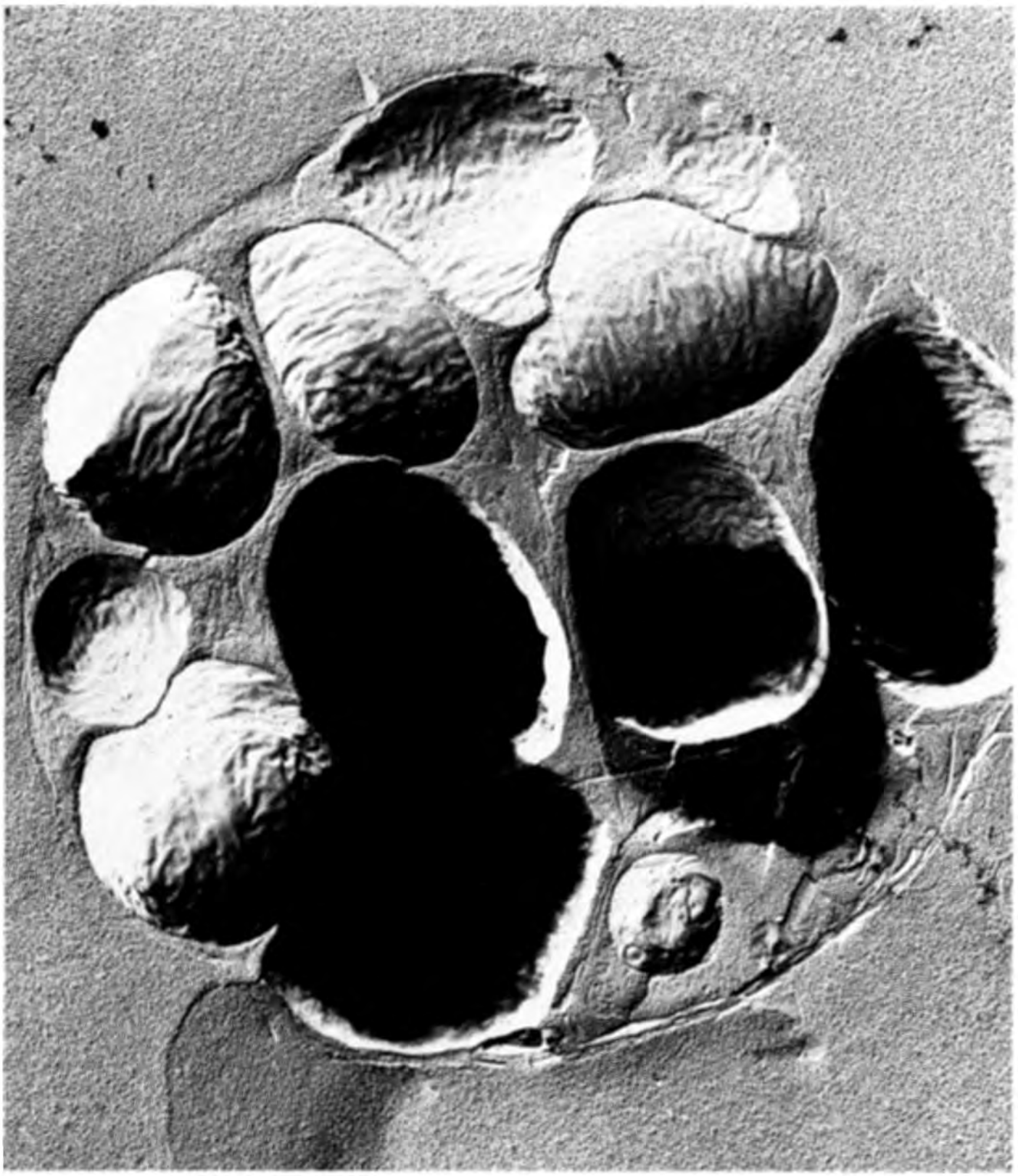
THE HARVARD FOREST, 1985-86

Harvard University



ACKNOWLEDGEMENTS

The Harvard Forest, as with all budgetary units within Harvard University, operates under the long-adhered-to dictum, "each tub on its own bottom". Applied to financial matters, this rule means that the Harvard Forest must pay its own way - from endowments, from federal grants, from gifts from foundations and other private agencies, and contributions from private citizens interested in the purposes and activities of the Harvard Forest and its faculty and staff. The Harvard Forest does not share directly in the University income from tuition, from University fund-raising campaigns or from other endowments. Again this year our research activities have been generously supported by the federal government and by foundations. Our on-going operations have been made possible by funds from endowments, and by gifts. Especially appreciated are the unrestricted gifts from Friends of the Harvard Forest whose annual contributions bring not only real support to our efforts but provide in addition the expression of confidence and interest in what we do each succeeding year.

Contributions during the year reported here include the following donors to whom we are indebted:

Atkins Garden Fund
Maria Moors Cabot Foundation for Botanical Research
Friends of the Harvard Forest
Andrew W. Mellon Foundation
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United States Department of Agriculture, Competitive Research Grants, Forestry
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United States Department of Energy
Marion and Jasper Whiting Foundation

A greatly enlarged view (44,000 x) is shown of a young sporangium of Frankia *sp HFPCpI1 grown in culture. The bacterium was originally isolated from root nodules of the sweet fern,* Comptonia peregrina, *and grown in pure culture in a nutrient medium in which it sporulates abundantly. The individual bean-shaped spores are approximately 1/1000th of a millimeter in diameter. Under favorable conditions, the spores will germinate, growing into filamentous colonies capable of reinfecting roots of* Comptonia *and forming symbiotic* N_2*-fixing root nodules. This freeze-etch electron microscope photograph was taken by Dale Callaham.*

ANNUAL REPORT OF ACTIVITIES AT THE HARVARD FOREST

1985 - 1986

STAFF

Paul O. Bofinger, Bullard Fellow (through August 1985)
Emery Boose, Computer Assistant
John Brady, Assistant to the Manager of the Black Rock Forest
Marcia Brightman, Librarian (part-time)
Garth Dickson, Woods Crew (part-time from September 1985 through April 1986)
Elaine Doughty, Laboratory Assistant (part-time)
John Edwards, Physical Plant Manager
Wayne E. Elliott, Custodian
Barbara J. Flye, Clerk Typist
Mark S. Fontaine, Research Assistant (from June 1986)
David R. Foster, Assistant Professor of Biology
Jerry F. Franklin, Bullard Fellow (September 1985 through June 1986)
Arturo Gomez-Pompa, Bullard Fellow (through August 1985)
Ernest M. Gould, Jr., Forest Economist, Senior Lecturer on Biology, Assistant Director of the Harvard Forest
Anne K. Hachey, Greenhouse Assistant (part-time)
Jeffrey A. Hart, Atkins Post-doctoral Fellow (through January 1986)
Edward Hyde, Woods Crew
Adrian M. Juncosa, Post-doctoral Fellow (through April 1986)
Jack J. Karnig, Forest Manager, Black Rock Forest
Hayes Lamont, Post-doctoral Fellow
Ralph L. Lundquist, Head of Greenhouse
Monica R. Mattmuller, Research Assistant
Gordon B. Mitchell, Woods Crew Superintendent
Frances O'Brien, Secretary
John Ogden, Bullard Fellow (from June 1985 through April 1986)
William A. Patterson, Bullard Fellow (through August 1985)
Frances N. Phillips, Secretary
Suzanne Racette, Research Assistant
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*
Stephen Safo-Sampah, Post-doctoral Fellow (from February 1986)
Dorothy R. Smith, Secretary
Charles C. Spooner, Woods Crew
Kevin Spooner, Woods Crew (part-time from June 1985 through June 1986)
C. Dana Tomlin, Associate of the Harvard Forest, Associate Professor of Landscape Architecture, Graduate School of Design
P. Barry Tomlinson, E. C. Jeffrey Professor of Biology
John G. Torrey, Charles Bullard Professor of Forestry and Director of the Harvard Forest
Julie Whitbeck, Research Assistant (from October 1985)
Gordon G. Whitney, Bullard Fellow (from July 1985 through July 1986)
Patricia H. Young, Laboratory Technician
Beata Zagorska-Marek, Visiting Scholar (through September 1985)
Jacek Zakrzewski, Bullard Fellow (through September 1985)

Ernest M. Gould, Jr., Assistant Director and Forest Economist at the Harvard Forest in Petersham was elected a Fellow of the Society of American Foresters in recognition of "outstanding service to forestry and the Society of American Foresters". Dr. Gould, who has served on the Harvard Forest staff since 1950, currently chairs the Massachusetts State Forestry Committee that wrote the Commonwealth's present regulations for forest-cutting practices. Gould also serves on the Massachusetts Forest Resources Advisory Council as its chairman and on the Massachusetts Water Resources Authority Advisory Committee.

In early February a reception was held at Shaler Hall celebrating the publication of P. Barry Tomlinson's *The Botany of Mangroves*, one of the Cambridge University Press Tropical Biology Series. Dr. Tomlinson was on sabbatical leave for the fall term 1985, travelling to New Zealand with stops at research institutions in England, Fiji, Sri Lanka, Singapore and Australia. During the spring term 1986, he returned to Australia for a brief visit to serve as a member of a review committee at the School of Botany, University of Melbourne. With the help of a grant from the Whiting Foundation, he spent several weeks at University College, Dublin as Visiting Professor assessing a slide collection on conifer embryology of the late Professor Joseph Doyle of that institution. The Doyle collection is now housed in the National Herbarium, Glasnevin, Dublin.

At the annual meeting of the Botanical Society of America held in Gainesville, Florida in August 1985, a Certificate of Merit of the Society was awarded posthumously to Martin H. Zimmermann in "appreciation of his singularly imaginative approaches to botany .... He is remembered for the breadth and precision of his scholarship, the enthusiasm and exhilaration of his teaching". Mrs. Zimmermann was in attendance at the meeting and accepted the Certificate. Martin was Director of the Harvard Forest from 1969 until 1984.

Former Director of the Harvard Forest, Albert C. Cline died on October 29, 1985 in Dunedin, Florida at the age of 93. Mr. Cline was Assistant Director under both Professor Richard Fisher and Ward Shepard, serving as Director from 1939 to 1946. Cline earned masters degrees in forestry both from the State University of New York at Syracuse and in 1923 from Harvard University. During World War II, Mr. Cline served in the Lumber and Products Division of the War Production Board and later served as Director of Foreign Forestry Services of the United States. In 1973 he was honored by the Society of American Foresters for 50 years of service to the organization.

John G. Torrey, current Director of the Harvard Forest, appeared briefly in a TV segment of the New England Science Gazette of the Eastern Educational Network, aired locally on Channel 2 Boston and Channel 57 Hartford. Dr. Torrey discussed the importance of symbiotic nitrogen fixing trees such as *Casuarina* for fuel wood and multiple purpose use in the developing countries of the tropics and sub-tropics. A full day of filming at Petersham was distilled into less than five minutes on the screen.

Ernie Gould accepts the certificate of his election as a Fellow of the Society of American Foresters from John Hibbard (left), Chairman of the New England Section. (Photo by Charles Levesque)

COURSES AND STUDENTS

Teaching by faculty on the staff of the Harvard Forest is divided between Cambridge and Petersham. During the fall term *Introduction to the New England Landscape* was given jointly by Dana Tomlin and Richard Forman to students of the Harvard Graduate School of Design, using the Harvard Forest and Petersham as their base.

In the spring term, Dr. Torrey gave his Freshman Seminar in *Plant Propagation* jointly with Dr. John Einset of the Arnold Arboretum and Mr. Conrad Smith of the Biological Laboratories in Cambridge. Field trips brought the students to Petersham on two weekends and to the Arnold Arboretum on two visits. Much of the class time was devoted to hands-on work in the greenhouses in Cambridge. Dr. Torrey contributed lectures on symbiotic nitrogen fixation to Biology 11, *Plant Physiology*.

Dr. Gould and Dr. Foster taught Biology 101, *Trees, Forests and Man*, a Cambridge lecture course with a weekend field trip to Petersham in the fall term. They also ran the Freshman Seminar on the *Harvard Forest* in the spring term, bringing students out to work at the Forest on four weekends concluding with research projects that involved all of the Forest faculty.

Dr. Foster directed Biology 204, *Topics in Paleoecology*. This spring the subject was Fire Ecology and participants included advanced undergraduates, graduate students and post-doctoral students.

In June 1986 Dr. Tomlinson, together with Dr. Peter F. Stevens, presented through the Summer School Program of Harvard University the well-established and popular course, Biology S-105 on *Plants of the Tropics*. This course is given at the Fairchild Tropical Garden, Miami, Florida and offers students at Harvard and other universities an opportunity to be exposed to tropical botany.

Deborah Marvel completed her PhD research and submitted her thesis in May 1986 (see Bibliography). Although her degree was in the Department of Organismic and Evolutionary Biology under the supervision of Dr. Torrey, her research on the molecular biology of a symbiotic nitrogen-fixing tree was carried out with Dr. Fred Ausubel in the Department of Molecular Biology of the Harvard Medical School at Massachusetts General Hospital. Upon the completion of her degree, Deborah took up an NIH post-doctoral fellowship in the Biological Laboratories in Cambridge with Dr. V. R. Ambrose, working with the molecular biology of development in nematodes.

Paul M. Rich completed his research for the PhD degree in November of 1985 in the Department of Organismic and Evolutionary Biology. His thesis was devoted to the mechanical architecture of arborescent rain forest palms of Costa Rica focused on *Welfia georgii* and *Iriartea gigantea*, members of the flora at the La Selva Biological Station in Costa Rica. His studies spanned the disciplines of biomechanics, developmental morphology and forest ecology. While at the Harvard Forest during the fall term, Paul presented a demonstration seminar on the application of his image processing system to a range of biological problems. Paul's thesis research was supervised jointly by Prof. Tomlinson and Prof. P. Ashton.

Ann Lewis continued full-time research for her PhD thesis concerned with embolism in xylem conducting tissues, supported in part by a Cooperative Education Agreement with the Forest Service. Ann consults regularly with her research mentor, Dr. Melvin T. Tyree, who has recently moved to a faculty post at the University of Vermont at the Maple Research Laboratory. She spent three weeks in the laboratory of Dr. Daniel J. Cosgrove of the Biology Department of Pennsylvania State University using special equipment, a pressure microprobe, to measure tensions in dehydrating *Sphagnum* moss cells which serve as a model for dehydrating xylem conduits.

Dr. Torrey supervised two students working for their degrees in sister institutions. Suzanne Racette, research assistant in Dr. Torrey's laboratory, is enrolled part-time in a Masters Degree program in Botany at the University of Massachusetts. Course work in Amherst is interdigitated with research in Petersham. Douglas Smithwood is involved in research on actinorhizal plants with Dr. Torrey, leading to a Masters Degree in Biology at Clark University, Worcester. Dr. Torrey has courtesy faculty appointments in each of these universities to make such arrangements possible.

Peter Schoonmaker has completed his course work and teaching responsibilities in Cambridge this academic year. He plans to move to Petersham in the fall term to carry on full-time research for his PhD thesis with Dr. Foster in forest ecology on the Pisgah Tract.

Tim Sipe, with his PhD advisor Fakhri Bazzaz and Harvard Forest staff, has selected sites for studies on the effect of gap size on regeneration in maples. His field studies in Petersham will be complemented by experiments using controlled environment facilities in Cambridge.

Charles E. Caron obtained his Masters of Forest Science degree in June 1985, having completed his thesis research on red oak regeneration in central New England in relation to the light environment created by red oak and white pine canopies. Chuck has taken a job in forest-related industry in nearby Hubbardston. His research was supervised by Dr. David Foster and Dr. Ernest Gould.

Ulrike Reutter, a PhD student at the Institüt for Systematische Botanik of the University of Heidelberg, West Germany, began a six-month period of study in April 1986, with the aid of a fellowship from the Federal German Republic. In collaboration with Dr. Tomlinson, she initiated a study of the demography and phenology of the six local species of *Lycopodium*, examining aspects of deterministic and opportunistic architecture and of vascular anatomy in relation to hydraulics.

Undergraduates enrolled for special courses in biology with the Harvard Forest faculty included Deborah Glueck, *Biology 91r* with Dr. Torrey. Dr. Gould and Dr. Foster taught *Biology 299, Forest Practice and Research,* taken by Charles Caron, MFS '86 and David Putnam, '86.

During the summer of 1986 we had a small group of undergraduate students in residence employed on work study or as faculty aides. Carolyn Malmstrom '87, worked briefly assisting with Dr. Torrey's projects and then joined Eric Berg '89 and Adam Brook '90 in our vegetation survey project. In addition, three graduate students from the Yale School of Forestry and Environmental Studies were employed to help with the survey and installation of field plots. These three obtained their Masters Degrees at Yale in the spring of 1986 and included Bruce Leighty, Brenda Lind and Sarah Warren.

Complementary to the formal teaching through courses is the Harvard Forest Seminar Series each year. Usually long-term visiting scientists at the Forest and many of the visitors passing through present current research ideas for discussion with the members of the Forest community. The seminars are scheduled to avoid conflict with seminar programs in Cambridge and serve to encourage interchange among resident scientists and visitors at an early stage in their stay in Petersham.

MEETINGS AND VISITORS

During the past year the Harvard Forest played host to a number of important national and international scientific meetings and entertained many visitors from around the world who were attracted by the past and present renown of Harvard University's forest.

On July 21-24, a UNESCO Conference on *Regeneration and Management of Tropical Forests* was held here. The meeting was organized by Dr. A. Gomez-Pompa, formerly of INIREB, Mexico, who was a Bullard Fellow during 1984-5. The conference served as a planning meeting for a larger international conference to be held at a later date.

On September 27-29, 1985 the Northeastern Paleoecology Conference was held at the Forest, organized by David R. Foster and Thompson Webb III of Brown University and sponsored by the International Quaternary Association. The four-day seminar was entitled *Paleoecology and Community Ecology of Eastern North America*. Hurricane "Gloria", scheduled to arrive in the middle of the conference, made a glowering but disappointing (to some) showing. The participants were exposed instead to remnants of the 1938 hurricane still evident on a field trip to Pisgah Forest in southern New Hampshire. The nearly forty participants included scientists from North United States, Wisconsin, Minnesota and as far west as Colorado.

On October 20-21, 1985 a sub-committee of the Visiting Committee to the Department of Organismic and Evolutionary Biology devoted their time and thoughts to the Harvard Forest and its function and role within the Harvard University community. These members included John Boyer, John Gordon, Hal Mooney, Cal Stillman and Richard Waring and were especially helpful to the faculty at the Harvard Forest in their review of our teaching, research and public service functions.

Other short meetings held at the Harvard Forest during November included the annual meeting of the New England Forestry Foundation on November 21-22 under the chairmanship of Hugh Putnam, Jr., Executive Director. On November 22nd a day-long conference on the biology of *Frankia* included participants from MIT, Wellesley College, Clark University, Hampshire College, Yale University and the University of Maine. Dr. David Benson of the University of Connecticut spoke on his research.

In mid-March a specialist meeting under the title *Forest Gap Workshop* was organized by Dr. Jerry F. Franklin of the U. S. Forest Service of Corvallis, Oregon who was a Bullard Fellow in residence in Petersham. Over the three days of March 19-21, a group of scientists explored such questions as what factors regulate gap formation in a forest; and what are the consequences of gap processes to community and landscape structure? The intention of the workshop was to foster the exchange of ideas and a consideration of directions for future research.

On April 11-13, 1986 forty scientists from across the United States and Canada met at the Harvard Forest for a workshop on the role of symbiotic microorganisms in facilitating tree growth via their interactions with tree root systems. The workshop focused on Vesicular-Arbuscular

mycorrhizal fungi and the actinomycetous bacterium *Frankia*. The first symbiont facilitates phosphate uptake by plants in mineral-poor soils and the second catalyzes the conversion of atmospheric nitrogen (N_2 gas) to organic form usable by the plant hosts. The conference, organized by Dr. Torrey, was a joint effort of the Harvard Forest and the Yale School of Forestry and Environmental Studies under their cooperative Program in Forest Microbiology, funded in part by the Andrew W. Mellon Foundation of New York.

Thompson Webb III and David Foster organized a fall conference on long-term vegetation and climate history. (Photograph by Nancy Eyster-Smith).

The 17th New England Fern Conference with about twenty-eight scientists in attendance was held May 23-25, 1986. Presentations, demonstrations, a field trip and plenty of time for informal discussions continue to attract a group of fern enthusiasts concerned also with other members of the lower vascular plants extending to the horsetails (*Equisetum*), the quillworts (*Isoetes*), and the lycopsids (*Selaginella*).

Other one-day meetings hosted by the Harvard Forest during the spring included the Massachusetts Department of Environmental Management, the New England Forest Economists, and the Swift River Valley Trust.

In addition, faculty members and staff played host to many individual visitors who came to discuss their research, visit the Fisher Museum or delve into the remarkable historical records of land use and management available in the Harvard Forest vault.

BULLARD FELLOWS

Jerry F. Franklin, Chief Plant Ecologist, Pacific Northwest Forest and Range Experiment Station and Professor of Forest Science at the Forest Sciences Laboratory at Oregon State University in Corvallis served as a Bullard Fellow from late August 1985 through the end of May 1986. Dr. Franklin has been involved with research on the ecological bases for management of northwestern United States forests for many years and is known for his role in organizing ecological research on Mount St. Helens

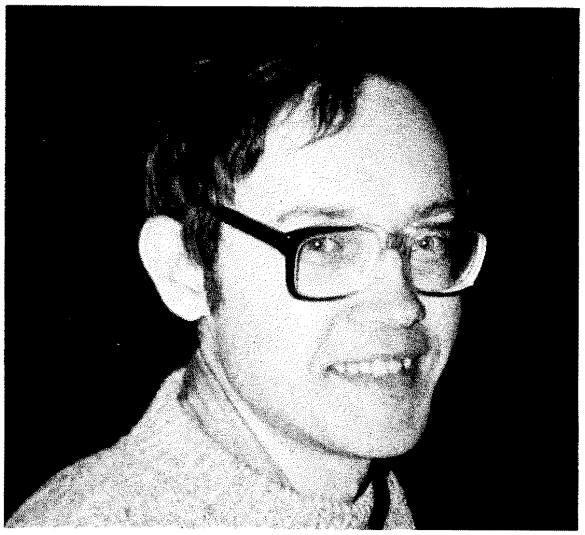
following its recent eruption. Dr. Franklin taught a course at the Yale School of Forestry and Environmental Studies and devoted much of his time to writing and lecturing on his research activities. Part of this effort was directed toward writing a book on *Structure and Function of Coniferous Forest and Stream Ecosystems* based on his considerable experience in the Pacific Northwest.

Dr. Franklin focused on the ecological consequences of the checkerboard pattern of clearcutting of Douglas fir forests in the Pacific Northwest. His study has shown that there are thresholds in the size of remnant forest areas and clearcut patches which are sensitive to disturbances such as windthrow and wildfire. The analysis showed the importance of extending forest and wildlife management considerations from the individual patch to the landscape.

A natural outcome of these considerations and related discussions with David Foster, Bullard Fellow Gordon Whitney and graduate student Tim Sipe, was the *Forest Gap Workshop* described earlier which was planned and chaired by Dr. Franklin.

John Ogden, Bullard Fellow for this academic year, came from the Department of Botany, University of Auckland, New Zealand with current interests in forest ecology and forest resources. His two seminars which were presented in the Harvard Forest Seminar Series reflected this research orientation. The first, *Big and Old: the success story of the southern conifers,* Araucaria *and* Agathis, concerned his ecological assessment of the past development of two giants in the New Zealand and Australia forests over a long time scale. His second seminar, *Practical aspects of aging trees and dendrochronology* generated considerable interest, discussion and controversy. Dr. Ogden is writing a book on the forests of New Zealand. Dr. Ogden was based in Cambridge in the laboratory of Dr. Solbrig in the Harvard University Herbaria and commuted to Petersham regularly to carry on some of his dendrochronological research in Shaler Hall.

Dr. Jacek Zakrzewski, Bullard Fellow through September 1985, completed his period of study by making an analysis of the hydraulic architecture of *Cornus alternifolia,* deploying a variety of techniques originally devised by Dr. Zimmermann. Perhaps his most original observation was the demonstration of vessels running directly from parent axis into sylleptic branches. He was assisted by Carolyn Hertzberg '85 as a summer employee who prepared botanical illustrations for Dr. Tomlinson as well. Dr. Zakrzewski returned to the Department of Forest Botany, Agricultural University of Warsaw upon the completion of his fellowship.



Gordon G. Whitney came to Petersham from the Department of Biology of the College of Wooster, Wooster, Ohio with primary research interests in forest ecology and, in particular, the changing landscapes of the northeastern United States. As an historical ecologist, he drew his documentary evidence of landscape change from a wide range of source materials -- travel accounts, government records, scientific and agricultural reports and the like. He is preparing a book on changing landscapes of the northeast, which reviews the effect of early aboriginal populations of the region, and documents the nature of the presettlement forest of eastern North America. Some of Dr. Whitney's approach comes across in his seminar titles: *The view from John Sanderson's son's farm,* and *Long-term ecological research by serendipity or Heart's Content Revisited*, and a seminar in Cambridge entitled *Stalking the Storefront Sowthistle or man as a maker of new plant communities*.

RESEARCH

Dr. Ernest Gould has continued as Chairman of the Massachusetts State Forestry Committee. The Committee's oversight of the Forest Cutting Practices Act suggests that, with somewhat less cutting in the state, the foresters and fire wardens have been able to give better supervision to harvest operations. It is also obvious that research will be needed to find out whether the results of the law are worthwhile. However, viewed as an educational effort, the Act is certainly aimed at the weakest link in the forestry system -- the loggers themselves.

In his role as citizen participant in the planning process, Ernie has kept himself informed of progress on the White Mountain National Forest. The new plan for the Forest was released this spring and legally challenged by the Conservation Law Foundation appealing for such national organizations as the Wilderness Society, National Audubon, Sierra Club and Defenders of Wildlife. Such local organizations as the Appalachian Mountain Club, Society for the Protection of New Hampshire Forests, New Hampshire Audubon and Massachusetts Audubon did not join in the appeal. Luckily, a stay of only that small part of the plan that involves harvest operations in or near former roadless areas has been requested. The planning which started in 1982 has been a learning experience that calls for thinking the unthinkable about forest planning in general and National Forest planning in particular.

Dr. David Foster's research continues to focus on three broad areas: the role of natural fires in boreal vegetation, landscape and stand effects of catastrophic wind on forest vegetation in central New England, and the modern and paleoecology of boreal peatlands. Travel by Dr. Foster to Labrador, Canada in August 1985 with George King of the University of Minnesota provided more data on the fire and vegetation history of that wilderness region. David spent the month of June 1986 working in Scandinavia on peatland and landscape history with colleagues from the University of Minnesota. Kevin Fetherston, candidate for the MFS degree, is completing a computer-based cartographic analysis of wind effects on forested landscapes that is being complemented by an analysis of individual tree and stand level responses under David's supervision.

During the period September 1985 - May 1986, Dr. P. Barry Tomlinson travelled extensively in search of research material on conifers with special emphasis on their vegetative morphology. He was able to see living specimens of almost all 50 genera of conifers either in natural surroundings (notably New Zealand, Fiji, Tasmania, New South Wales and Western Australia) as well as in cultivation in the British Isles. Most emphasis was on the southern sub-tropical family Podocarpaceae which has been relatively neglected by botanists and which does not do well in cultivation in the States. A notable collection assembled by Dr. Christopher Page at the Royal Botanic Gardens, Edinburgh, Scotland was examined and an exchange of material arranged. A special study of seedling morphology in relation to systematics was initiated as well as a study of the architecture of the genus *Phyllocladus* which photosynthesizes by specialized planar branch complexes (phylloclades).

Dr. Tomlinson has been involved in numerous collaborative research efforts with post doctoral fellows: Dr. Beata Zagorska-Marek, who was supported by Cabot Funds, returned to her position in Poland in October of 1985. In February 1986 Dr. Jeffrey Hart completed a period of study at Harvard Forest as an Atkins Post-doctoral Research Fellow with a special interest in the systematics and phylogeny of the conifers. Dr. Adrian Juncosa, with support from the National Science Foundation, completed a two-year study in April 1986 of embryology, floral structure, and development of selected representatives of the tropical family Rhizophoraceae, which includes several genera of mangroves. The study shows that there are stages in the early development of the peculiar viviparous seedlings of these mangroves which can be equated with comparable stages in terrestrial representatives. Dr. Juncosa has taken a position at the University of California, Davis.

Dr. Hirokai Hatta, Curator, Tsukuba Botanic Garden of the National Science Museum, Japan, visited the Harvard Forest in May as part of a tour of herbaria and botanical institutions in North America, which included the Arnold Arboretum and the Harvard University Herbaria. Primarily interested in *Cornus*, Dr. Hatta examined local species in collaboration with Dr. Tomlinson, but also studied the local flora and vegetation for comparison with his native Japan.

A study of bud morphology in six of the eight known species of the tropical sea-grass genus *Halophila* was continued with Dr. Usher Posluszny, University of Guelph. In this genus preformation is exceptional since up to eight orders of branches may be developed within a bud a little more than 3 mm long. Analysis of serial sections was facilitated by a video-recording system which allows frame-by-frame storage of sequential images.

Dr. Tomlinson collaborated with Dr. Paul Cox, Brigham Young University, on pollination of seagrasses at Laucala Bay, Suva, Fiji in which pollen release and surface pollination was observed for the first time in *Halophila* and *Halodule*. This observation raises interesting questions as to the extent of such pollination in marine angiosperms. Are the extensive populations in deep water ever successfully pollinated?

Dr. Torrey's research centers on the symbiotic relationship between the filamentous bacterium *Frankia* of the Actinomycetales and a range of woody dicotyledonous hosts - an association that results in fixation of dinitrogen from the atmosphere and beneficial growth of the host plant. Three main aspects of the actinorhizal association continue under study: the infection process, the development of *Frankia* vesicles (site of the nitrogen-fixing enzyme, nitrogenase) and the initiation and development of sporangia by *Frankia* both when grown *in vitro* and as an endophyte within the host plant.

In his studies of sporulation by *Frankia* strain CpI1 grown in culture Dr. Hayes Lamont analyzed the suppression of sporulation by low concentrations of glutamine. This suppression is accompanied by growth of the filamentous form of *Frankia* and the suppression also of vesicles and nitrogenase activity. The closely related amide asparagine, although metabolized by *Frankia* strain CpI1, failed to suppress vesicle formation or sporangia formation although nitrogenase activity was inhibited initially. These and similar experiments may lead to a better understanding of sporulation in the nodules of the host plant.

In studies of endophyte sporulation emphasis has moved from *Myrica gale* to another local species, the speckled alder, *Alnus incana* ssp. *rugosa*. In local populations of this plant, spore (+) and spore (-) nodulated plants have been observed in different field situations, often in close proximity. Efforts are being made to establish spore (+) populations in the greenhouse and to isolate and culture a spore (+) strain of *Frankia*.

A program involving cell-wall hydrolyzing enzyme activity in *Frankia* has been initiated in Dr. Torrey's laboratory by Stephen Safo-Sampah who arrived in Petersham in January 1986, having completed his PhD degree in the Department of Wood Science and Technology, University of California at Berkeley. Dr. Safo-Sampah is studying cellulase activity in *Frankia* strain HFPCcI3. This research relates closely to a collaborative effort between Dr. Torrey and Ann Hirsch of the Department of Biology of Wellesley College, Wellesley, Massachusetts. With funding from the Competitive Grants Program of the USDA Forestry Program, a search will be made, using a clone bank of *Frankia* DNA, for the genes in *Frankia* responsible for cellulose digestion. Cell wall digestion is involved in the infection process and may also play a role in the saprophytic life of *Frankia* in the soil.

Dr. Barbara Mosse was appointed a Visiting Scientist to the Harvard Forest from February through June 1986, under the Harvard-Yale Program for Forest Microbiology supported by the A. W. Mellon Foundation. Dr. Mosse was formerly on the staff of the Rothamsted Experimental Station, Harpenden, England and is well known for her investigations of Vesicular-Arbuscular mycorrhizal (VAM) fungi. During her residence in Petersham, Dr. Mosse pursued research on two problems in relation to VA mycorrhiza; one, the establishment of pot cultures of several species of VA mycorrhizal fungi for use in experimental work and two, the axenic growth of VA microorganisms.

It was found that *Glomus intra-radices* from starter inoculum from Native Plants, Inc., *Glomus versiforme* and *Gigaspora gigantea*, provided by the University of Rhode Island, could make extensive mycelial growth without actually producing VA infection in carrot roots transformed with *Agrobacterium rhizogenes*, when both were grown together in a dilute root culture medium containing normal macronutrient salts, minor elements, sucrose and vitamins.

The growth obtained was sufficient to suggest that axenic culture is feasible if appropriate conditions could be maintained. Outstanding questions are: is an intermediate phase necessary during which the fungus can adapt to a free-living state while growing in the presence of roots without actually causing infection, and how can independent growth be improved by changes in the culture medium?

Dr. Walter Völlenkle of the Austrian Federal Institute for Scientific film in Vienna was a Visiting Scholar to the Department of Visual and Environmental Studies of Harvard University from April through August 1986, basing his activities and operations at the Harvard Forest in Petersham. As an advisor for biology and medicine at his home institute, Dr. Völlenkle came to the United States to study scientific film techniques as they applied to his special field of interest. He was committed to filming evidence of damage to forest trees related to acid precipitation in the northeastern United States. While at Harvard Dr. Völlenkle studied biological films produced in the United States and travelled extensively in western Massachusetts, Vermont and eastern New York state, filming areas showing symptoms in conifers not unlike those he had filmed in Western Germany. While in Petersham, he showed several films which had been produced at his institute in Vienna.

FOREST OPERATIONS

Vegetation Survey. - In the spring of 1986 we began an ambitious vegetation survey of the Harvard Forest using color infrared photographs taken in the fall of 1985 for the Massachusetts Department of Environmental Management. These photos were designed especially to detect "stressed" trees as part of a study of air pollution impacts. Prints were made available to us together with photogrammetric equipment by Professor William MacConnell of the Department of Forestry and Wildlife Management of the University of Massachusetts in Amherst and were used to identify our forest stands as a first step in the inventory process.

During the summer of 1986 three Harvard undergraduates and three Yale graduate students began the process of making new stand maps, locating permanent plot centers for each and measuring a sample of the overstory trees. Probably a total of 3,000 plots will be established in the process of covering the entire forest in Petersham. Plot data along with the maps generated will eventually be computerized as part of our long-term process of updating our forest record system. This project has involved Ernie Gould and John Edwards throughout the summer.

Timber Harvesting. - The woods crew and John Edwards have continued with a program of silvicultural research. Operations in Tom Swamp I included the first thinning of red pine plantation 25-A and continuation of the third thinning in the Tom Swamp East hardwood study area. In TS VII a combination patch cut and improvement cut was made on about three acres of the mixed wood stand last treated in the winter of 1954-55. To date, approximately 6 thousand board feet of red oak, white pine and hemlock saw logs have been harvested from TS VII, and 30 cords of firewood from TS I and TS VII are now drying in the processing yard. We continue to fire the boiler of the main building with our own cordwood.

Buildings and Grounds. - Major efforts have again been devoted to improvement of the physical plant. In the basement of Shaler Hall room renovations have included construction of additional bench space for microscopy for Dr. Tomlinson and his associates. The laboratory space formerly occupied by Dr. Zimmermann has been completely refurbished to provide cubicle, hood and bench space for forest microbiological work in relation to the Harvard-Yale Program in Forest Microbiology.

Smoke and heat detection devices have been installed in the dormitory areas as part of our long-term efforts to provide fire protection throughout Shaler Hall as well as all the residences. Other improvements include a new septic system to service the Community House, new shower stalls and floors in the upstairs bathrooms of Shaler Hall, a new telephone system and improved storage areas.

Harvard Forest Library. - With cooperation from the other Harvard libraries, the Harvard Forest Library this year has received several superseded copies of reference works. Among these are: *Subject Guide to Books in Print, British Books in Print, American Library Dictionary*

and *The Publishers' Tradelist Annual*. At the same time, we have increased the frequency of inter-library exchanges between our library and several other Harvard libraries. An on-going index of the year's acquisitions has been compiled, and a copy distributed to the Harvard University Herbaria Library. Updated lists of all of our holdings are being printed at Yale University. We have recently purchased a microfiche reader to enable researchers at the Harvard Forest to use the Union Catalogue and Boston Consortium microfiche here.

Gordon Mitchell operating back-hoe, Charles (Pete) Spooner on bulldozer with John Edwards (right).

After twenty-three years of continuous service as a member of the woods crew, Edward M. Hyde (Bud) has chosen to retire. His services and friendly manner will be missed at the Forest.

HARVARD BLACK ROCK FOREST - CORNWALL, NEW YORK

Forest operations. - Cutting continues in Compartments XI and XII by contract with a local logger. Two additional logging operations are taking place in Compartments VI and XXIII to improve composition and to salvage trees killed by the 1981 gypsy moth infestation. We have marked 62 acres in Compartment IX for cordwood thinning. Expected yield is 316 cords but, due to problems of access, this marked area has not yet been contracted for harvest.

Nearly one-quarter of our 3,600 acre woodland was heavily defoliated by gypsy moths during May and June 1986. Actual acreage devastated in 1986 was 853 acres. Last year only 23 acres immediately west of Sphagnum Pond was affected. The recent attack occurred in the upland chestnut oak - red oak forest in the Sutherland Pond and Jims Pond areas. A map was drawn of the affected area and filed for future reference.

The Town Board of Cornwall has approved the abandonment of a one-third mile segment of Old West Point Road near the Upper Reservoir which will allow the relocation of our main gate, solving recent problems with littering around the Reservoir.

Research. - The gypsy moth problem is a major concern in Cornwall. A long-term gypsy moth study being conducted by Dr. Clive G. Jones of the Institute of Ecosystems Studies from the Cary Arboretum of the New York Botanical Garden continues into its fourth year. The study, in collaboration with Dr. William Wallner of the U. S. Department of Agriculture Forest Service, involves a comprehensive sampling design to quantify gypsy moth distribution, abundance and habitat characteristics. The Harvard Black Rock Forest is one of four sites being studied in the northeastern United States

Karen Moore who laid out the grid of plots in the Frog Hill area in 1984 continues to supervise the sampling process and Lucien Curtis makes a monthly bird census. Dr. Jeffrey Glitzenstein, a post-doctoral associate of the Institute of Ecosystem Studies, has begun a study in the Sutherland Pond area to determine past gypsy moth activity by the use of dendrochronology, using species pairs of oak and ash.

Susan L. Kelley of Lehman College is studying seedling survival of the striped maple, *Acer pennsylvanicum*. Ms. Kelley who is a Masters degree student under the supervision of Dr. Dwight Kincaid of Lehman College, is sampling seedlings and saplings of striped maple in the Mt. Misery area of the Forest in an effort to determine factors which influence mortality.

Long-term silvicultural plots established as early as the 1930's along Birch Spring Hill Road have been measured for the ninth time as part of data collection started in 1936. Summaries, tables and graphs of the long-term data have been prepared and await assessment by forestry staff.

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August 1986

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