



# THE HARVARD FOREST, 1978-79

Harvard University



*Frontispiece: These white-faced hornets knew how to make paper from wood fibers millions of years before we did. There was a nest that reached enormous proportions on the maple tree next to the garage. Its growth was observed and photographed, and the snow finally brought it down. In this photograph by William Ormerod, a worker can be seen adding a strip of paper to an outside wall.*

ANNUAL REPORT OF HARVARD UNIVERSITY ACTIVITIES  
AT THE HARVARD FOREST 1978-79

STAFF

The staff during the year consisted of the following persons:

Stanley R. Gemborys, Bullard Fellow  
Ernest M. Gould, Jr., Forest Economist, Senior Lecturer in Biology  
David E. Hibbs, Research Fellow in Silviculture (from September 1, 1978)  
Hisao Honda, Bullard Fellow (from April 9, 1979 until June 4, 1979)  
Ayodeji A. Jeje, Bullard Fellow (until September 30, 1978)  
Jack J. Karnig, Forest Manager  
Larry Klotz, Cabot Research Fellow (until August 15, 1978)  
Peter Kung Woo Lee, Cabot Research Fellow  
Walter H. Lyford, Soil Scientist, *Emeritus* (deceased March 11, 1979)  
William Pengelly, Cabot Research Fellow  
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*  
Christa R. Schwintzer, Honorary Research Fellow  
John D. Tjepkema, Assistant Professor of (Soil) Biology  
P. Barry Tomlinson, Professor of Botany  
John G. Torrey, Professor of Botany  
Lawrence J. Winship, Research Associate (from October 1, 1978)  
Eliezer Zamski, Bullard Fellow (until August 31, 1978)  
Martin H. Zimmermann, Charles Bullard Professor of Forestry and  
Director of the Harvard Forest

Supporting personnel included:

Alison Berry, Research Assistant  
Catherine M. Danahar, Business Secretary and Librarian  
Lynn Disney, Research Assistant  
Wayne E. Elliott, Custodian  
Karen Esseichick, Research Assistant  
Vibeke Holm, Assistant to the Librarian  
Edward H. Hyde, Woods Crew  
Colleen Kelly, Research Assistant (until June 15, 1979)  
Shirley P. LaPointe, Greenhouse Assistant  
Earl O. Lucas, Woods Crew (until August 18, 1978)  
Ralph Lundquist, Research Assistant (from March 5, 1979)  
Monica R. Mattmuller, Research Assistant  
Jeffrey McElroy, Research Assistant (until February 28, 1979)  
Donald C. Mitchell, Assistant to the Manager of the Black Rock Forest  
Gordon B. Mitchell, Woods Superintendent  
Frances E. O'Brien, Secretary  
William S. Ormerod, Research Assistant (from July 8, 1978)  
Frances N. Phillips, Secretary  
Dorothy R. Smith, Secretary  
Charles C. Spooner, Woods Crew (from May 21, 1979)  
Charles F. Upham, Woods Crew, retired (working part-time)



On March 11, 1979 we received the sad news of Walter Lyford's sudden death. Walter was the Forest's Soil Scientist from 1960 until his retirement in 1976 when he moved to his home in Sturbridge. He still came occasionally to Petersham to complete some of his work. We always enjoyed his cheerful presence. Two of his papers are in an editorial stage and will probably be published as Harvard Forest Papers in the near future.

Larry Klotz, who worked in Barry Tomlinson's group on vascular anatomy of monocotyledons, left us in August 1978 to take up the position of Assistant Professor in the Department of Biology in Shippensburg State College in Shippensburg, Pennsylvania. David Hibbs is our new silviculturist. He arrived here in the fall of 1978 after having received his PhD in the Department of Forestry and Wildlife Management of the University of Massachusetts in Amherst. He did his thesis on the life cycle, demography and seed dormancy of striped maple with Brayton Wilson who had himself, a number of years ago, been a staff member at the Harvard Forest. Another new research associate is Larry Winship; he is working with John Tjepkema and did his graduate work in the Department of Biological Sciences of Stanford University on nitrogen assimilation in lupins.

Jeffrey McElroy, our greenhouse man, left us in February in order to make a collecting trip to South America and to take up graduate studies at Cornell in the fall of 1979. He has been replaced by Ralph Lundquist, a resident of Petersham. Earl Lucas of the Woods Crew left us last year; he was replaced by Charles Spooner. Colleen Kelly, Research Assistant to John Tjepkema, left us to take up graduate studies at the University of Illinois.

On October 25, 1978, during the National Convention of the Society of American Foresters in St. Louis, Missouri, Martin Zimmermann was given the Barrington Moore Memorial Award "for outstanding achievement in biological research contributing to the advancement of forestry". This is a particular honor as this was, to our knowledge, the first time that the award was given to a person who is not a member of the Society. -- At the Annual Meeting of the New England Section, Society of American Foresters, in Burlington, Vermont on March 8, 1979, Ernest Gould was given an inscribed plaque for "distinguished service to the forestry profession".

## 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), at the same time he taught a new course, *Biology of Gymnosperms* (Biol. 102), and Martin Zimmermann gave *Structure and Physiology of Trees* (Biol. 111). During the spring term, John Tjepkema offered *Soil Biology and Ecology* (Biol. 108), Barry Tomlinson *Plant Form and Structure* (Biol. 168) and (with Tom Givnish) *Biological Plant Morphology* (Biol. 210), and John Torrey (with Conrad Smith) Freshman Seminar on *Plant Propagation*; the latter included two weekend trips to the Harvard Forest. Dwight Baker taught a tutorial course entitled *Aspects of Biological Nitrogen Fixation*. Tutorial courses appear collectively under the number 99hf in the catalog and are taught over the fall and spring semesters.

During the summer of 1978, Barry Tomlinson taught *Plants of the Tropics* (Biol. S-105) at the Fairchild Tropical Garden with Peter Stevens of the Arnold Arboretum as co-instructor.

Two courses were based at the Harvard Forest. In the fall Ernie Gould and John Tjepkema, with the assistance of Christa Schwintzer and David Hibbs, offered *Soil, Land and Human Environment* (Biol. 298). In the spring we again had the *Freshman Seminar on the Harvard Forest* which is a joint effort of all of us.

Close collaboration with the Yale School of Forestry and Environmental Studies continued. Ernie Gould taught a course at Yale on *The Economics of Forest Operating Units* (730B), and David Smith, Yale's silviculturist, brought his class up to the Harvard Forest for a weekend in March. Other collaborative efforts include John Torrey's teaching with Natural Sciences Division Faculty one day a week during the fall term at Hampshire College in Amherst, Massachusetts, *Grass, Sheep and Dogs*, establishing the New England Farm Center.

Barry Tomlinson participated in teaching *Fundamentals of Tropical Ecology* (79.1) given by the Organization for Tropical Studies in Costa Rica during February.

The Department of Landscape Architecture again brought their graduate students to the Harvard Forest for a few days prior to registration in September 1978.

The following students were engaged in independent studies, working toward their PhD degrees with members of our staff: Dwight Baker, Ann Bubnitz, Julian Hadley and David Wheat. David Wheat passed his thesis exam in January, 1979. He will stay on for a few months in Cambridge as a post-doctoral fellow of Barry Tomlinson.

Kathryn Saterson, a special student, took an independent course (Biol. 299) with John Tjepkema, *Soils and Old Field Succession*. Two students from overseas spent a few months here, Peter van den Tweel from Wageningen (see last year's report) returned to the Netherlands in October, 1978. Beate Hass-

pacher from the Swiss Federal Institute of Technology stayed at the Forest during April and May, 1979 to see some of our work on the functional aspects of wood anatomy. She began a project on the measurement of vessel lengths.

We occasionally serve on thesis committees at other universities. Thus, Ernie Gould is on the committee of four forestry students at Yale, namely, Clark Binkley, Pierre LaFond, Denise LaFond and Richard Kelley. The first of these finished his degree during the past year. Martin Zimmermann serves on two thesis committees of the University of Maine, Christopher Murdoch and Steven Day, both working on pathology problems of the American elm. John Torrey not only collaborates with Hampshire College, where he served as an advisor to the undergraduate research project of Susan Knowlton, he is also a Research Associate of the University of Massachusetts and serves on the thesis committee of Dale Callahan, who was a research assistant here earlier and Allison Berry, who is now a research assistant in his laboratory at the Forest.

Two Yale forestry students are stationed here for the summer of 1979 in connection with the Yale-Harvard joint program. Dwight Jensen is assisting with the silvicultural work of David Hibbs and Stan Gemborys; Keith Kreit is helping John Torrey and Christa Schwintzer with their research on nitrogen fixation. Amelia Maloney is helping in John Torrey's laboratory during the summer of 1979.

## MEETINGS

The Forest was host to many meetings again this year. In September 1978, the third annual A. LeRoy Andrews Bryological Foray took place here for the first time. There were about thirty-five participants. In November 1978, the Northeast Forest Economists met here again. Also in November we hosted the first Annual Northeast Paleobotanical Conference. In January there was another informal gathering to discuss nitrogen fixation, organized by the group who work here on this topic. In March a number of botanists came to Petersham in order to discuss tropical botany at Harvard, an assessment of present capability and future needs.

In May a group of twenty-five scientists from a diversity of fields - medical, mathematical, botanical, geomorphological, paleontological and engineering - met to discuss methods of analyzing "tree" shape, taken in its broadest sense, i.e., a network with only one possible pathway between any two points in the system. This meeting entitled *Mathematical Trees in Principle and Practice* was organized jointly by Barry Tomlinson and Tom McMahon of the Department of Engineering and Applied Sciences.

At the end of May, 1979, the tenth Annual New England Fern Conference met here again.

## YALE - HARVARD JOINT PROGRAM

When Charles H. W. Foster became Dean of the Yale School of Forestry and Environmental Studies, he hoped to bring about closer understanding between interested people at Yale and Harvard. Hank had been a Bullard Fellow at Harvard and was on the Board of Overseers so his interest in both institutions was natural. Through his efforts the Yale - Harvard Joint Program of Forest Studies got underway in 1979 for an experimental three-year period.

We plan to cover common interests in forest biology, forest economics and policy, forest management and forest information. The first meeting of representatives of both faculties was held in Petersham this spring to find which of these common interests would benefit from closer cooperation.

Ernie Gould is acting as program director in close collaboration with Dave Smith at Yale. Guidelines for project proposals have been set up and Hank has been able to find private contributions of financial support. Eventually we hope to find support for three doctoral and post-doctoral fellowships, but meanwhile, work in several areas of interest can go forward. A number of the present projects are described elsewhere in this report. From this small start we hope to see a new era of cooperation start between Yale and Harvard that will benefit all who are concerned with forest resources.

## BULLARD FELLOWS

Stanley R. Gemborys, Associate Professor of Biology at Hampden-Sydney College, is working on the structure, dynamics and pattern of the hardwood forests of the Bowl Natural Area, Wonalancet, New Hampshire, a cirquelike structure located in the White Mountains. Indications are that it has never been cut or burned and that the last significant natural disturbance was the hurricane of 1815. Large segments of the Bowl were unaffected by this event, leaving stands that developed without disturbance for over 400 years. A successional scheme was created based on studies of forty-five 20 x 30 m plots. The initial state is composed of young yellow birch invading after a catastrophic windstorm. As the forest develops, beech and sugar maple become established and eventually replace the yellow birch. The ultimate forest is not of static composition but oscillates between beech and sugar maple dominance. Seven of the sample plots were used to study the effect of microtopography with the aid of a computer program developed by workers of the Yale School of Forestry and Environmental Studies. This showed that yellow birch seedlings are common on the edges of the hollows. Soil transects showed formations similar to those found in the Harvard Forest by Earl Stephens in the late 1950's (see the paper by Oliver and Stephens cited in last year's annual report). -- Tree age and diameter are commonly thought to be closely related, but in some cases they are not (e.g. the paper by Oliver in the bibliography). A variety of forest types are being studied to clarify this question.

Hisao Honda of the Kanebo Institute for Cancer Research, Kobe, Japan, visited the Harvard Forest from April through June as a Bullard Fellow. He has extensive experience in theories of development. Here at the Forest he worked with Barry Tomlinson on the simulation of tree growth, using the computer facilities in Cambridge. During his stay he was able to elaborate existing programs for artificial tree models, based partly on information obtained from a study of actual trees during a visit to Fairchild Tropical Garden in Miami. Dr. Honda will continue the development of these programs in Japan.

## RESEARCH

Ernie Gould continued his research in land use with an increasing emphasis on the problems of rural assessment and taxation. In addition, he reviewed the present forest land use situation in each of the New England states and New York in preparation for a meeting late in July. Ernie continues to apply his expertise in various types of public service. He continued on the advisory board of the Massachusetts Heritage Program which is now fully manned and collecting data on rare and endangered species, points of geologic interest and on landscapes of historic significance and outstanding attractiveness. The legislation recommended by the Forestry Program Review Board (see the last two annual reports) is being considered again by the General Court. Because many interested people, especially legislators, had never seen the report of the Review Board, the Board members contributed enough money to publish it. This must set some kind of record for devotion to duty among volunteer state boards. We hope that with better information available, the legislature will vote favorably this year.

Barry Tomlinson is doing a survey of the vascular anatomy of the family Araceae in collaboration with James C. French, a post-doctoral fellow working at the Fairchild Tropical Garden with support from the National Science Foundation. The aroids are very diverse in their vegetative morphology, with frequent sympodial branching. Preliminary observations show a diversity of vascular modifications much greater than that of any other family of monocotyledons. Other collaborative efforts include a review of rhizome geometry in herbaceous plants with Adrian Bell, a former Cabot Research Fellow, now at the University College of North Wales, Bangor, Wales. This survey shows that patterns are precise and have considerable adaptive significance. After completing his PhD, David Wheat is investigating the way in which the vascular system of the monocotyledonous vine *Flagellaria* develops at levels where the stem dichotomizes. Barry Tomlinson's other research includes studies of 3-dimensional anatomy of *Lycopodium* and the morphology and anatomy of aquatic monocotyledons in preparation for a volume of the series "Anatomy of Monocotyledons".

Karen Esseichick, who works in Barry Tomlinson's laboratory, reorganized the Harvard Forest herbarium which was assembled mostly in or before 1945. It was found to include approximately 2300 sheets representing plants native to Petersham, a total known flora of 713 species. With the aid of this herbari-



um, which is being updated as needed, an illustrated key to the local flora is being made for later student use.

Following previous work by Stephens, Raup, Swan and Oliver here at the Forest in the study of succession, David Hibbs is investigating vegetation changes following the 1938 hurricane. This study is unusual in that it is not merely concerned with old field succession but utilizes permanent plots set out right after the hurricane and periodically remeasured. David Hibbs is also interested in gap dynamics - forest processes related to small openings within the forest. He is investigating how size of the opening affects species survival. Different species are adapted to different light and water conditions; long-term forest composition is therefore considerably influenced by gap dynamics.

Although the old riddle of how sap ascends into the tops of trees was solved in principle years ago, there are interesting aspects about which we know very little. Vessels are of limited length for reasons of safety. For example, if a vessel is injured, it becomes air-filled, but damage is confined to the individual compartment. Investigations are now under way in Martin Zimmermann's laboratory to study how water flows through wood. Wall-staining dye can be applied to a small section of the xylem. The dye track is later followed with the shuttle microscope; the resulting motion-picture film shows how the water has moved from one vessel to another. We have also found by the same method that non-conducting vessels can usually be traced to injuries.

In the late winter of 1979 studies were begun in collaboration with Robert Gregory of the U. S. Forest Service in Burlington, Vermont on the diurnal changes of pressure in the wood of maple and other trees. This study is aimed at a better understanding of maple sap flow.

Motion pictures are also a useful way to study phloem transport. David Fensom of Mt. Allison University in Sackville, New Brunswick, has assembled a sizable group of investigators to study the transport of  $^{14}\text{C}$ -marked sugars. Radioactivity profiles are obtained every few seconds along the stem of a plant. We put these successive profiles on motion picture film in our laboratory; the resulting moving radioactivity profile makes some aspects of translocation directly visible. -- Peter Lee continued his chromatographic analysis of sieve-tube exudate and found that the D-mannitol/sugar concentration ratio of white ash shows diurnal fluctuation. It is hoped that this will give us the basis for a series of ratio-wave experiments during the present summer.

Christa Schwintzer continued her field studies of the ecology of sweet gale (*Myrica gale*) at Harvard Pond. She determined the seasonal pattern of nitrogen fixation, the effect of root temperature on nitrogen fixation, and the annual rate of nitrogen fixation. Nitrogen fixation by root nodules began in late May when the leaves unfolded, reached its maximum rate in July and stopped in late October several days after all leaves had fallen. Nitrogen fixation was strongly temperature dependent within the range of temperatures observed in the field, having low values at  $5^{\circ}\text{C}$  and increasing with temperature to above  $20^{\circ}\text{C}$ , the highest soil temperature measured. Year-



*Christa Schwintzer examining a weekly air temperature record at the instrument shelter in the open peatland of Tom Swamp. (Photograph by William Ormerod)*

ly rates of nitrogen fixation at both the lakeshore and the open peatland (24 and 34 kg N/ha x yr respectively) were equivalent to 4-5 times the amount of nitrogen added by rain- and dustfall, the largest other known input of nitrogen to these sites. The amounts fixed provide a substantial fraction of the nitrogen requirement of the sweet gale shrubs and when released to the wetland system through decay of leaves and other dead plant parts, make a major contribution to the nutrient status of the wetlands in which sweet gale is found.

One of John Tjepkema's research projects has been to investigate the rate of denitrification in forest soils. This work was carried out by Peter van den Tweel in the summer of 1978 and by Colleen Kelly in the spring of 1979. Nitrous oxide flux was used as a measure of denitrification, and the results indicate that denitrification is very low in typical soils of the Harvard Forest. Thus it is probably not a significant source of nitrogen loss from our soils.

The other major project has been measurement of the energy required for nitrogen fixation. The initial investigation was a comparison between root nodules of legumes, which are formed in association with rhizobia, and the nodules of the woody plants that are induced by actinomycetes. It was found that the energy used for nitrogen fixation by the two groups of plants was surprisingly similar. This was not necessarily expected, in view of the major differences between the two kinds of nodules in such things as the means of oxygen regulation.

Larry Winship continued these studies of the energy cost of nitrogen fixation by studying the gas exchange of intact, attached nodules, mostly of alder. He is measuring the effect of environmental parameters, such as nodule temperature, oxygen concentration and shoot photosynthesis upon nitrogen fixation and nodule respiration. In collaboration with Ken Reed of Yale, Larry is designing and constructing a system to study leaf gas exchange of nitrogen-fixing plants. This work is going on at Yale and is supported by funds from the Yale-Harvard joint program fund.

John Torrey's group has made excellent progress in the study of the bacterial symbionts which cause the formation of nitrogen-fixing root nodules on a range of woody dicotyledonous plants. With the knowledge gained from the successful isolation by Dale Callahan last year of the actinomycete from *Comptonia peregrina* (a *Frankia* sp.), they have now successfully isolated and tested several other species from other hosts. Using the microdissection method, Alison Berry isolated the endophyte from the red alder (*Alnus rubra*). She has shown it to be both infective and effective in fixing atmospheric nitrogen in a number of hosts including *Alnus rubra*, *A. glutinosa*, *A. viridis* ssp. *crispa*, *Comptonia peregrina* and several *Myrica* species.

Using sucrose-gradient fractionation, Dwight Baker isolated an effective endophyte from *Alnus viridis* ssp. *crispa*. This isolate also cross-inoculates widely within the genus *Alnus* and *Myrica* species. In addition, he isolated an actinomycete from root nodules of *Elaeagnus umbellata*. This species is interesting; it causes nodule initiation and development, but the internal structure of the endophyte is abnormal and the nodules are incapable of fixing dinitrogen.

Susan Knowlton has been studying a complication of the infection process in actinorhizal plants. The microorganism *Frankia* lives in the soil, probably in filamentous form, but also in resistant spores. Infection of the host plant is by penetration of root hairs. The present evidence from aseptic culture studies of seedlings of *Alnus rubra* suggests that *Frankia* alone is unable to penetrate the root hair but requires the presence in the root environment of other microorganisms, probably other bacteria which cause root hair deformation, making the root hair susceptible to infection.

In April, 1979 an International Workshop supported by the National Science Foundation and entitled *Symbiotic Nitrogen Fixation in the Management of Temperate Forests* was held at the School of Forestry, Oregon State University, Corvallis, Oregon. Seven of John Torrey's group were invited to attend and received travel support for participation.



*Early invasion of nodule cortical cell in Casuarina glauca. Mag. ca. x4160. (Scanning electron micrograph by Dwight Baker)*

John Torrey spent the summer of 1978 in Hawaii at the Institute of Pacific Islands Forestry with Roger Skolmen, Project Leader of the Institute, studying the occurrence of actinomycete-induced nodulation on roots of the eight or more species of *Casuarina* that occur on the islands. Field collections of root nodules and seeds of *Casuarina* were made on three of the islands. Species identification was greatly aided by the computerized records of Forest Service plantations. *Casuarina* (ironwood or Australian pine) is a woody dicotyledon native to Australia, but widely planted. In the United States it grows in Hawaii, Southern California and Southern Florida. It grows well in poor soil as it fixes nitrogen and is therefore often used in land reclamation. Efforts are now being made to isolate and culture its actinomycete endophyte.

## FOREST OPERATIONS

As our woods crew was reduced to two men for most of the year, they were kept busy primarily by maintenance work such as mowing, clearing roads and trails, repairing equipment, snow removal. During mid-winter they repaired and painted windows of Shaler Hall. Less than 2% of crew time was spent on woods operations but a few trees were cut in Tom Swamp I near Sunset Lane. This operation was the continuation of a small scale cutting mentioned in last year's report. However, we expect that our forest operations will increase again in the near future. A larger flow of wood from our forest should help to bear the sharply increasing cost of heating which is at this moment done primarily with oil.

## HARVARD BLACK ROCK FOREST

Detailed tree measurements in many locations date back to the early days of the Forest. Harold Tryon collected these data with great precision; Benjamin B. Stout, during his tenure, carefully remeasured the same trees in these permanent sample plots. This procedure continues to the present on a schedule of every five years. Remeasurement took place this past winter in Compartment IV just south of the Clark Lot. It is interesting to note that trees thinned twenty years ago are growing four times faster than comparable specimens left in a natural, crowded condition.

The girdling-thinning experiment on Old West Point Road in Compartment V has been completed. This cutting was a financial as well as an aesthetic success. Located as it is, alongside the primary access into the Forest, we advertize proper management and stewardship of our timber resource.

The thinning operation in Compartment XII mentioned in last year's report is nearing completion. Don Mitchell, Assistant Manager, has been working at this site when road conditions permitted access. So far, the logging impact in terms of slash buildup is minimal when viewed from the road or from the Scenic Trail.

Continued high density of deer in the Forest is causing some problems in establishment of regeneration following timber harvests. Periodic checks of recently logged areas reveal a disturbing lack of oak seedlings. This situation continues to prevail in spite of three successive hunting seasons when antlerless deer have been fair game for party permit holders. Plans have been made by the Department of Environmental Conservation to enlarge the permit area and to issue a larger number of permits this coming fall. Only time will tell whether this change will accomplish the intended purpose of thinning the deer herd.

The Continental Road barn required rehabilitation of a part of its foundation and siding. This work was contracted out. Interior repairs were done with oak planks sawed from four trees from the Forest.

Road repairs this spring occupied the customary weeks of concentrated effort. Culverts needed to be replaced and covered with fill material. Most of our road network needed regrading and ditching. Assistance in the form of manpower came from members of the Black Rock Fish and Game Club. On June 23 and 24, 1979, forty men from the Club labored each day on the roads; a dramatic improvement was observed as a result of their efforts.

Jack Karnig's affiliation with the Cornwall Conservation Commission, spawned another cooperative venture between the Forest and Town of Cornwall. With State financial assistance the Commission hired a summer employee to locate, measure, describe and map town wetlands. Using the Forest for a headquarters, Richard Terpening conducted the wetland survey under Jack Karnig's supervision. The project reached its successful completion on August 18, 1978.

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This is a list of publications which have appeared in print between July 1, 1978 and June 30, 1979. 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, 1979

Martin H. Zimmermann  
Director