which are taken from the Museum and the number of people whom we see walking the trail, we estimate that well over a hundred persons have used this added feature during the month of June, 1970.

RESEARCH

Much of Dr. Gould's work this year has been a continuation of studies described in last year's annual report. The Town of Petersham has financed the second season of mapping land holdings, and the ownership of about one-third of the town has been delineated. This year's work is progressing on schedule and we have again hired Mr. William R. Niedzwiedz to work on this project. Cooperation continued with the Petersham Conservation Commission and their project for the year is concerned with defining the status of public ways in town. Research into the town records has produced some interesting information on the development of roads since the town was established in 1733. Because transportation is so essential to land use, this project fills a gap which may lead to some fresh understanding of man's use of the local landscape.

Dr. Gould's work on the use of computers in the forest planning process has continued in cooperation with Dr. William O'Regan. This has been coupled with some further experiments with controlling vegetation to enhance the natural roadside views along the Harvard Pond margins.

Mr. Lyford continued to examine the root systems of mature red oaks. Roots 17 meters long were excavated and their branching habit studied. Repeated observation of red oak roots returning to the surface from lower horizons (see last year's report) led to a study of roots in the forest floor. Preliminary counts show 1000 live root tips in a cubic centimeter of the forest floor of a 70-year-old hardwood stand, plus some 2000 root stumps (former root tips). This large number of root tips in such a small volume suggested that a study of the interrelation among roots and soil particles should be accomplished with standard microtechnique procedures. With Dr. Morey's help forest floor samples were impregnated with epon and thin sections were prepared for future examination.

During his study of roots in the soil, Mr. Lyford continued his observations on soil dynamics, particularly the role of small animals in moving soil, injuring roots, etc. Termite activity was studied in North Carolina in collaboration with A. E. Shearin, a retired soil scientist. Preliminary examination shows that much of the wood on the forest floor



Above: Portion of red oak root system isolated from the forest floor. The largest root tip is about 1/3 mm in diameter.

is tunnelled by termites and ants and many of these tunnels are filled with soil. In addition it was noted that termites carry moist soil up the trunks of standing dead trees to heights of over 3 meters. This has some interesting implications from the standpoint of soil and root dynamics with which very few soil scientists are concerned. Though termites are rare at the Harvard Forest (only two colonies have been found so far), there are other small animals at this latitude influencing soil development in similar ways.

A new exploratory study has been initiated by Mr. Lyford in collaboration with Dr. Gould concerning the heads of upland watersheds. These small watersheds on low relief have a considerable area of swampy headlands and intermittent rather than perennial streams. Several on the Forest are essentially undisturbed by man and so may be valuable for water quality studies. Better knowledge of small watersheds may also be useful in planning the use of land for many purposes.

Dr. Swan has been working on four different projects. Using computers he applied statistical procedures to evaluate ecological data collected in vegetational surveys. Tests of these procedures have helped to show their weak points (see the article cited at the end of this report). He also wrote a program to compare forest inventory data with site information obtained from topographic and soils maps. Data from the Harvard Forest records have been assembled on computer cards and an attempt will be made to summarize available information about species-site relations.

In previous annual reports studies on the relative importance of disturbance and succession over the past 300 years in the Pisgah Tract (S.W. New Hampshire) have been described. During the past year compelling evidence has been obtained about the importance of disturbance in the 2500acre "virgin" Pisgah Forest, using data collected in 1929-30 by three Master's students of the Harvard Forest. From these data, differences in forest composition can also be described in terms of land form. Conclusions are substantially different from those of published reports for the same area.

Because there are so few phenological studies available for New England forests, Dr. Swan recorded time of leaf opening, fall, flowering and fruiting of 216 trees of the common species growing at different elevations in the Harvard Forest. This study is in its second year.

The mechanism of flow of maple sap has been of special interest to plant physiologists of New England. Drs. Iten and Sauter have joined forces in an experimental investigation of this problem. The absorption and release of water, changes in water carbohydrate content in isolated stem sections of sugar maple (Acer saccharum Marsh.) were followed in a temperature-controlled chamber (see illustration below). In early spring an incubation of stems at 20° C induced resynthesis of starch from sucrose. The activities of amylase

and phospho-glucoseisomerase of extracts were found to be dependent on preceding storage temperature. Cytochemical methods showed increased enzymatic activity (dehydrogenases of the Krebs cycle and acid phosphatases) in those ray cells ("contact cells") which are connected to vessel elements by special pits during the bleeding period but not during the following vegetation period.



Experiments were also started in an attempt to induce physiological stages in the laboratory by hormonal treatment.

In collaboration with his wife, Elsie D. Morey, Dr. Morey completed a research project on the structure and chemistry of a mineralized lignite (Miocene) from Senftenberg, Germany. The lignite showed structural similarity to wood of several modern species of the Taxodiaceae. On the basis of birefringence, staining and solubility properties, cellulose was identified in the walls of latewood tracheids. However there was structural evidence suggesting the specimen was attacked by cellulose-destroying bacteria at an early stage of sedimentation. Solubility tests showed also the presence of lignin whose abnormal fluorescence seems to indicate incipient geochemical deterioration. Presence of significant amounts of cellulose and lignin in the lignite indicates that both of these cell-wall constituents may function as progenitors of coal.

Dr. Morey's oak-root study, which had been started in collaboration with Mr. Lyford, showed well-defined cork cambia in fine roots of less than 0.15 mm diameter, and the presence of both cork and vascular cambia in fine roots of a diameter between 0.15 and 0.5 mm. The ultimate ends of the fine roots in litter and humus are mostly mycorrhizal as indicated by morphological and fluorescence properties.

Dr. Skene continued his study of vessel length. In American beech (<u>Fagus grandifolia</u> Ehrh.) vessel lengths range from 5 to over 95 mm, with most of the vessels being shorter than 20 mm. This is much shorter than would have been anticipated from previously published reports. In collaboration with Assistant Professor Paul Holland of the Statistics Department the calculations originally developed for determining vessel-length distributions have been related to a more general statistical theory, the renewal theory.

In a study of tracheid development in hemlock (<u>Tsuga canadensis</u> Carr.), Dr. Skene found a correlation of annual-ring width with the rate of tracheid production (except for the least vigorous trees which had a shorter growing season). There is strong evidence that the higher rates of tracheid production are due to a higher rate of cell division in the cambial zone. The greater number of cells in the cambial zone made a relatively small contribution to the higher rates of tracheid production. The radial growth rates of the tracheids during the enlargement phase were more or less constant (1.5 to 3μ /day) and the period of time required for the completion of radial growth decreased with the size of the tracheids, from about 20 days in May to 7 days in August. The rate of secondary-wall deposition was also more or less constant (0.1 to $0.2\mu^{-}/\mu$ /day) and the time required increased with the volume of the wall, from about 10 days in May to 50 days in early August. Neither of these rates appeared to depend much on tree vigor. -- Papers about both of Dr. Skene's projects are in preparation.



Dr. Tomlinson returned to Miami from his sabbatical leave in New Zealand in November 1969. He continued to develop an understanding of those monocotyledons which have secondary thickening by an extensive investigation of the genus Cordyline. In this he has been much assisted by Dr. J. B. Fisher, a Cabot Foundation Research Fellow working at the Fairchild Garden. This experimental work is directed towards an understanding of the hormonal control of shoot morphology in the commonly cultivated Cordyline terminalis.

Much of Dr. Tomlinson's time during spring and summer of 1970 has been devoted to the continued accumulation of information about the growth of native trees in sub-tropical Florida. Illustrations for a proposed book which will describe this work are being prepared by the Botanical Illustrator of the Fairchild Garden, Miss Priscilla Fawcett.

My own work in collaboration with Dr. Tomlinson on the anatomy and the development of woody monocotyledons continued. I visited Miami in December and Dr. Tomlinson was at the Forest during March. The vascular pattern of further palms and other monocotyledons was studied and a number of variations of the basic principle have been recognized. We now believe that the vascular principle in all monocotyledons is similar and consists of two systems, an inner

Above: The course of vascular bundles in the stem of a monocotyledonous tree with secondary thickening growth (<u>Dracaena fragrans</u>, a small species of dragon tree). It is impossible to unscramble such a complex vascular system with conventional procedures. Our cinematographic method of analysis, however, makes the task relatively easy.



Above: Sample illustration by Priscilla Fawcett for Dr. Tomlinson's book on South Florida trees, showing fruits of the red mangrove (<u>Rhizophora mangle L.</u>). and an outer one. The inner one seems to be unique to monocotyledons, it usually is the more elaborate of the two. The outer one is of considerable significance only in those monocotyledons which have secondary growth. All plants other than monocotyledons which we have studied either ourselves or in the literature (ferns, conifers, dicotyledons) have only one vascular system, and it resembles more the outer system of the monocotyledons.

RESEARCH FACILITIES

Room No. 7, which is located immediately south of the main corridor in Shaler Hall, was transformed into a laboratory during the past winter with Cabot funds. This room had served as a drafting room for many years, and later held one or two desks for students or visiting scientists. Benches with electric and gas outlets, wall cabinets and greatly improved lighting make this room a laboratory suitable for physiological and biochemical work. Dr. Iten is occupying it at the present time.

LONG-TERM SILVICULTURAL RESEARCH

The main operation of the year centered in the Waldo Lot, (Tom Swamp X), an area that was given to the Forest in 1963 and has since received no treatment. A 15-acre portion in the northwest corner of the tract supports a 60-year old stand of mixed hardwood with scattered groups of white pine. This first treatment was a combined improvement cutting, thinning and partial harvest designed to upgrade this portion of the tract. The object was to remove poorly formed trees suitable for fuelwood, release selected crop trees and harvest a few mature sawlogs. So far, a bit over eight cords per acre have been cut leaving the residual trees in condition for improved growth.

Another mixed hardwood area on a peninsula at the southern end of Harvard Pond (TS VII) was treated with a thinning designed to promote rapid growth and open the view from the highway to the pond. The present stand is volunteer growth following a stand of large white pines blown down in 1938. About three cords of wood per acre was cut from this small area and the undergrowth was removed in an attempt to open a view of the pond for motorists. Sprouting has been prolific and it will be difficult to hold an open understory without the use of herbicides.

The reproduction cut on three acres of Slab City VIII was completed along with the crown thinning in Tom Swamp II. Both these cuttings were described in last year's report. This year all operations produced a total of 155 cords of fuelwood plus 3,156 board feet of sawlogs. Our four man wood crew spent 40 percent of their time on such experimental cuttings and 60 percent of their effort on the maintenance of buildings, grounds, roads, short-term research operations and the like.



Above: Hardwood thinning and sprout control. In the winter of 1967-68 a heavy thinning cut 60% of the basal area from this 43-year-old hardwood stand in Tom Swamp IV. About 13 cords per acre were cut and 12 were left standing with individual crop trees free to expand their crowns. In June of 1968 sprouts threatened to obscure the spacious view that had been created by the thinning so these young sprouts were sprayed with 3.1 gallons per acre of a mixture of 1 part 2,4,5-T to 40 parts of kerosene. Another 6.7 gallons were added a year later to eliminate skips and resprouts. This amounted to a total of about one pound of herbicide acid per acre at a cost of \$25 for labor and materials. The picture shows the sprayed area on the left and the unsprayed control on the right of the banded tree in July 1970. Sprouts of the unsprayed area are well over Dr. Swan's head.

FOREST OPERATIONS AT THE BLACK ROCK FOREST

On December 22, 1969, a heavy ice storm struck this general area. One-half to three-quarters of an inch of ice accumulated on twigs, thus causing considerable top breakage in the hardwoods and some uprooting primarily in coniferous plantations. With the advent of spring, a largescale clean-up operation had to be launched to insure emergency vehicle access during the potential fire season in early spring.

Logging this past year was limited to salvage operation on droughtkilled oaks along Jim's Pond Road. Twenty-five cords of wood were cut, processed and delivered by our contractor. There is a continually increased demand for fuelwood, but we cannot make full use of this market opportunity because of limited labor and machinery.

Data and photographs on aesthetic thinnings have been compiled during the past decade. It is hoped that this material can be combined with similar results obtained in Petersham by Dr. Gould and published in 1971.

The continually increasing number of visitors to the Black Rock Forest is reflected by the steady demand for the new trail map.

Petersham, Massachusetts August, 1970 Martin H. Zimmermann Director

PUBLICATIONS

The following articles have appeared in print during the fiscal year of 1969-70:

- Critchfield, W. B. 1970. Shoot growth and leaf dimorphism in Boston Ivy (Parthenocissus tricuspidata). Am. J. Bot. 57: 535-542.
- Foster, C. H. W. 1970. The Northfield mountain pumped storage project counterpoint to Con Ed. Harvard Forest Paper No. 19.
- Gould, E. M. Jr. 1969. Scholars in the Forest. Southern Lumberman 219 (2728): 185-188.
- Gould, E. M. Jr. 1970. Forestry in Massachusetts. In: "A Half Century of Forestry 1920-1970." pp. 17-24. Published by the New England Section, Soc. Amer. Foresters.
- Morey, P. R. and E. D. Morey 1969. Cellulose and lignin in Senckenberg lignite. p. 152, Abstracts XI Int. Bot. Congress, Seattle, Wash. U.S.A.
- ødum, Søren 1970. Dendrological material collected in North America. Bot. Inst., Royal Vet. & Agricult. Univ., Copenhagen (mimeo).
- Swan, J. M. A. 1970. An examination of some ordination problems by use of simulated vegetational data. Ecology 51: 89-102.
- Tomlinson, P. B. 1969. The anatomy of the vegetative organs of <u>Juania</u> australis (Palmae). Gentes Herbarum 10: 412-424.
- Tomlinson, P. B. 1970. Monocotyledons towards an understanding of their morphology and anatomy. In: "Recent Advances in Botanical Research" R. D. Preston, ed., Vol. 3. Academic Press, London.
- Tomlinson, P. B. and M. H. Zimmermann 1967. The "wood" of monocotyledons. Bull. Internat. Assoc. Wood Anatomists 1967/2: 4-24. (Because of continued demand, this paper has been reprinted.)
- Zimmermann, M. H. and P. B. Tomlinson 1969. Vasculation in the stem of arborescent monocotyledons. p. 248, Abstracts XI Int. Bot. Congress, Seattle, Wash. U.S.A.

Reprints of some of these papers may be obtained by writing either to the individual authors or to The Harvard Forest, Petersham, Mass. 01366, U.S.A.