

# THE HARVARD FOREST, 1977-78

Harvard University



Frontispiece: Transverse section through a small stem of the black mangrove (Avicennia germinans (L.) Stearn). This tree grows along salt water shores in southern Florida. One of its peculiarities is that portions of phloem, the sugar transport tissue (the black dots in this photograph) develop inside the wood. In "normal" trees, e.g. those of the Harvard Forest, the phloem is the innermost layer of the bark outside the wood. (See page 10 of this Report). Magnification ca. x60.

## ANNUAL REPORT OF HARVARD UNIVERSITY ACTIVITIES AT THE HARVARD FOREST 1977-78

### STAFF

The staff during the year 1977-78 consisted of the following persons:

Ernest M. Gould, Jr., Forest Economist Ayodeji A. Jeje, Bullard Fellow (from October 1, 1977) Jack J. Karnig, Forest Manager Larry Klotz, Cabot Research Fellow Peter Kung Woo Lee, Cabot Research Fellow (from October 1, 1977) Craig G. Lorimer, Research Fellow in Silviculture (until August 31, 1977) Walter H. Lyford, Soil Scientist, Emeritus William Pengelly, Cabot Research Fellow (from September 1, 1977) Hugh M. Raup, Charles Bullard Professor of Forestry, Emeritus Christa R. Schwintzer, Honorary Research Fellow (from September 1, 1977) John D. Tiepkema, Assistant Professor of (Soil) Biology P. Barry Tomlinson, Professor of Botany John G. Torrey, Professor of Botany Eliezer Zamski, Bullard Fellow (from August 10, 1977) Martin H. Zimmermann, Charles Bullard Professor of Forestry and Director of the Harvard Forest

Supporting personnel included:

Nancy Levinskas Armstrong, Research Assistant (until August 31, 1977) Alison Berry, Research Assistant (from August 29, 1977) Dale Callaham, Research Assistant (until September, 1977) Catherine M. Danahar, Business Secretary and Librarian Wayne E. Elliott, Custodian Anne Faulkner, Laboratory Technician (until June 12, 1978) Vibeke Holm, Assistant to the Librarian Edward H. Hyde, Woods Crew George T. Kenney, Woods Crew (deceased, September 16, 1977) Shirley P. LaPointe, Greenhouse Assistant Earl O. Lucas, Woods Crew (from May 1, 1978) Jeffrey McElroy, Research Assistant Monica R. Mattmüller, Research Assistant Donald C. Mitchell, Assistant to the Manager of the Black Rock Forest Gordon B. Mitchell, Woods Crew Superintendent Frances E. O'Brien, Secretary Frances N. Phillips, Secretary (from March 1, 1978) Dorothy R. Smith, Secretary Theresa A. St. Helaire, Secretary (until January 31, 1978) Charles F. Upham, Woods Crew, retired (working part-time) Robin van Alstyne, Laboratory Assistant (from March 1, 1978)

Craig Lorimer, our silviculturist, left us at the end of the summer 1977, to take up the position of Assistant Professor at the University of Wisconsin in Madison. Despite efforts, we have not been able to fill this position again during the 1977-78 academic year, but shall do so shortly. Peter Lee joined us on October 1, 1977. He received his Ph.D. from the University of Nevada in Reno. William Pengelly joined John Torrey's group on September 1, 1977 as Research Fellow. He is a third-year graduate student from the Department of Biology of Princeton University, coming to us via the University of Illinois. Christa Schwintzer came to the Forest when she married John Tjepkema. She has since been appointed Honorary Research Fellow. She is a plant ecologist and still holds an associate professorship at the University of Wisconsin in Green Bay. Ann Hirsch, a second-year post-doctoral fellow with John Torrey, working in Cambridge, left June 30, 1977 to take up the position of Assistant Professor at Wellesley College.

Last year brought a fairly extensive turnover of supporting personnel. Peter Del Tredici, who left us on June 30, 1977, was replaced by Jeffrey McElroy to run the greenhouses. Dale Callaham, Research Assistant in John Torrey's group, went to graduate school at the University of Massachusetts. Nancy Armstrong left also. New assistants are Alison Berry and Robin van Alstyne. Terry St. Helaire, representing the fourth generation Upham to work at the Harvard Forest, left us at the end of January in order to go back to college. She has been replaced by Frances Phillips.

George Kenney died suddenly while doing survey work with the other members of the woods crew in Tom Swamp Tract X. George worked at the Harvard Forest for 27 years. He was an old-time citizen of Petersham and Selectman for several years, but we remember him as the cheerful man who was so much a part of the Forest. No matter what kind of work he did, or how pleasant or nasty the weather, George always knew how to make life appear better by making some encouraging remark or little joke. His position has been filled by Earl Lucas who joined us on May 1, 1978.

#### STUDENTS

The following courses were offered 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. John Torrey taught Plant Growth and Development (Biol. 165). For the 18). possible replacement of, or alternation with, the land use course (Biol. 298, see previous annual reports), Ernie Gould and Martin Zimmermann offered a new course during the fall semester entitled Trees, Forests and Man (Biol. 101). This was designed to give an overview of tree growth and the values we realize from forests both here and abroad. The course turned out to be surprisingly successful as it attracted 40 (registered) students. The initially assigned lecture room in the Science Center was too small, students were sitting on the floor and in the hall. We finally found a "home" in the Botanical Museum (above the glass flowers). A full weekend at the Harvard Forest was a part of the course; we divided the class into two groups and hired a Harvard Shuttle Bus for each of the weekends.



The woods crew during a snowstorm in March, 1977. From left to right: George Kenny, Edward Hyde, Gordon Mitchell (Photograph by Regula Zimmermann).



Above: In February the Freshmen must put on snow shoes...

During the spring term, John Torrey taught *Plant Physiology* (Biol. 11) in collaboration with Lawrence Bogorad and Frederick Ausubel. He also offered his Freshman Seminar on *Plant Propagation* with Conrad Smith. This group also spent a weekend at the Harvard Forest. John Tjepkema offered his course, *Soil Biology and Ecology* (Biol. 108) for the second time.

In February Barry Tomlinson participated in the OTS Course (78.1), Tropical biology: an ecological approach, in Costa Rica. Harvard is a member university of the Organization for Tropical Studies.

For some time we have been considering ways and means of drawing the Harvard and Yale forest enterprises closer together. As one way of starting closer working relationships, Ernie Gould taught a course on the Economics of Forest Operating Units at the Yale School of Forestry and Environmental Studies. He is also serving on three Yale doctoral thesis committees in forest economics. As time goes on we hope to broaden the area of cooperation.



... to study the woods at their first seminar meeting.

Two courses were based at the Harvard Forest. During the summer of 1977, *Plants in Relation to their Environment* (Biol. S-146) was offered for the last time. This was a successful course, but an "expensive" one in respect to time and money. As we have stepped up our undergraduate teaching during the fall and spring semester, we decided to discontinue this course and thus liberate our time during the summer for research. During the spring term the *Freshman Seminar on the Harvard Forest* was again given.

The Department of Landscape Architecture again brought their graduate students to the Harvard Forest for a few days prior to registration in September 1977.

The following students took units of undergraduate and graduate research. Christine Kacandes (Radcliffe '78) did an undergraduate honors thesis with John Torrey entitled *Excised Root Culture of Helianthus an-* nuus L. and secondary thickening. Biol. 311: Cecilia Lenk, Wood Anatomy, and German Literature on Vegetation History; Julian Hadley, Conductivity of the Xylem in Fraxinus americana.

The following graduate students, working toward a Ph.D. degree at the Department of Biology in Cambridge, have advisors located at the Harvard Forest: Dwight Baker (since October, 1977 working on his thesis research at the Harvard Forest), Julian Hadley, and David Wheat.

Sally Kleinfeldt, graduate student at the University of Michigan in Ann Arbor, continued her study on plant-herbivore interactions at the Harvard Forest. Barbara Goldoftas is assisting in her work during the summer of 1978.

Douglas Wright, on leave from Harvard College, worked in John Torrey's laboratory from October 5, 1977 to April 10, 1978. Peter Bowne (Hampshire College '78) worked in John Torrey's laboratory from September 6, 1977 until February 1, 1978 on his Division III research on nitrogen fixation in *Myrica gale*. Susan Knowlton, also from Hampshire College, has worked on her Division III research in John Torrey's laboratory since February 1, 1978.

Peter van den Tweel arrived on May 17, 1978 to spend a few months here as part of his forestry program in Wageningen, Netherlands. On plots in several typical places in the forest he is studying denitrification in the soil with John Tjepkema. He is also working with Ernie Gould planning a thinning operation in Tom Swamp I, remeasuring some long term plots and analyzing stand development.

The following persons were employed as laboratory aides at various times during the year in John Torrey's laboratory: Sarah Corey, Susan Bissell and Kathleen O'Grady. During the summer of 1978 Christa Schwintzer is assisted in her work by Lynn Disney, John Tjepkema by Colleen Kelly and Ayo Jeje by Barbara Zimmermann (Skidmore '79).

#### MEETINGS AND VISITORS

In October, 1977 the Northeast Forest Economists had another productive meeting at the Forest. This annual event is a chance for the forest economists to discuss ongoing work. There is no set program and no prepared papers, just a lively exchange of views. - The Trustees of Reservations held their annual management staff conference here for three days in November.

On April 3-5, 1978 the Harvard Forest and Cabot Foundation served as hosts to an informal conference of scientists from the United States and Canada on symbiotic nitrogen fixation by actinomycete-nodulated plants, organized by John Torrey and John Tjepkema. Thirty talks were given during the three-day program, ranging from reports on the isolation and culture of the actinomycetous endophyte to structure and function of the nodules on a number of woody dicotyledons. The participants included microbiologists, plant physiologists and biochemists as well as foresters and horticulturists. A number of reports centered on the practical usefulness of these actinomycetorhizal plants for interplanting or as a nurse crop with important forest plantations. The published proceedings of the meeting will be in the form of a special issue of the *Botanical Gazette* to be published in the future.

The 9th New England Fern Conference took place here on May 19-21, 1978. Shaler Hall was filled to capacity, as usual, for this occasion. It was again particularly well attended by students.

The 4th Cabot Symposium, held at the Forest in April, 1976 has now finally appeared in print entitled *Tropical Trees as Living Systems*, published by the Cambridge University Press (see bibliography at the end of this report).

The Harvard Forest and the Fisher Museum served again as host to numerous groups from all over New England.

Individual scientists from all over the world visited again this year.

#### BULLARD FELLOWS

Ayodeji Jeje, Senior Lecturer in Chemical Engineering at University of Lagos, Nigeria, arrived at the Forest on September 30, 1977. He is working on three research projects; transpiration and oil accumulation in the fruits of the African oil palm, Elaeis guineensis, flow resistances in xylem vessels, and cavitation in isolated xylem strands. - The work on palm fruits revealed a correlation between the rates of moisture loss from developing fruits and oil accumulation. Most of the exocarp oil is formed within three weeks in two distinct phases, an exponential rate of oil accumulation when, presumably, neutral fat globules are nucleated, and a steady growth rate of the oil in eleioplasts. Increased transpiration accompanies oil formation but even before oil formation started, transpiration was significant. - In the literature, various floating correction factors are being used to compare the xylem to ideal capillaries. In many plants a wide range is found for the factors, even for segments on the same branch. This study is an attempt to take a fundamental approach. Rings of secondary wall of various thicknesses and configurations are found in many xylem vessels. Work in progress reveals that certain wall sculptures may reduce flow resistance by as much as 40%, compared to ideal capillaries. Literature reports indicate a greater incidence of vessels with smaller diameters, but at the same time with more wall sculpturing, in plants of cool climates at higher latitudes and altitudes. It seems that the increased resistance to flow of the smaller vessel is compensated for by certain wall sculpturings. - The cavitation research is proceeding along the lines described in last year's annual report (p. 11); this work was begun when Ayo Jeje spent the summer of 1976 at the Harvard Forest with a grant from the Nigerian government.



Above: Ayodeji Jeje (left) and Barbara Zimmermann (right) checking out the high speed camera (up to 11,000 pictures per second) and the illumination system which are used to study xylem flow and cavitation.

Eliezer Zamski came to the Harvard Forest from the Hebrew University of Jerusalem on August 10, 1977. In continuation of his past studies of supernumerary phloem, he investigated the three-dimensional structure and mode of secondary growth of Avicennia, a mangrove tree. He found the following sequence. (1) Few parenchyma cells are formed by the cambium toward the inside. (2) Xylem is formed toward the inside and up to 10 files of parenchyma cells toward the outside. (3) A ring of sclereids, 1-3 cells thick, develops 1-3 cells from the outer limit of the secondary parenchyma. The sclereids start to develop very early, sometimes when only four outer cambial derivatives have been produced. (4) The cambium gradually ceases to function and phloem strands are formed by cell divisions in the parenchyma files. Only short fragments of cambium are left on the inside of the phloem. (5) A new cambium develops in the outermost parenchyma file, immediately outside the sclereids. The origin of the new cambium is therefore within the outer parenchyma, within the first derivatives of the previous cambium (see the frontispiece). The phloem strands form many tangential links within the same ring, as well as radial links between successive rings. Eli Zamski is now studying *Bougainvillea*. - Another project is the study of functional longevity of sieve tubes in *Fraxinus americana* during the period of phloem reactivation in the spring. For this he developed a histochemical test for sugar containing cells, based on the reaction of sugars with 5-diazouracil. Some of the previous year's sieve tubes are reactivated in the spring to provide sugar transport to growing points, but these are crushed when the new sieve tubes, which are connected with the new leaves, are formed.

#### RESEARCH

Ernie Gould continued his work on land-use and planning. The Massachusetts Forestry Program Review Board (whose work was briefly discussed in last year's report) achieved a striking consensus that the State Cutting Act should be revitalized. The final version of the new act proposed by the administration followed the Board's suggestions almost to the letter. The bill was favorably reported by Ways and Means but then got lost in the log jam created by the state budget dispute. It is hoped that this vital bill will get through next year. - Ernie is currently serving on the Advisory Council for the Massachusetts Heritage Program which is designed to preserve critical parts of our natural and man-made environment.

Barry Tomlinson returned from the South Pacific in August, 1977. He spent most of the fall term writing up for publication the results of the preceeding seven months field work. In collaboration with others, two books were seen through the final stages of publication (see the bibliography). Collaborative research continued with two former post-doctoral fellows, Adrian Bell (now at the University College of North Wales) on a review of rhizome geometry in plants, and with Usher Pozluszny (now at the University of Guelph) on floral morphology in sea grasses. Barry's main research activity is the study of shoot morphology in such diverse plants as *Heliconia*, *Nelumbo*, *Anisophyllea* and *Acorus*.

Larry Klotz completed the comparative anatomical survey of stems of fossil and modern palms on which he had been collaborating with Barry Tomlinson. The results of the survey support the concept of the palms as a very "natural" family, for they are distinguishable from other families of arborescent monocotyledons by a combination of anatomical characteristics of the stem. In contrast, within the family it is generally difficult or impossible to assign specimens of stems to a taxonomic group of palms with certainty because the anatomical characteristics show variability or intergradation within the taxonomic groups or even within a single stem. These results are important in the study of fossil monocotyledonous stems because they allow statements about the relation between fossil and extant groups to be made with greater precision. Larry also spent three months (January to April) teaching a course in floral biology as a substitute for Dr. Rolf Sattler at McGill University in Montreal, Canada. Tree architecture can be studied not only in morphological terms, but also from a functional point of view. With Monica Mattmüller's help, I continued to study the hydraulic architecture of some of our diffuseporous trees. Much of this work has been described in last year's report. Hydraulic conductivity (the ease with which water can move from roots to leaves) is about three times greater in the stem than in the branches. Junctions (from stem to branch, branch to twig, etc.) are hydraulic bottlenecks. The functional significance of this was discussed in last year's report. Since then we have found that the constriction at the junctions is primarily due to a narrowing of vessels immediately above the branch insertion.

Susan Sovonick-Dunford from the University of Cincinnati and Roger Lee from Memorial University of New Foundland (with a student helper, Barbara Smith), both previous post-doctoral fellows, spent the summer of 1977 here to continue their study on sieve-tube pressures in white ash.

Peter Lee is studying the quantitative histochemistry of  $\alpha$ -D galactosidase in lilac and white ash. He found the highest enzyme activity in conducting phloem and the lowest in xylem and pith. This work is aimed at a better understanding of how sugars, on their way from leaves down in the inner bark, are removed from the conducting sieve tubes to be used for growth and storage. Peter devoted a good deal of his time to preparing gas chromatographic methods for analysis of sieve-tube exudate. During the summer of 1978 he will try to find substances in the sieve tubes whose concentration varies considerably diurnally, in order to track long-distance transport along stems of tall trees.

Translocation studies, academic as they may appear on first sight, assume a very practical importance when applied to plant pathology. Pathogens as well as their metabolites are carried in the translocation streams. And of course, interruption of transport, especially water transport, can cause instantaneous death of the plant. With Barry Tomlinson and Janet McDonough, I attended the third meeting of the International Council on lethal yellowing (Jupiter, Florida, October 30 - November 3, 1977). Lethal yellowing is caused by a mycoplasma-like organism and has destroyed millions of coconut palms in the Carribean area, including South Florida. Subsequently, I was invited to attend a seminar on plant mycoplasma diseases in Taiwan (April 3 - 7, 1978), where many agricultural crops are suffering from mycoplasma diseases.

Christa Schwintzer spent most of the fall and winter analyzing data obtained in Northern Lower Michigan during the past three summers concerning bogs, swamps, fens and marshes. She is continuing her work in wetland ecology by studying the autecology of sweet gale (*Myrica gale*), a non-leguminous nitrogen-fixing shrub that occurs abundantly along the edge of Harvard Pond and throughout the extensive open area in Tom Swamp. Her primary effort is being focused on determining the amount of nitrogen fixed by these shrubs on a yearly basis, under field conditions. She wants to see if these amounts are large enough to be significant for the nutrient status of the wetlands in which sweet gale is found. Prior to registration as a graduate student at the Department of Biology, Todd Kana spent the summer of 1977 working with John Tjepkema, studying nitrogen fixation in plants that lack the root nodules in which this process normally occurs. Most such plants growing in wet soils had substantial nitrogen fixation associated with their roots, while those growing in soils of normal moisture generally had little activity. An exception was a bulrush that was growing in a soil of normal moisture content, yet had substantial nitrogen fixation. This may have been due to the compaction of the soil which created anaerobic conditions similar to those of wet soils.

John Tjepkema's own research project for the year was to measure the amount of nitrogen fixation in the soils of the Harvard Forest. Nitrogen is lost from forests by timber harvests, stream runoff, forest fires and denitrification. It has been thought that these losses are balanced in part by gains from nitrogen fixation. However, his results show that in the soils studied, nitrogen fixation is negligible compared to the input of nitrogen in precipitation. Thus it is important to consider whether forest management practices on such soils might result in nitrogen losses that exceed the inputs of nitrogen from precipitation (and any other atmospheric inputs).

The primary research effort in John Torrey's laboratory during the past year has been to understand the nature of the actinomycete which causes nodulation in *Comptonia peregrina*. Isolation and culture of the filamentous bacterium which infects roots of *Comptonia* and produces N<sub>2</sub>-fixing nodules have been confirmed and observations extended to its behavior in culture and its effectiveness in nodulating other plants by cross-inoculation. Suspensions of pure cultures of the "*Comptonia* isolate" are now known to produce effective nodules not only on *Comptonia peregrina* seedlings grown in sand culture or aeroponics, but also the closely related *Myrica gale*, *M. cerifera* and more distantly related plants including *Alnus glutinosa*, *A. crispa*, *A. rugosa* and *A. rubra*. The last of these species is especially interesting since red alder represents one of the most important commercial species among the actinomycetorhizal plants as a whole.

Cultures of the *Comptonia* isolate, together with seeds and information were sent to M. Lalonde of the C. F. Kettering Research Laboratory in Yellow Springs, Ohio in whose laboratory similar work was in progress. He confirmed observations made at the Harvard Forest and extended them. In collaboration with M. P. Lechavalier of the Waksman Institute of Microbiology of Rutgers State University, John Torrey is pursuing the chemical characterization of the cell wall and contents of the actinomycete with a view to characterizing its taxonomic position. The organism appears to belong to a previously undescribed group.

In addition, a serious effort has been made to establish the conditions under which seedlings of the different species can be grown aseptically so that studies can be made of the infection process following inoculation with the *Comptonia* isolate. Most woody species with which we are concerned have an inherent seed dormancy which presents problems, and tend to have internal microbial contamination, at least within the fruit and perhaps even the seed, which makes sterile culture difficult. This study continues with numerous problems still awaiting solution.

Using the very sensitive radioimmune assay for indoleactic acid he developed during his graduate studies, William Pengelly has been studying the auxin levels of pea nodules, pea root apices and other plant parts. He and Ann Hirsch, who has been studying the effect of boron deficiency on root growth in sunflower, are together attempting to determine whether the cessation of root elongation following boron deficiency is related directly to the auxin levels of the root tissue.

As part of a large, national research effort, Jerry Melillo of the Marine Biological Laboratory at Woods Hole, Massachusetts is carrying out a nutrient cycling study in a red pine plantation and a mixed hardwood stand in Prospect Hill Tracts I and VIII. This was started in the summer of 1977; several persons helped him during the project. The study was designed to characterize the impact of disturbance on nitrogen cycling in the two forest ecosystems. Trenches 1 meter deep were dug around 1 meter square sample plots, they were lined with plastic and refilled, and all vegetation was cut on the plot. Ammonium and nitrate of the soil moisture of sample and control plots is monitored with porous cup lysimeters. The plots at the Harvard Forest show relatively small nitrogen losses when compared with plots in northwestern forest stands. This experimental perturbation differs from clearcutting and other destructive disturbances. Ecosystem responses are separated into two components, the magnitude of the response and the rate of return following perturbation. New experiments are being started to discover how high nitrate losses are prevented.

#### FOREST OPERATIONS

The emergency salvage of conifers, wind-thrown by a storm during the late winter of 1976 - 77 and described in last year's annual report extended into September, 1977. By the end of the year, the woods crew had salvaged 29,500 board feet of logs which were sold roadside to the Curtis Lumber Company of Hubbardston, Massachusetts. Most of the above volume was red pine, but included some white pine, spruce and ash.

Large amounts of time were again spent on road clearing and brushing of trails and on building maintenance. Unusually large amounts of time and effort have also been expended on vehicle and equipment repair. This reflects the advanced age and deteriorating condition of some of our equipment. The men manage to make repairs but each year parts are becoming more difficult to obtain and more costly.

### HARVARD BLACK ROCK FOREST

John Bascietto, a graduate student from New York University, completed his field research on the ecology and microenvironment of beaver (*Castor canadensis* Kuhl). He submitted his thesis for a master's degree which was awarded early in 1978. A copy of John's research is on file in the Black Rock Forest Library.

Roderick Douglass and Brian Steinberg signed on as research aides for the summer of 1977. Rod had just graduated from SUNY College of Environmental Science and Forestry at Syracuse. He was accepted as a graduate student at Purdue University beginning in September, 1977. Brian, a workstudy student from Harvard, had just completed his sophomore year in liberal arts. Their major contribution to the Forest was an in-depth inventory of vegetation in Compartment II, northwestern portion of our property. They also assisted with several maintenance projects.

The periodic remeasurement of silvicultural study plots established back in the 1930's continues to occupy considerable time and energy. The most recent series to be checked was 4a2 and 4a-2c, located near Arthurs Pond. We have remeasured the walnut trees surrounding the office building on Continental Road and made new survival counts on the conifers planted in the clearcuts created in 1971, 1972 and 1973.

The girdling - thinning experiment on Old West Point Road in Compartment V is nearly completed. Cordwood sales resulted from this operation as well as from thinning at the north end of Compartment IV near Pecks Pond. We benefitted by the ready accessibility of both cuttings during the winter when virtually every segment of the Forest was impassable due to deep snow conditions.

Plans have been carefully formulated to thin a small stand of oakmaple in Compartment XII near Sutherland Pond. To date, a complete inventory has been made and the trees to be cut are marked. Logging is scheduled to begin in July or August, 1978. Since this cutting is traversed by the Scenic Trail, we intend to take extraordinary measures to leave it in the best condition possible and to use it as a demonstration of "good" forestry.

The north end of the Old Continental Road was abandoned about ten years ago because it proved too costly to maintain for vehicle use. However, the roadbed serves as a trail and many people use it to gain access to the Forest. On this road a bridge crossing Canterbury Brook had rotted so badly that it became a hazard even to pedestrians. We ripped out the old stringers, replaced them with durable railroad ties, and covered these with treated planks. At the present time that same bridge will easily sustain the weight of a fully loaded dump truck.

The Forest continues to attract many hundreds of visitors from near and distant places. This past April, Jack Karnig conducted a guided tour for local hikers under the partial auspices of the Cornwall Conservation Commission. About twenty-five persons attended and marveled at seeing the New York City skyline from the summit of Eagle Cliff.

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This is a list of publications which have appeared in print between July 1, 1977 and June 30, 1978. 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.

Petersham, Massachusetts August, 1978 Martin H. Zimmermann Director



This Harvard Forest seal was designed, hand carved in mahogany and presented to the Harvard Forest by Phil Craul who was a Bullard Fellow in 1976-77 (see last year's annual report). It is now mounted in the entrance of Shaler Hall.