



THE HARVARD FOREST, 1986-87

Harvard University





Perched atop Camel's Hump, in the Green Mountains of Vermont, are (l. to r.) Walter Völlenklee, Hubert Vogelmann and Peter Hannah in the spring of 1986 when Dr. Völlenklee visited on his filming trip for production of the documentary on effects of acid deposition on northeastern American forests. The 27-minute film entitled *Waldsterben Auch in Amerika?* has received critical acclaim at the International Film Congress. Italian and English versions are in preparation. Dr. Völlenklee was a Visiting Scholar at the Harvard Forest during early 1986 from the Austrian Federal Institute for Scientific Films in Vienna. Dr. Hannah is a former Bullard Fellow on the Faculty in Forestry at the University of Vermont. Dr. Vogelmann of the Department of Botany, University of Vermont has been involved in research on acid deposition for a number of years.

(Photograph by Tony Talbot)

Front cover:
Brooks Pond (Harvard Pond) on a lazy summer's day in August.

(Photograph by Jan Silvester)

ANNUAL REPORT OF ACTIVITIES AT THE HARVARD FOREST

1986-1987

PERSONNEL

Ruhama Berliner, Bullard Fellow (from November 1986)
Emery Boose, Computer Assistant
Gloria Boucher, Custodian (from May 1987)
John Brady, Assistant to the Manager of the Black Rock Forest
Marcia Brightman, Librarian (part-time)
Elaine Doughty, Laboratory Assistant (part-time)
John Edwards, Physical Plant Manager
Wayne E. Elliott, Custodian (until March 1987)
Marion L. Ellsworth, Laboratory Aide (part-time from December 1986)
Barbara J. Flye, Clerk Typist
Mark S. Fontaine, Research Assistant (until August 1986)
David R. Foster, Assistant Professor of Biology
Ernest M. Gould, Jr., Forest Economist, Senior Lecturer on Biology,
Assistant Director of the Harvard Forest
Anne K. Hachey, Greenhouse Assistant (part-time)
Edward Hyde, Woods Crew (until January 1987)
David H. Jackson, Bullard Fellow (from September 1986 through June 1987)
Jack J. Karnig, Forest Manager, Black Rock Forest
Hayes Lamont, Post-doctoral Fellow (until June 1987)
Ralph L. Lundquist, Head of Greenhouse
Monica R. Mattmuller, Research Assistant (until September 1986)
Gordon B. Mitchell, Woods Crew Superintendent
Ellen Moriarty, Graphic Artist (from January 1987)
Theresa Morris, Groundskeeper (from April 1987)
Frances E. O'Brien, Secretary
Frances N. Phillips, Secretary
Suzanne Racette, Research Assistant
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*
Stephen Safo-Sampah, Post-doctoral Fellow
Warwick B. Silvester, Visiting Scientist (from September 1986)
Dorothy R. Smith, Secretary
Charles C. Spooner, Woods Crew
Tokushiro Takaso, Post-doctoral Fellow (from October 1986)
Donald Theoe, Bullard Fellow (October-November 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
Shean-Shong Tzean, Post-doctoral Fellow (from May 1987)
Julie Whitbeck, Research Assistant (until June 1987)
John Wisniewski, Woods Crew (from January 1987)
Patricia H. Young, Laboratory Technician (until December 1986)

STAFF

David R. Foster, Assistant Professor of Biology and Forest Ecologist on the Harvard Forest staff for the past four years, has been promoted to Associate Professor of Biology, effective July 1, 1987.

In August 1986, Dr. Torrey was invited to attend the annual national meeting of the Botanical Society of America held in conjunction with the AIBS meeting on the University of Massachusetts campus at Amherst. At the annual banquet of the Society, Dr. Torrey was presented with the Certificate of Merit of the Botanical Society of America "in recognition of distinguished achievement in and contributions to the advancement of botanical science".

One of the important features of the continued effectiveness of the Harvard Forest as a center for research and teaching is the dedicated service of its staff. For example, Gordon ("Buzz") Mitchell of the woods crew was presented a twenty-five-year chair award from Harvard University in 1976. He is now in his thirty-sixth year of service. This year, after twenty-three years as a member of the woods crew, Edward ("Bud") Hyde elected to retire. A dinner was held in his honor in January at which time he was presented with an anniversary clock. Bud's position on the woods crew has been taken by John Wisniewski.

Wayne Elliott, faithful and cheery custodian at the Harvard Forest, retired after fifteen years of continuous service. His long service was celebrated with a dinner party held in his honor in April. Wayne's friends joined in presenting him with a monetary gift directed toward his gardening enthusiasm and skills.

Monica Mattmuller served at the Harvard Forest for fifteen years, most of that time as research assistant to Martin Zimmermann. Her voluntary institutional roles here included photographer, gardener and landscaper, animal lover and consultant, purveyor of Harvard Forest tee-shirts, bird watcher and feeder - all in addition to her laboratory skills. Monica accepted a position this year at the New England Regional Primate Research Center in Southboro, Massachusetts.

Patricia Young, who was employed in Dr. Torrey's laboratory for the past eight years, worked her way up from laboratory aide to lab technician. In 1986 she moved her family to Pelham and took a position in charge of the Bioshelter at Hampshire College in Amherst. Elaine Doughty has taken on the responsibility of our culture collection.

The University issues Golden ID cards to staff with fifteen years of continuous service. Proud possessors of this form of recognition include Frances O'Brien, Secretary.

After two years' service as research assistant in Dr. Torrey's laboratory, Julie Whitbeck has travelled to Stanford, California to continue her education working for a PhD degree in the Department of Biological Sciences of Stanford University.

This past winter staff members, students and visiting scientists enjoyed "relaxing" by playing volleyball regularly at the YMCA in Athol. The team that was generated from these activities became serious and, once again sparked by "Hot Shot" Foster and "Boomer" Sipe, they entered the annual volley ball tournament. A hotly contested competition ended with the Harvard Forest team, dubbed the "Woods Crew", bringing home the trophy "Athol Area YMCA 1987 Volleyball Champions". The trophy now graces the table in the Reading Room for all to admire.

COURSES AND STUDENTS

In their teaching, faculty of the Harvard Forest, who are themselves peripatetic, tend to take their students to where the action is. During the fall term Dr. Foster taught Biology 160, Forest Ecology, a lecture course in Cambridge with three weekend field trips to Petersham. In the Spring he offered Biology 204, Topics in Paleoecology, which this year provided an introduction to methods and equipment for research in Quaternary Paleoecology. Three weekend projects were chosen to provide broad exposure to problems and approaches ranging from field work to laboratory study to the presentation of results. The first weekend involved the re-investigation of Gould's Bog, a site in the Prospect Hill Tract that was first described in 1954 by Margaret Davis, a student of Hugh Raup's. During the second field trip the class surveyed and cored Peacham Bog in northern Vermont. Their studies revealed that the site is the first raised bog to be discovered in Vermont and showed that the peatland was established through the swamping of forest, rather than through the infilling of lakes which is the general process of bog formation in New England. In the final project the group studied the age-structure and growth dynamics of a portion of the Pisgah Forest using dendrochronological techniques.

In Cambridge Dr. Tomlinson taught Biology 18, Diversity in the Plant Kingdom, Biology 102, Biology of Gymnosperms and one week of Biology 104, Plants and Human Affairs. In June 1987 in Miami, Florida Biology S-105, Plants of the Tropics was taught for its thirteenth year by Dr. Tomlinson at the Fairchild Tropical Garden. This year the course was a mini United Nations because, of the nine students in the class, six were from foreign countries, one coming directly from Zurich, Switzerland. In the fall term 1986 Dr. Torrey's course, Biology 215, Roots and Rhizosphere, was offered and stirred up a little dust. A day-trip to the Harvard Forest was included. In the spring term 1987 Dr. Torrey gave three lectures on symbiotic systems affecting plant growth as his contribution to Biology 11, Plant Physiology, offered in Cambridge. The Harvard Forest Freshman Seminar with full enrollment involved Professors Foster, Gould, Tomlinson and Torrey in the spring term.

Professors D. Tomlin and R. Forman of the Department of Landscape Architecture, Graduate School of Design, again collaborated in the course Introduction to the New England Landscape based in Petersham each September. In the spring semester Professor Tomlin ran Landscape Planning and Design Studio in Cambridge.

Ann Lewis and Emery Boose in relaxed mood in the recreational area behind the Community House. An indispensable couple at the Harvard Forest, both have been in student status the past six years. Emery is completing his degree in Sanskrit and Indian Studies and, on the side, keeps us up-to-date in computer technology.

(Photo by N. J. Torrey)



Ann Lewis completed her PhD thesis preparation at the Harvard Forest in the Department of Organismic and Evolutionary Biology of Harvard University. Dr. Torrey chaired the PhD thesis examination in July 1987. By special arrangement Dr. Melvin Tyree of the Department of Botany, University of Vermont supervised Ms. Lewis' thesis research and served as external examiner on the thesis committee. Dr. P. B. Tomlinson served as the third thesis committee member. Dr. Lewis will continue her research in residence at the Harvard Forest for the fall term 1987 with the support of the USDA Forest Service.

Kevin Fetherston was awarded the MFS degree from Harvard in June 1987. His thesis, supervised by Dr. Foster, involved a cartographic analysis of damage to the Harvard Forest from the 1938 hurricane.

Peter Schoonmaker received his MA degree from the Department of Organismic and Evolutionary Biology, passed his PhD Qualifying Examination in May 1987 and is continuing full-time research on the long-term forest dynamics at Pisgah State Park in New Hampshire. Peter served as teaching fellow in Biology 18 with Professor Tomlinson during the fall term.

Tim Sipe passed his PhD Qualifying Examination in May 1987 and continues his thesis research on tree seedling physiology and growth in canopy gaps supported by a National Science Foundation grant to his thesis supervisor, Professor F. Bazzaz. Tim was a teaching fellow in Biology 7B, Introductory Biology, in the fall term.

Douglas A. Smithwood completed his thesis for the master's degree in Biology at Clark University in Worcester in the spring of 1987. Douglas worked at the Harvard Forest under the supervision of Dr. Torrey on effectivity of symbiotic nitrogen fixation in actinorhizal plants.

Suzanne Racette, who is a research assistant in Dr. Torrey's laboratory, is enrolled part-time as a master's degree student in the Department of Botany, University of Massachusetts. Suzanne has completed her courses and is working on her thesis on the biology of symbiotic nitrogen fixation in Gymnostoma, an important tree of the family Casuarinaceae that grows in Papua New Guinea and other tropical islands of the South Pacific.

In July 1986, Dr. Torrey served as external examiner on the PhD thesis exam of Darwin Burgess at the University of Guelph in Ontario. He also served as co-sponsor for undergraduate Margaret Asomaning who worked with Dr. Fred Ausubel on a Biology 90r senior thesis during the academic year. Undergraduate Aron L. Silverstone wrote his undergraduate senior thesis under the supervision of Dr. John Einset. Dr. Torrey served as a member of his thesis committee and reader of the thesis.

During the winter two student interns from other colleges worked on projects at the Harvard Forest in Petersham under the supervision of Drs. Foster and Gould. Jeffrey Fohl, Connecticut College and Will Anderson, Sterling College, resurveyed permanent plots established in 1967 by Walter Lyford on Prospect Hill. The entry and analysis of these data on micro-computers will provide an assessment of long-term changes, mortality and recruitment in hardwood forests.

Harvard Forest summer students included Suzanne Panico (Harvard '90), Marianne Wang (Harvard '90), Will Anderson (Sterling College '87) and Gregg Cassidy (U. Mass '87). Time and effort was devoted to establishing and surveying permanent plots on the Tom Swamp Tract.

MEETINGS AND VISITORS

The Harvard Forest joined in Harvard's 350th Anniversary Celebration by scheduling its annual meeting of the Friends of the Harvard Forest on Sunday, September 7, 1986, the last day of the celebration and by devoting the occasion to an historical retrospective of the Harvard Forest and a pond-side visit to the site of the Fisher Memorial. Despite early rainfall that dictated an indoor picnic luncheon, we all enjoyed the informality of the day and were able to proceed in clearing weather to the Harvard Pond and to join in reminiscing about the older times. David Foster had us thinking, in fact, about Late-Pleistocene days just to get in the proper frame of mind. It was a special day, commemorating the 80th anniversary of the Harvard Forest as well.

On November 9-15, 1986 the Harvard Forest hosted a group of fifteen trained foresters from tropical countries at the Fourth Tropical Trees Coordination meeting of the Committee on Research Grants of the Board of Science and Technology for International Development of the National Academy of Sciences. Foresters from tropical countries as distant as Thailand, Argentina, Chile, the Congo, Kenya, the Phillipines and India or as close as neighboring Mexico presented the progress of their research to each other, to the Committee, and to participants from the United States. In addition, they were instructed by international specialists in soil assessment and management and on the beneficial effects of soil micro-

organisms on tree growth. Instructional staff included Professor Charles Davey of North Carolina State University, Dr. Joann Roskoski of NIFTAL, University of Hawaii, Professor Warwick Silvester, University of Waikato, New Zealand and Dr. Maria Valdez, National Polytechnic Institute of Mexico as well as staff members of the Harvard Forest.

The forestry group went on a field trip to the Dana entrance of the Quabbin Reservoir under the leadership of Ernest M. Gould, Jr., Assistant Director of the Harvard Forest and Bruce Spencer, Forester of the Metropolitan District Commission. The tropical visitors were repaid for tolerating the cold by sightings of white-tailed deer and a coyote as well as learning about management practices directed toward wildlife conservation and improved water production for the famous Boston water supply. Other field trips took the group to red pine stands in the Harvard Forest for demonstrations of studies of mineral nutrient cycling and of root function by Knute Nadelhofer and Paul Steudler of the Ecosystems Center based at the Marine Biological Laboratories at Woods Hole, Massachusetts who use the Petersham forest as one of their experimental sites.

On April 30 and May 1, 1987 the Harvard Forest hosted a group of a dozen scientists representing several departments within Harvard University and specialists from other universities or agencies to consider the topic: Assessing forest ecosystems using remote sensing: what can private universities do? Several informational presentations were made. Dr. Philip Craul, SUNY, Syracuse reviewed the possibilities using satellite imaging; Dr. Richard Waring, Oregon State University and the Ecosystems Center, Marine Biological Laboratories, discussed ground assessment; Dr. Richard Forman, Graduate School of Design, Harvard University presented connections with landscape ecology, Dr. Fakhri Bazzaz, Organismic and Evolutionary Biology, outlined methods of confirmation using controlled environments, and Dr. M. McElroy of the Department of Earth and Planetary Sciences of Harvard University presented a broad view of the changing gaseous environment of the Earth with emphasis on the biological origins of such gases as carbon dioxide, nitrous oxide, methane and ozone.

In discussions directed at the specific needs of the scientific research and educational community of Harvard University, and the role the Harvard Forest might serve, there was general agreement that the greatest gap lay, not in remote sensing - per se, but rather in the broad field of soil science, a discipline currently unrepresented at Harvard and more or less unfilled since the retirement of Walter Lyford at the Harvard Forest in 1976.

All participants at the meeting agreed on the importance of soils as a part of the multi-faceted problems confronting ecologists - requiring expertise in soil characteristics, soil physics, organic matter and humus, water relations, soil microbiology, nutrient cycling, heat budgets and perhaps the use of remote-sensing techniques in assessing forest soils. These considerations were reviewed in light of future faculty appointments at the Harvard Forest.

Seminars - During the academic year a series of seminars is scheduled at the Harvard Forest, dependent on the availability of speakers and the

pertinence of the subject. Formal meetings such as those described above usually offer opportunities for staff and students to attend on an informal basis - one of the fringe benefits of our role as hosts.

Meetings hosted by the Harvard Forest during the year included the Massachusetts Audubon Society, New England Area State Foresters, Massachusetts Association of Conservation Commissions, New England Forestry Foundation, New England/New York Forest Products Utilization Conference, New England Fern Conference and a visit by forestry students from the University of Munich which was arranged by Professor Clark Binkley of Yale University.

BULLARD FELLOWS

David H. Jackson, Professor of Forest Economics and Management at the School of Forestry, University of Montana in Missoula spent most of his Bullard Fellowship from September 1986 through June 1987 in Cambridge while residing with his family in Wellesley. He travelled to Petersham on many occasions, largely for collaborative research with Ernie Gould. While in Cambridge, Dr. Jackson audited a series of refresher courses in the Kennedy School and elsewhere within the University, shared an office in the Harvard University Herbaria, and wrote a number of research papers centering around his past experiences and current thinking on timber supply, local and regional demand and competition in the timber market. He presented seminars in Cambridge, in Petersham and at the University of Vermont at Burlington. His contacts in Burlington led to further consultation with the School of Natural Resources on multiple resource analysis.

Ruhama Berliner came to the Harvard Forest as a Bullard Fellow from the Department of Agricultural Botany, Faculty of Agriculture, the Hebrew University of Jerusalem in Rehovoth, Israel. Her recent background was a study of the ecology of desert plants in Israel and the importance of mycorrhizal fungi on plant occurrence and distribution. Her research in Petersham with Dr. Torrey has concerned ecological aspects, especially the influence of soils, on symbiotic associations occurring in the Harvard Forest. Her studies involved an examination of the mycorrhizal status of the common plants forming the forest canopy and in understory vegetation. In tests using the most probable number method, Dr. Berliner has attempted to estimate the potential for infectivity by vesicular-arbuscular mycorrhizal (VAM) fungi in soils collected from mixed hardwood and from conifer stands. Preliminary experiments suggest that the infective potential in these soils is low. However, root samples show wide spread occurrence of VAM fungi, especially in understory plants.

Donald R. Theoe, Governmental Programs Forester of the Washington State Department of Natural Resources, came to the Harvard Forest in Petersham in October 1986 already immersed in the subject of his Bullard study project - the life of Richard Thornton Fisher, first director of the Harvard Forest from 1907-1934 and forester of national prominence. During October Don Theoe reviewed files and documents available in the Harvard Forest vault and travelled around Massachusetts, meeting and interviewing people who knew Mr. Fisher personally or who were interested in his role in forestry. Mr. Theoe came to his interests in Professor Fisher through a natural process. He served as Director of Professional Programs of the

Society of American Foresters for six years during which time he visited most of the forestry schools of the United States. He had read of the early history of forestry in the United States and of Professor Fisher's role as an early leader in American forestry. His plan under the Bullard Fellowship program was to bring together as much information as possible and ultimately to write an account of R. T. Fisher and the Harvard Forest in the early history of American Forestry. His activities were summarized in a seminar presented at the Harvard Forest and will be published in due course.

RESEARCH

A rising interest in non-point water pollution is focusing attention on agriculture and forestry. In Massachusetts this has taken the form of a special "Generic Environmental Impact Report" (GEIR) being done for forestry by the Department of Environmental Management (DEM) with the assistance of a Technical Advisory Committee (TAC). Dr. Ernest Gould has become Chairman of the TAC.

The GEIR aims to summarize the state of our knowledge about the impact that forest practices can have on such elements in our environment as water, soil, vegetation, wildlife, recreation, aesthetics, cultural and historical sites, noise and air quality. Mitigation measures will also be evaluated. How the Massachusetts State Forest Cutting Practices Act and the management of State Forests and Parks affect our environment will be appraised in light of these possible impacts. The whole study may well be of landmark significance.

Dr. Gould has continued to be involved with planning for the use and development of the White Mountain National Forest (WMNF) in his role as an "intervenor" in the appeal against the newly proposed plan. He has done a study of some of the most important economic impacts of the proposed plan and shown that timber production makes a significant contribution to the local economies of upstate New Hampshire. In fact, the federal income tax generated by WMNF timber harvesting seems enough to pay the annual operating budget for the Forest, thus making all the other environmental, scenic and recreational values available at no cost to the Treasury.



Ernie and Anne Gould at Community House picnic.

(Photo by N. J. Torrey)

The way National Forest Planning is developing at the present time suggests that management decisions will depend much more heavily in the future on detailed site-specific analyses of options. The day of reliance on grand generalizations is rapidly being done away with by public clamor, legislators and the courts. In light of this and the rapid development of computer-driven geographic information systems, Dr. Gould and others at the Harvard Forest have begun to explore how these tools can be applied to determining whether forest land management for timber is a viable option for a tract of the WMNF. Dr. Dana Tomlin's MAP program will be combined with regression models developed by Drs. David Jackson and Ernie Gould while David was a Bullard Fellow this year. They plan to pursue this project as financing and time are available.

David Foster's continued research on the development of boreal landscapes led to three trips to Scandinavia during the past year. In July, 1986 he worked on maritime bogs on the island of Andøya, northwestern Norway in collaboration with H. E. Wright, University of Minnesota. These field studies were followed by an excursion throughout western Norway studying cultural history and its effects on vegetation, sponsored by Bergen University. In September, 1986 Dr. Foster travelled to northernmost Sweden and the Royal Research Station in Abisko National Park to present the results of collaborative research with Professor Nils Malmer, Lund University, on peatlands in central Sweden. Central Sweden was also the focus of studies in June, 1987 with H. E. Wright.

Continuing his collaborative research with the Limnological Research Center at the University of Minnesota, Dr. Foster completed a study with George King and Mary Santelmann of the flora, chemistry and paleoecology of mires in Labrador and adjacent Quebec.

Studies on the dynamics of temperate forests continue to be pursued. Working with Gordon Whitney, former Bullard Fellow, Dr. Foster completed an analysis of floristic differences between old-growth and second-growth forests in central New England. Data for this study come, in part, from early studies by Griffith, Hartwell and Shaw, by Branch, Daley and Lotti, and by Cline and Spurr at the Pisgah Forest in southwestern New Hampshire and in the Town of Petersham.

The work of Kevin Fetherston on hurricane change at Pisgah and that of Peter Schoonmaker involving sediment cores for pollen analysis and historical reconstruction of the Pisgah Forest during the last 2,000 years all add to a better understanding of the long-term dynamics of the Pisgah Forest. Dr. Foster plans to continue this computer-based study with the help of Emery Boose and the improved computer facilities made possible by National Science Foundation funds.

Travel once again played an important role in the teaching and research activities of Dr. Barry Tomlinson. Lecture trips in the United States took Dr. Tomlinson to the University of Montana at Missoula as invited graduate speaker, to an international symposium on palms at the Bailey Hortorium at Cornell University and to the Zilker Botanic Garden in Austin, Texas as adviser to the Board of Directors.

Field work included visits to field stations of the Organization for Tropical Studies in Costa Rica, collaborative work in St. Croix, U. S. Virgin Islands with Dr. Paul Cox of Brigham Young University of Provo, Utah on underwater pollination in the seagrass Thalassia and work in Texas and Arizona on the arborescent monocotyledonous family Nolinaceae. Dr. Tomlinson also completed work at the Royal Botanic Garden, Edinburgh, Scotland which was part of a general survey of coniferous shoot morphology. This work was supported by a grant from the Whiting Foundation.

Ulrike Reutter returned to the University of Heidelberg, West Germany in October 1986, after completing a demographic study of Lycopodium lucidulum. It was found possible in her studies to date growth events over periods of as much as 20 years by morphological analysis.



Harvard Forest scientists on an outing. (l. to r.): Ruhama Berliner, Tokushiro Takaso, Jan Silvester, Hayes Lamont and Shean-Shong Tzean. In front: Warwick Silvester. (Photograph by W. Silvester)

Dr. Tokushiro Takaso from the Makino Herbarium, Tokyo, Japan worked with Dr. Tomlinson during the period October 1986 to June 1987 on aspects of gymnosperm morphology. An investigation of the architecture and shoot development of the southern hemisphere podocarp Phyllocladus was completed. True distichy was shown to exist in the development of the flattened leaf-like phylloclades, each of which represents three branch orders. Phyllocladus was shown to lack this flattened branch structure in its seed cones. Dr. Takaso worked extensively on ovule and cone development, using the scanning electron microscope (SEM) facilities of the Museum of Comparative Zoology in Cambridge.

Dr. Torrey's major research interest continues to center on a series of problems in symbiotic nitrogen-fixing trees and the biology of the soil actinomycete, Frankia that nodulates actinorhizal plants.

Dr. Warwick Silvester, of the University of Waikato, Hamilton, New Zealand spent the year at the Harvard Forest as visiting scientist with support from the Mellon Foundation grant. Dr. Silvester's research centered on the physiology of dinitrogen fixation both in Frankia grown in pure culture in defined media and in root nodules of actinorhizal plants including Alnus, Myrica and Casuarina. In cooperation with Dr. Larry Winship of the School of Natural Sciences of Hampshire College, he created elegant continuous flow-through systems that allowed the nodulated roots to be exposed to above- and below-ambient oxygen tensions. Continuous short- or long-term measurements were possible of acetylene-reduction (nitrogenase) activity by Frankia. These systems show remarkable adaptations to external pO_2 (partial pressure of oxygen) having the capacity to optimize to oxygen concentrations over a wide range (2-60%) of oxygen concentration. Each of the three host genera behaves somewhat differently in the adaptive responses.

Dr. Hayes Lamont, post-doctoral fellow in Dr. Torrey's laboratory joined Dr. Silvester in a collaborative effort studying the nature and modification of the vesicle envelope which forms the outermost layer of the swollen terminal endings of Frankia grown in aerobic culture. The thickness of the vesicle envelope is related to the pO_2 at which the cultures are grown. Using the lipid-soluble fluorescent dye Nile Red, Hayes and Warwick were able to demonstrate that the vesicle envelope is lipid and that the fluorescent intensity parallels the envelope thickness observed with dark-field illumination.

Dr. Stephen Safo-Sampah has confirmed that Frankia HFPCcI3 grown in synthetic liquid media containing pyruvate or propionate will convert Whatman #1 filter paper to soluble, short-chain polymers and to glucose. The cellulolytic activity of this bacterial culture continues to be a matter of great interest, suggesting the possibility that this enzyme(s) could function in the process of cell wall dissolution in the infection of host plant roots or alternatively may play a role in the saprophytic life of Frankia in the soil.



Dr. S. S. Tzean is a post-doctoral fellow working with Dr. Torrey. Dr. Tzean comes from the Department of Plant Pathology and Entomology of the National Taiwan University of Taipei in Taiwan, Republic of China with financial support from the National Science Council of Taiwan. His research is concerned with two aspects of Frankia symbioses. One involves the possible interactions between Frankia and VA mycorrhiza in Alnus-microbial associations. The other problem concerns the physiology of spore germination activators on overcoming Frankia spore dormancy. Dr. Tzean will spend about five months in Petersham, following an initial period of research at Rutgers University.

FOREST OPERATIONS - PETERSHAM

Vegetation Survey. Periodic inventories of the Harvard Forest have been undertaken at 10-15 year intervals since 1907. In general these surveys have involved the mapping of forest stands followed by intensive sampling. These data are good records of the forest's conditions that help define growth and development. The latest mapping and inventory were initiated in the summer of 1985.

During the summer of 1986 three Harvard undergraduates and three Yale graduate students completed the first phase of the vegetation survey of the Prospect Hill Tract, establishing over 675 permanent plots and mapping 252 separate stands with a total volume of just under 3 million board feet of lumber and the equivalent of 8400 cords of firewood-quality timber. For the summer of 1987 four students, including two Harvard undergraduates, continued the vegetation survey, moving on to the Tom Swamp Tract. Supervision of this project is under the direction of Drs. Gould, Foster and John Edwards. For the students, the summer experience includes intense field work combined with laboratory-based interpretation of aerial photographs, mapping, and computer storage of inventory data. At least another full summer's work will be needed to make the comparable assessment of the Slab City Tract and complete Phase I of the vegetation survey.

With the award of a National Science Foundation grant from the Biological Research Resources Program our computer facilities will be notably improved allowing us to digitize our stand maps and make inventory data readily available on the computer.

Timber Harvesting. Silvicultural research continues on Tom Swamp VII, Prospect Hill VIII and Prospect Hill I. To date, approximately 3,000 board feet of hemlock and white pine saw logs and 15 cords of cordwood have been removed from TSVII as part of a combination patch cut and improvement cut. Six thousand board feet of Norway spruce and red oak sawlogs and 26 cords of wood have been removed from PHVIII as a result of a combination seed tree plantation thinning and improvement cutting. Five thousand board feet of cabbage pine sawlogs and 12 cords of firewood were removed from PHI to make room for our plantations and lumber sticking area.

Buildings and Grounds. Efforts continue at the Forest to improve on existing structures. Phase II of the fire detection system is now complete in Shaler Hall. The Fisher Cottage received a much needed painting as well as considerable improvements aimed at reducing energy consumption. Many landscaping and grounds projects as well as the complete restoration of a 1966 Chevrolet C-60 dump truck donated by a local lumber company continue to keep the woods crew busy.

HARVARD BLACK ROCK FOREST - CORNWALL, NEW YORK

Forest Operations. A selection harvest of primarily oak sawtimber was made in Compartment XXIX during late October, 1986. Fifty thousand board feet of logs were sold to the J & J Log and Lumber Corporation of Dover Plains, New York. A detailed report on all phases of this operation has been placed in our files.

The cordwood thinning begun last year in Compartment XXIII has progressed according to plan. This in-house cutting by John Brady is improving the stand while producing a modest income from stumpage.

Unusually heavy rainstorms in late March and early April 1987 caused considerable damage to our roads. A great deal of time and effort has been exerted to effect repairs. By the end of the fiscal year, all of our primary roads were made passable for passenger vehicles. We are also on an intensive program of upgrading our trails. We are clearing debris, cutting brush and repainting faded trail markers.

During the months of January and February, John Brady built about a dozen wood duck nesting boxes. He used sturdy one inch oak lumber which we had stocked for this purpose. These boxes are installed around some of our ponds to increase nesting opportunities for these colorful ducks.

Research. Gypsy moth research by Dr. C. G. Jones of the Institute of Ecosystem Studies of the New York Botanical Garden completed the third year of investigations. Moth populations remained low in the Frog Hill area where study plots are being monitored. As reported last year, severe defoliation took place in the southwest portion of the Forest. Fortunately, that epidemic population collapsed as of the spring of 1987. Limited tree mortality seems to result from one defoliation. Two successive defoliations appear to be adequate cause for large-scale mortality of large overstory trees.

The oak seedling survival study noted in previous annual reports is being continued. Interim progress has been described in the New York Forester, a quarterly publication of the N. Y. Society of American Foresters.

We have been testing survival rates of oak, walnut and white spruce seedlings out-planted into man-made clearings. To date, survival has been erratic because deer seem to consider our efforts as some type of dietary supplement to their normal food supply. We are presently fencing individual seedlings to discourage such depredations.

Wildlife Studies. Deer populations in the Black Rock Forest are of considerable interest from a number of points of view. Statistics on population numbers are maintained from various sources. In the period from August through October 1986 deer population surveys were made by John Brady with the help of volunteers from the Black Rock Fish and Game Club, using spotlights after dark. In February 1987 a deer management conference was held at the Black Rock Forest organized by Jack Karnig, Manager of the Black Rock Forest.

In June 1987 John Brady attended a deer management conference at Warren, Pennsylvania. Interaction between deer populations and forest stand maintenance and seedling establishment continue to be a matter of interest and concern.

Other Activities. The Harvard Black Rock Forest, with its well mapped and marked trails and scenic views, receives many hikers and nature lovers as visitors throughout the year. In some cases the resident manager is

sought out by them for special information or instruction. This year was no exception with perhaps an increase in interested visitors. In October 1986 Jack Karnig hosted Bullard Fellow, Donald Theoe, who was pursuing leads related to his studies of Professor Fisher. Also in October, the Black Rock Forest hosted four Russian entomologists who were interested in the research on gypsy moths conducted by the Institute of Ecosystem Studies. Increased interest in the Forest was shown also by visitors from educational institutions in and around the greater New York area related to the potentially more active use of the Forest for research and teaching.

ACKNOWLEDGEMENTS

The year 1987 marks the end of a special era in botanical research at Harvard University. Over the past fifty years the endowment from the Maria Moors Cabot Foundation for Botanical Research has provided financial support for a broad spectrum of research in plant science both in Cambridge and in Petersham. According to the original bequest, income from the endowment was directed to three purposes: "The primary purpose is, by artificial selection and by other methods, to increase the capacity of the Earth to produce fuel by the growth of trees and other plants; secondly, to increase and cheapen other products of the vegetable kingdom valuable to man; third, to disseminate information helpful and stimulating to others who may wish to enter this field of effort".

Over the years the Cabot Foundation of Harvard University became well known through its sponsorship and publication of six major symposia, by plant research, through the publication of innumerable research papers by its faculty and through its support in construction and equipping of research facilities in Cambridge at the Biological Laboratories and the Harvard University Herbaria and in Petersham at the Harvard Forest. With Godfrey L. Cabot's expressed interest in the growth of trees, the Harvard Forest has especially felt the undergirding provided by this bequest.

However, in accordance with the original bequest, "on June 1, 1987, the funds of this foundation (are) to be added to the unrestricted funds of the College....." Those of us associated with the Cabot Foundation over the years are grateful for the original benefaction and acknowledge its importance to botanical research over this past half-century. The transition to more general uses by the College will be gradual and some continued recognition of the botanical sciences will be perpetuated - for example, in the Maria Moors Cabot Professorship of Biology currently held by Professor L. Bogorad and in on-going endowment support for some of the facilities created from the Cabot Foundation funds.

Acknowledgement is made once again this year of substantial support for research activities at the Harvard Forest from federal governmental agencies and from private foundations.

At the top of our list we acknowledge the generous unrestricted gifts from Friends of the Harvard Forest who continue to show their interest in our activities and thereby express confidence in the importance of the role to be played by the Harvard Forest in the community, in the state and in the world at large.

Contributions during the year toward the work described in this Annual Report include gifts from the following donors to whom we are indebted:

Friends of the Harvard Forest
Atkins Garden Fund
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The foregoing is a list of publications which have appeared in print between July 1, 1986 and June 30, 1987. 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, Massachusetts 01366, or where the address is given, directly to the authors.

Petersham, Massachusetts
August 1987

John G. Torrey
Director



Most of the Harvard Forest "family" on the front steps of Shaler Hall, August 3, 1987.

(Photograph by W. Silvester)