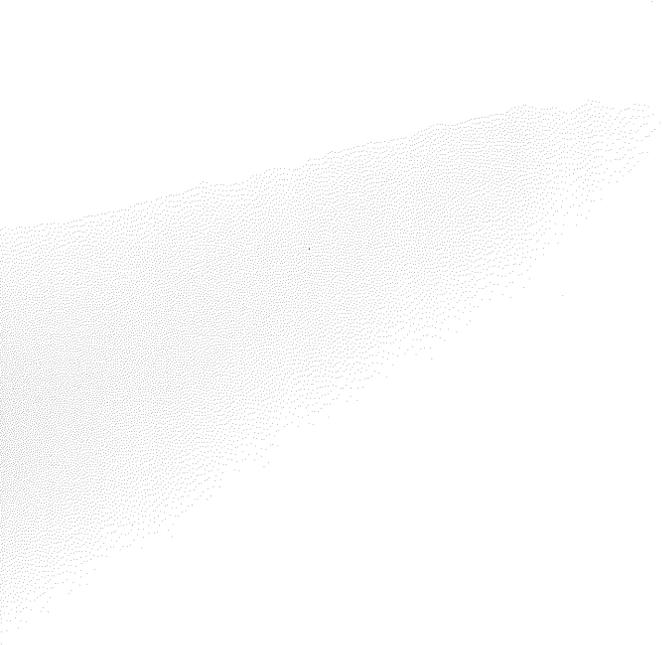




# THE HARVARD FOREST, 1979-80

Harvard University





*Frontispiece: The clearcut operation in PH VII, and the alder-poplar plantation described on page 12, are in the background of this picture. The fuelwood will help heat Shaler Hall this winter. The Pierce Farm cellar hole is immediately to the right of the viewer. The area to the left of the road and behind the viewer is the thinning operation in PH VIII described on page 12.*

*(photograph by Bill Ormerod)*

ANNUAL REPORT OF HARVARD UNIVERSITY ACTIVITIES

AT THE HARVARD FOREST 1979-80

STAFF \

Alison M. Berry, Research Assistant  
Robert J. Cartica, Research Assistant  
Catherine M. Danahar, Business Secretary and Librarian  
Lynn D. Disney, Research Assistant  
Wayne E. Elliott, Custodian  
Karen Esseichick, Research Assistant (until May 31, 1980)  
Ernest M. Gould, Jr., Forest Economist, Senior Lecturer in Biology  
David E. Hibbs, Research Fellow in Silviculture  
Vibeke L. Holm, Assistant to the Librarian  
Edward H. Hyde, Woods Crew  
Ayodeji A. Jeje, Visiting Scholar (from January 1, 1980)  
Jack J. Karnig, Forest Manager  
Shirley P. LaPointe, Greenhouse Assistant  
Peter Kung Woo Lee, Cabot Research Fellow (until January 31, 1980)  
K. Alan Longman, Bullard Fellow (from October 1, 1979)  
Ralph L. Lundquist, Research Assistant  
Monica R. Mattmuller, Research Assistant  
Robert F. Metcalf, Bullard Fellow  
Donald C. Mitchell, Assistant to the Manager of the Black Rock Forest  
Gordon B. Mitchell, Woods Crew Superintendent  
Dennis Newbanks, Cabot Research Fellow (from February 1, 1980)  
Frances E. O'Brien, Secretary  
William S. Ormerod, Research Assistant  
Frances N. Phillips, Secretary  
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*  
Christa R. Schwintzer, Bullard Fellow  
Dorothy R. Smith, Secretary  
Charles C. Spooner, Woods Crew  
John D. Tjepkema, Assistant Professor of (Soil) Biology  
P. Barry Tomlinson, Professor of Botany  
John G. Torrey, Professor of Botany  
Charles F. Upham, Woods Crew, retired (working part-time)  
Lawrence J. Winship, Research Associate  
Patricia H. Young, Greenhouse Assistant  
Martin H. Zimmermann, Charles Bullard Professor of Forestry and  
Director of the Harvard Forest

Ernie Gould was appointed as a member of the National Forest System Advisory Committee last October. This group is set up to study the problems faced by the National Forest administrators and advise the Secretary of Agriculture about desirable solutions. He has attended one meeting in Washington, D. C. and one in Asheville, North Carolina. The group is especially interested in how Forest Service problems vary from region to region, how the Resource Planning Act can contribute to the solution of local problems and how likely solutions to energy shortages will impinge on our forests.

David Wheat, who obtained his PhD with Barry Tomlinson, continued his work as a post-doctoral fellow for a few months and then took up a position with Arthur D. Little, Inc. in Cambridge, in April, 1980.

Dennis Newbanks, a tree pathologist who received his PhD with Terry Tattar of the Shade Tree Laboratory of the University of Massachusetts, has joined Martin Zimmermann as a post-doctoral fellow to study the failure of water conduction in trees.

## STUDENTS

The following courses were taught in Cambridge by our staff members. During the fall term Barry Tomlinson gave, in collaboration with other members of the Department of Biology, *Diversity in the Plant Kingdom* (Biol. 18). He also participated in *Biology of the Ferns* (Biol. 247), accompanying the class on its field trip to Jalapa, Mexico in December, where he supervised two student field reports on rhizome architecture. Also in the fall, Ernie Gould and Martin Zimmermann offered *Trees, Forests and Man* (Biol. 101) for the second time, again drawing a relatively large number of students (45). The field trip to the Harvard Forest was made in two sections on two weekends for a non-required 100 course. In the spring, John Tjepkema offered *Soil Biology and Ecology* (Biol. 108). The *Harvard Forest Freshman Seminar* was given in the spring, a joint effort of all of us, based at the Harvard Forest on four weekends.

The following students took independent study courses. Kimberly Raleigh worked on *How to Bring a Previously Unmanaged Forest Stand in Northern New England Under Control* with Ernie Gould and Martin Zimmermann (Biol. 299r). Theresa Gruber wrote an honor's thesis with Barry Tomlinson, entitled *The Branching Pattern of Hypolepis repens* (Biol. 96r). Ann Bublitz, Colin Goodall and Julian Hadley took 300 level courses with members of the Harvard Forest staff.

The Department of Landscape Architecture of the Graduate School of Design began their year with a visit to the Forest prior to registration. This year they spent most of a week in September and ran several field courses for their new students.

In April the Harvard Forest was host to another Yale class in forest management decisions operated by Professors Binkley and Dykstra. This group spent two days here and on the Quabbin reservation, checking on watershed

and aesthetic forest management.

Ernie Gould is on the thesis committees of three students at the Yale School of Forestry and Environmental Studies, Pierre and Denise Lafond and Richard Kelley.

John Tjepkema is a member of the thesis committee of Michael San Francisco in the Biology Department of Boston University. Martin Zimmermann is serving on the thesis committees of Christopher Murdoch and Steven Day of the Department of Botany and Plant Pathology, University of Maine. Steven completed the requirements of his degree in May 1980.

John Torrey served on the Division II program of Geof Nolin at Hampshire College and continues to serve as the research advisor of Alison Berry who is working for her PhD at the University of Massachusetts at Amherst.

Two Yale forestry students are stationed here for the summer of 1980 in connection with the Yale-Harvard joint program. Bruce Kernan is assisting David Hibbs with his silvicultural work and John Arnone is helping Christa Schwintzer in her work on nitrogen fixation. Elizabeth Markell (Radcliffe, 1983) is collaborating with Martin Zimmermann in his work on vessel length during the summer of 1980. Sarah Corey is helping in John Torrey's laboratory.

## MEETINGS

The Forest hosted many meetings again this year. On September 21-24, 1979, a workshop was held here by the palynologists of northeastern North America, but participants came from as far as England and Colorado. This was organized by Norton Miller of the Harvard University Herbaria. -- In October, Crown-Zellerbach sponsored a short seminar at the Yale School of Forestry and Environmental Studies. The second half of this meeting was held at the Harvard Forest. William Bentley of Crown-Zellerbach, a past Bullard Fellow, was the prime mover in this program to bridge the gap between industry and academia. -- Also in October, we hosted the Second Annual Northeast Paleobotanical Conference. -- A workshop organized jointly by Yale University and the National Research Council concerning *Age and Growth Rate Determination for Tropical Trees: New Research Directions* (Co-chairmen Graeme Berlyn and F. Herbert Bormann), was held at the Harvard Forest on March 31 to April 3, 1980. There were five working groups, Wood Anatomy, Dendrochronology, Wood Chemistry, Isotopes, and Demography-Biometry. Participants represented research organizations of about ten countries. The proceedings will be published as a Yale Forestry Bulletin. -- Finally, in May 1980, the eleventh Annual New England Fern Conference met here again.

## BULLARD FELLOWS

K. Alan Longman, a Principal Scientific Officer at the Institute of Terrestrial Ecology's Research Station near Edinburgh, Scotland, is working on aspects of developmental physiology related to tree improvement. Factors

stimulating reproductive activity, still little understood, can be studied more effectively if cones or flowers can be reliably induced in relatively young trees. Two approaches, successful in Britain, are being applied to different species here - for example, in collaboration with the Shade Tree Laboratory at the University of Massachusetts in Amherst, an attempt has been made to bring a crop of tested, tolerant elms into flowering and fruiting. Bark-ringing (girdling) of selected branches is being used both for elm and in a similar trial with chestnut sprouts, with the aim of developing practical techniques for hastening the breeding of more resistant forms. In the Cupressaceae and Taxodiaceae, treatment with gibberellin (GA<sub>3</sub>) strongly promotes male and female cone initiation, and this has been used on sparsely coning or purely vegetative specimens of *Sequoiadendron* and *Metasequoia* at the Arnold Arboretum. Other research in progress includes an investigation into the possibilities of stimulating basal sprouts from trees without cutting them down, in order to provide 'juvenile' material for vegetative propagation of selected trees. A study of simple injection methods for a variety of purposes has shown that at least 300 ml of an aqueous solution can be injected with an ordinary plastic syringe into a sugar maple, even when it is leafless and bleeding sap.

Robert F. Metcalf, Jr. is a retired mechanical engineer who has become interested in the management of small woodlots. He attended the Yale School of Forestry and Environmental Studies during 1977-78 and attended some courses at Harvard. A small Bullard Fellowship enabled him to pursue his interest by contacting many government and private agencies in all six New England states and to do library work in woodlot reclamation and management. He prepared and presented a slide show and exhibits concerning land use history and management of a family woodlot.

Christa Schwintzer was awarded a Bullard Fellowship for the year 1979-80. As her research is closely related to that of the group studying nitrogen fixation, it is described there, in its usual place.

## RESEARCH

Ernie Gould continued his research on forest land planning and taxation. As part of this, he made a brief consulting trip to New York for the Adirondack Park Agency. This Agency is charged with regulating many kinds of land use that may be deleterious to the Park area, among these is clear cutting. It is interesting to note that whole-tree harvesting is already being practiced in part of the area; the chips are being sent to Burlington, Vermont as fuel for the municipal power company. -- The report of the Conference on Non-Industrial Private Forestry mentioned in last year's report was completed in August and published by the U. S. Forest Service. A national meeting was held to draw together the regional reports and the results of this have just been published.

Two Harvard Forest Papers have been published reporting on several years of Walter Lyford's research (see bibliography). The first of these (HF Paper No. 21) describes the development of the root system in northern red oak. Although Walter wrote this before his retirement, he kept "polishing" it afterward. It contains a wealth of information about red oak root systems, painstakingly

gathered as only Walter had the patience to do. The second (HF Paper No. 22) was written by Jim Patric, Project Leader of the U.S. Forest Service's Timber and Watershed Laboratory in Parsons, West Virginia, a former M.F.S. student at the Harvard Forest and later, Bullard Fellow. It concerns soil-water relations at the headwaters of a forest stream in Prospect Hill Tract I. Jim, who had helped Walter with planning and instrumentation of this project, spent the month of June 1979 at the Harvard Forest to gather and organize Walter's records.

David Hibbs continued his work on regeneration in small forest openings, the hypothesis being that opening size determines species composition and therefore, in the long run, affects forest composition. He is currently concerned with the effect of light levels. He also completed a study on leader growth and meristem death in eastern hemlock, relating his observations to the question of hemlock's architectural model. -- White pine has been described as a standard in the precolonial forest; its origin is uncertain. By following the development of pines in the surrounding dominant pines, David hopes to clarify the origin of the species. He also collaborated with Jack Fisher of the Fairchild Tropical Garden in a study of tree architecture of several *Terminalia* species in Jamaica, and its ecological implications.

Karen Esseichick, in collaboration with Barry Tomlinson, David Hibbs and Alan Longman, completed an illustrated field key to the woody plants of the Petersham area and has drafted keys to most other plant groups. This work was largely based upon the collections in the Harvard Forest Herbarium.

Barry Tomlinson spent much of his time writing. He completed another volume in the series *Anatomy of Monocotyledons*, edited by C. R. Metcalfe and published by Clarendon Press, Oxford. It deals with the Helobiae (Alismatidae), a group mainly of water plants, putatively primitive among monocotyledons. It not only surveys the vegetative anatomy of the plants, which is often reduced in relation to the aquatic environment, but departs from the style of previous volumes in the series by including detailed information about the morphology of reproductive and vegetative parts. Much original information has been added. Another completed book deals with the *Biology of Trees Native to Tropical Florida*. It is the result of extended periods of observation beginning at the time when Barry was on the staff of the Fairchild Tropical Garden. This flora is unique to the United States in that 80% of its species are tropical with a wider distribution in the West Indies. The volume is illustrated by Priscilla Fawcett.

Much of Barry Tomlinson's research was in collaboration with others. With Jack Fisher of the Fairchild Tropical Garden and Hisao Honda of the Kanebo Institute (Kobe, Japan), a former Bullard Fellow, programs were developed, based on measured examples of tropical trees by which tree growth can be simulated. In one of these studies it was shown that bifurcation ratio is not a fixed property of a developing tree as is frequently assumed. Another demonstrated how the interaction between crowns of trees could be quantified.

Eliezer Zamski, a former Bullard Fellow, spent the month of August 1979 at the Harvard Forest to continue his study on growth ring formation in relation to the morphology of *Avicennia* with the help of our equipment for cinematographic analysis (see the last two annual reports). This was partly supported by the Atkins Fund.

David Wheat, a former graduate student working with Barry Tomlinson, continued as post-doctoral fellow for a few months, studying floral development of mangroves of the family Rhizophoraceae. The morphological pattern is the basis for a surprising diversity of pollination mechanisms. He also looked at the developing vascular system of *Flagellaria indica*, a monocotyledonous climbing plant, at the level where the shoot bifurcates. As expected, there is an equal distribution of vascular tissue at the level of bifurcation.

The survey of the vascular system of the family Araceae (aroids) continued at the Fairchild Tropical Garden in collaboration with Jim French and support of the National Science Foundation. In the tropics these plants show considerable diversity of growth form. The nodal anatomy is quite complex with patterns that are often systematically useful.

The pattern of vascular development in arborescent monocotyledons has been studied for many years by Martin Zimmermann in collaboration with Barry Tomlinson. Its three-dimensional complexity makes it extremely difficult to describe with words and two-dimensional illustrations. We have the impression that only few plant anatomists really understood our papers, as most of the reactions we received, over the years, were quibbles about terminology. We hope that the situation will be improved by the publication of two films by the *Institut für den wissenschaftlichen Film* in Göttingen, Germany in which animated diagrams explain the sequence of events. Martin has been working on these films for several years with Monica Mattmüller's help. He recently spent a few days in Göttingen, working with the Institute's staff on the synchronization of explanatory text. It is hoped that these films will become generally available within the coming year.

The length of the water-conducting units in the wood of trees, called vessels in dicotyledons (broadleaf species), plays an important role in both the efficiency of water conduction and safety of the system. Knowledge of vessel length is therefore of more than academic interest, but very little information is available about this. All we know about our tree species from the literature is the approximate length of the longest vessels. Observations in Martin Zimmermann's laboratory indicate that this is very misleading. While in ring-porous trees many vessels are very long, occasionally as long as the whole stem, the longest vessels of diffuse-porous trees are always a small minority. In black cherry, for example, the longest vessels may be as long as one meter. But these represent far less than 0.5% of all vessels seen on a transverse section; 80% of them are shorter than 20 cm. Our measurements of vessel-length distribution initially is a survey of the most common species of our forest, secondarily it will inform us about length distribution within individual trees, diameter-length relationships, etc.

Dennis Newbanks' emphasis of research is in the area of wilt disease physiology. He is currently using cinematographic analysis to study the pattern of pathogen movement with regard to xylem dysfunction in Dutch-elm diseased trees and *Verticillium*-wilt maples.

Ayodeji Jeje continues his studies of fluid mechanics of water movement in capillary tubes, a study which will be useful in understanding the characteristics of water flow in the wood and its failure by cavitation of



*Calculating vessel length distribution in a stem of white ash by measuring the rate of air flow through successively shorter stem segments at given pressure gradients. From left to right: Monica Mattmuller, Martin Zimmermann and Liz Markell. (Photograph by Bill Ormerod)*

the water columns. He also has begun to measure the resistance to gas exchange in leaves. This concerns the pathways by which  $\text{CO}_2$  enters leaves during photosynthesis and  $\text{H}_2\text{O}$  vapor is lost during transpiration. An attempt is being made to relate the inner structural characteristics of leaves to the rates of gas exchange.

During the past year, Christa Schwintzer largely completed two studies in an ongoing series of field studies of the ecology of sweet gale (*Myrica gale*) in Tom Swamp. She estimated the total amount of nitrogen fixed in the open peatland by all living agents using the acetylene reduction technique to determine the importance of sweet gale relative to other agents of fixation. The total fixed was approximately  $35 \text{ kg ha}^{-1}\text{yr}^{-1}$ . Of this, 34 kg was contributed by sweet gale root nodules, 0.5 kg by microorganisms (possibly bluegreen algae) on the moss and litter covering the ground surface, and the remaining 0.5 kg by bacteria (free living or associated with roots) in the aerobic and anaerobic peat below the surface. Thus there is little nitrogen fixation in this weakly minerotrophic peatland, aside from that by sweet gale. Christa also examined the relationship between nodule phenology, endophyte morphology and nitrogenase activity together with Alison Berry and Lynn Disney. As far as we know, this is the first study of nodule phenology and endophyte morphology in an actinomycete-nodulated plant. They found some distinct seasonal patterns. Growth

of existing nodules began in early May and was largely complete by early July. Nitrogenase activity was only found in tissues formed during the same year. Endophyte (a prokaryotic filamentous bacterium, i.e. an actinomycete) existed as thin scattered hyphal threads in the host cells near the nodule apices in early spring. Vesicles (terminal swellings of branch hyphae) were first seen in late May when nitrogenase activity appeared and filled almost all endophyte-containing cells throughout the season of nitrogen fixation. In fall the vesicles senesced and sporangia filled with spores appeared in some nodules. The endophyte overwintered as scattered hyphal threads near the nodule apices and as spores. -- With John Arnone, Christa is examining the effect of shoot illumination in sweet gale on nitrogenase activity in the field and in potted plants.

John Tjepkema continued his research on the protection of nitrogenase from oxygen in nitrogen-fixing root nodules. In work carried out by Bob Cartica, nodules of *Parasponia* were studied; this is the only nonlegume with *Rhizobium*-induced root nodules, and the study of it will help determine whether it is feasible to try to nodulate nonlegume crop plants with *Rhizobium*. He found that, as in legumes, the nodule structure serves to protect the rhizobia from oxygen. In contrast, in work done with John Torrey and Bill Ormerod, it was found that actinorhizal nodules have an entirely different means of regulating oxygen concentration. Nitrogenase is confined to vesicles which appear to be analogous to the heterocysts of bluegreen algae which have a special cell wall which restricts oxygen diffusion into the cell. This allows nitrogen fixation by the actinomycetal endophyte to occur at atmospheric pressures of oxygen. Thus the endophyte itself, rather than the nodule structure, provides protection against oxygen.

Larry Winship and John Tjepkema continued their research on the energy cost of nitrogen fixation by root nodules. In April they gave a paper entitled "Energetics of Biological Nitrogen Fixation of Dinitrogen" at a conference held at Michigan State University and sponsored by the United States Department of Energy. They find that energy use by nitrogen fixing alder nodules is generally very efficient, even under a range of environmental parameters such as temperature, reduced  $pO_2$ , and elevated  $pCO_2$ . A method for measuring nitrogen fixation by  $N_2$  uptake from the gas phase was also developed. Nitrogen fixation is usually measured by using  $^{15}N_2$  isotope or by the reduction of acetylene to ethylene. However, the former method is slow and expensive while the latter method is indirect. Unfortunately, measurement of  $N_2$  uptake directly can be used only under very limited conditions.

Part of the work done in John Torrey's laboratory this year has already been discussed, namely the field study of nodule phenology and endophyte morphology in *Myrica gale* and the demonstration of nitrogenase activity by cultures of endophyte from actinorhizal nodules. With regard to the latter, nitrogenase activity occurs only when vesicles appear in the cultures, demonstrating conclusively that the vesicles are the site of the enzyme nitrogenase. One is now in the position to study this important enzyme in the free-living cultured bacterium, the first demonstrated case of nitrogen-fixing capacity in an actinomycete. The work was the collaboration of John Tjepkema, John Torrey and Bill Ormerod.

During July, August and September 1979, John Torrey was actively engaged as project director for the forage project of the New England Farm Center Associated with Hampshire College in Amherst, Massachusetts. Attention was focused

on the propagation, planting and management of *Alnus* species, especially *A. rugosa*, as possible feed stocks for sheep. These perennial plants grow rapidly on poor acid soils of New England, fix dinitrogen from the atmosphere, thereby improving the soil, and produce foliage with high protein nitrogen palatable and nutritious for sheep. This work is part of the overall program of the Center to revive sheep farming in New England.

In February 1980, John Torrey and family left the country for a sabbatical leave. At the invitation of botanists in Japan and with the support of the Yamada Foundation, John Torrey visited a number of universities and major botanical research centers, spending two weeks in Tokyo and three in Kyoto. In addition to lectures at universities in these cities, trips were made also to Okazaki, Osaka, Mishima, Nagoya, and Tsukuba. Contacts were made with botanists, plant physiologists, agronomists and foresters in the fields of plant tissue culture and biological nitrogen fixation.

From early March John Torrey pursued research in Canberra on the native Australian actinorhizal plants of the genus *Casuarina*. His research was carried out in the laboratory of A. H. Gibson of the Division of Plant Industry, CSIRO, Canberra and with the cooperation of members of the Division of Forest Research, CSIRO. *Casuarina* is the most important tropical member of the actinomycete-nodulated woody dicots and is increasingly important to developing countries of the tropics in shelter belt plantations, land stabilization and for reclamation, fuel, forage and other uses. The aim is to develop a better understanding of the microbial member of the symbiosis and to facilitate methods of propagation and nodulation of *Casuarina* seedlings to be used in large-scale plantations. Efforts were made to isolate and culture the bacterial endophyte from field-collected nodules. John participated in several meetings in Australia and visited a number of research groups. At the end of July 1980 the Torreys returned to the United States via Honolulu, Hawaii where he made further collections of *Casuarina* nodules and seeds and paid a visit to research foresters at the Institute of Pacific Islands Forestry.

## THE HARVARD FOREST LIBRARY

Maintaining an up-to-date catalog for a research library as diverse as that at the Harvard Forest is not an easy matter. We solved the problem of prompt shelving some years ago, but only at the expense of eliminating subject matter cards from the catalog. This deficiency we are about to correct by shifting to a computer system that will make our new catalogs. The FAMULUS program was developed by the U. S. Forest Service at the Pacific Southwest Forest and Range Experiment Station in Berkeley.

For several years we have been key punching citation cards for each item in the library. Each citation includes author, title, date, publisher, key words to describe the contents, shelving location and, if desired, an abstract. Catching up on the whole library has been a big job but now, about 150,000 cards later, it's over 90 percent complete. Our new catalog is developed and printed by computer so that for each section of the library we have alphabetized lists by author, by title, and also by key words showing the ci-

tation numbers in which each descriptor appears.

Now that catalogs are easily duplicated by computer we are able to have a copy in Petersham, another in our offices in Cambridge and a third at the Yale School of Forestry and Environmental Studies. When they develop similar catalogs we expect to exchange library listings regularly, thus making better use of both libraries.

## FOREST OPERATIONS

We have a number of red pine plantations, most of them established in the late 1920's. This year we decided to experiment with (partial) harvests and selected for this two stands located in Tom Swamp Tracts VIII and IX. Portions of these stands were (1) clearcut, (2) untreated as controls, (3) row-thinned every third row, and (4) row-thinned, take-two, leave-two. Large poles are shipped to Canadian utility companies, small trees and tops are chipped and will heat Montgomery Rose in Hadley this winter, and short logs are milled locally. This operation is carried out by a private contractor under the supervision of David Hibbs.

Our records show that during past winters, years ago, before we heated Shaler Hall with oil, we burned a little over 100 cords of wood per winter. We still have our old wood-burning furnace and plan to save oil this coming winter by burning wood again during the coldest months. In anticipation of this, the crew clearcut a three-acre hardwood stand in Prospect Hill Tract VII, near the old Pierce Farm. The area had been clearcut in 1936 and contained mixed hardwoods of both sprout and seedling origin. Because of the known age of the trees, and by measuring the amount of wood removed, we could estimate the mean annual growth during the past 43 years had been 0.75 cords per acre per year; this is about average for southern New England.

On the clearcut area John Tjepkema established a hybrid poplar - black alder plantation. Black alder is a tree with nitrogen-fixing root nodules. As the leaves fall to the ground and are decomposed, the fixed nitrogen will become available to the interplanted poplars and may increase their growth rate. Hybrid poplars are being studied because they are very fast growing and yield more biomass per acre than most other trees. It is of interest that hybrid poplars were previously studied at the Harvard Forest during the period of 1947-1955 by Scott Pauley, a tree geneticist.

Across the road from this stand, also next to the Pierce Farm, but in Prospect Hill Tract VIII, I selected a stand for a high thinning in order to get firewood for the Director's House. This is a one-man operation, a good balance against the time I have to spend at my desk. The area had been clearcut in 1937. By January 1980 thinning was completed in the part next to a swamp consisting mostly of red maple. The Freshman Seminar Class measured an area of 0.2772 acres by triangulation and estimated the standing tree volume by measuring every tree with calipers. The results of these measurements showed that the thinning had harvested about a third of the tree volume. The average growth per acre per year was 0.97 cords.

As our maintenance vehicles are getting rather old, the crew had to spend a fair amount of time with repairs. All in all, the maintenance of machines, tools and vehicles consumed 1,366 man hours of crew time. Maintenance of buildings and grounds also requires time; during the winter and early spring, for example, windows and frames of Shaler Hall were painted.

## HARVARD BLACK ROCK FOREST

As of July 1, 1979, Jack Karnig assumed part-time employment, requiring him to devote three days a week to Black Rock Forest. This allows him to spend the remainder of each week on his consulting forestry practice.

The Cornwall Conservation Commission followed up last year's wetlands study with an inventory of open space in the Township. Frank Gagliardo, a Syracuse University graduate student, was hired to undertake the survey during the summer months of 1979. He used the Forest as his base of operations; Jack Karnig supervised and helped direct this study. An aerial photo with transparent land use overlays was produced as part of the report. This will continue to be useful to government officials and commissions for planning purposes.

Donald Mitchell continues to maintain our roads and trails. In addition, he completed thinning a two-acre segment of woodland in the eastern edge of Compartment XII. This area borders the Jims Pond Road and is bisected by the Scenic Trail. This was done with great care so that hikers would not be upset by a denuding of the landscape and the sudden appearance of logging slash.

Another thinning operation took place in Compartment VII along White Oak Road. John Brady, an independent contractor, cut marked timber during the fall and winter using a quadractor for skidding. He will continue this work during the summer of 1980. Additional small scale harvesting has taken place in Compartments III and IV adjacent to the Hulse Road. Also, 40.3 thousand board feet of primarily oak timber was sold to the Black Bear Logging Company from the lower level of Sackett mountain in the extreme western portion of the Forest. This latter cutting could not have taken place under normal conditions due to steep terrain but an opportunity to do so presented itself when a harvesting job on land of the adjoining ownership allowed access to our timber.

Early in September 1979, a severe windstorm uprooted many trees in the Forest. Roads blocked by trees were cleared with the help of several volunteers from the Black Rock Club. It took about three weeks to open the entire road network. -- In recent years we have been repeatedly plagued by heavy rains which seriously eroded our Forest roads. This year the deluge arrived on March 21 with nearly six inches of rain in less than 24 hours. It became necessary to close all of the Forest to motor vehicles because of about a dozen impassible washouts. Volunteer assistance in the form of manpower and heavy equipment from the Black Rock Club helped repair most of the damage by June 1st.

This spring the NY-NJ Trail Conference has been involved with relocating the Scenic Trail. Under the supervision of John Bleninger, trail supervisor, the westernmost segment of this trail has been shifted to tie in with a large-

scale relocation designed to avoid some private land. As soon as the new trail location is made permanent, we expect to incorporate the change into a revised trail map to be published in the coming months.

Ongoing studies mentioned in previous annual reports are still in progress. These include the black walnut study located behind the Forest residence on Continental Road and the conifer outplanting experiment to show the effects of deer browsing. The pitch pine progeny test, being conducted in New Jersey, required remeasurement in May 1980.

The Forest House has been equipped with an airtight stove in the living room and the house was insulated. This reduces oil consumption during the winter by about two-thirds.

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This is a list of publications which have appeared in print between July 1, 1979 and June 30, 1980. Publication lags one or more years behind the description of research in this report. Many of these publications are available as reprints. If you are interested in receiving any of these, please write to the Harvard Forest, Petersham, MA 01366, or where the address is given, directly to the authors.

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