

# THE HARVARD FOREST, 1989 - 90

Harvard University



## HARVARD FOREST SUMMER RESEARCH ASSISTANTS - 1990

### Harvard Forest Survey and Inventory

Martha Varnot - Barre, MA  
Debbie Hogan - Harvard University

### LTER - Stem maps and blowdown survey

Karen LeClair - Paul Smiths College  
John Quisel - Harvard University

### Petersham Land-use and Vegetation History, Geographic Information Systems

Martha Kennan - Salem State College

### Pisgah Tract: Old-growth response to disturbance

Joel Gerwin - Harvard University  
Eowyn Nilson - Bennington College  
Anne Smyth - Harvard University

### Bazzaz Group: Gap regeneration, and plant resource utilization

Wendy Doherty - College of the Atlantic  
Bill Patterson - Cornell University

### Trail Exhibit and Interpretation - Museum Intern

Sarah Sheldon - University of Massachusetts



Back row (l. to r.):  
K. LeClair, M. Kennan,  
D. Hogan, M. Varnot

Front row (l. to r.):  
J. Quisel, J. Gerwin,  
A. Lezberg, A. Smyth

(Photo by M. Fluet)

*Front Cover:* As part of the Long Term Ecological Research (LTER) program at the Harvard Forest, experimental blowdowns, like that on the Prospect Hill tract illustrated on the front cover, are being created to simulate the impact of hurricanes to the forests of New England. Following the pulldowns, researchers in the LTER will analyze microclimate, nutrient cycling and carbon dynamics, trace gas fluxes, vegetation development, physiological and demographic changes in tree seedlings, deer browsing and other aspects of ecosystem change. Date of pulldown: September 28-29, 1989; date of photograph: June 5, 1990. (Photo by M. Fluet)

# ANNUAL REPORT OF ACTIVITIES AT THE HARVARD FOREST

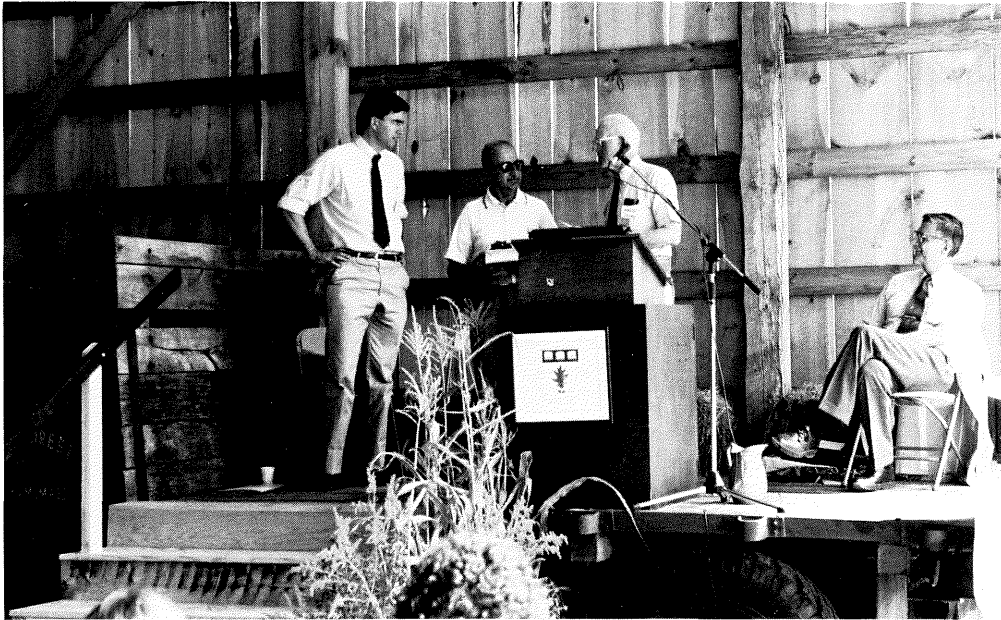
1989-1990

## PERSONNEL

A. E. Akachuku, Charles Bullard Fellow (until September 1989)  
Donna Barker-Berlo, Research Assistant (until May 1990)  
Emery R. Boose, Computer Manager (from July 1989)  
Jeanne M. Boutelle, Custodian  
Jeannette M. Bowlen, Accountant (from September 1989)  
John R. Brady, Assistant to the Manager of the Black Rock Forest (until September 1989)  
Elaine D. Doughty, Laboratory Assistant  
John A. Edwards, Forest Manager, Harvard Forest  
Marion L. Ellsworth, Laboratory Aide (part-time until May 1990)  
Marcheterre Fluet, Research Assistant (from November 1989)  
Barbara J. Flye, Secretary  
David R. Foster, Associate Professor of Biology and  
Assistant Director of the Harvard Forest  
Denise C. Gaudreau, Research Associate  
Anne K. Hachey, Greenhouse Assistant (part-time until May 1990)  
Donald E. Hesselton, Woods Crew  
Heather A. Jacobson, Research Assistant (from August 1989)  
Jack J. Karnig, Forest Manager, Black Rock Forest (until September 1989)  
Ann L. Lezberg, Research Assistant  
Isabelle F. Louis, Post-doctoral Fellow (Mellon)  
Ralph L. Lundquist, Head of Greenhouse (until May 1990)  
Ellen G. Moriarty, Graphic Artist (part-time)  
Frances E. O'Brien, Secretary (until October 1989)  
John F. O'Keefe, Museum Coordinator  
George F. Peterken, Charles Bullard Fellow (from September 1989 to June 1990)  
Frances N. Phillips, Secretary  
Suzanne E. Racette, Research Assistant (until May 1990)  
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*  
Robin W. Scribailo, Post-doctoral Fellow (NSERC)  
Dorothy R. Smith, Secretary  
Charles C. Spooner, Woods Crew  
Keith A. Spooner, Woods Crew (part-time)  
Russell D. Stafford, Research Assistant (from June 1990); MFS candidate  
(from September 1990)  
Tokushiro Takaso, Post-doctoral Fellow (NSF) (until May 1990)  
C. Dana Tomlin, Associate of the Harvard Forest; Associate Professor, Ohio  
State University  
P. Barry Tomlinson, E. C. Jeffrey Professor of Biology  
John G. Torrey, Charles Bullard Professor of Forestry and  
Director of the Harvard Forest  
Gordon G. Whitney, Research Associate  
John S. Wisnewski, Woods Crew  
Tad M. Zebryk, Research Assistant; MFS candidate (from September 1990)

## STAFF

The annual meeting of the Friends of the Harvard Forest in early September 1989 was a special occasion. The all-day program included an outdoor buffet luncheon served under a striped tent, following the dedication of the Gould Audio-Visual Education Center and the first showing of the A-V program entitled "The Harvard Forest" directed by John O'Keefe, Fisher Museum Coordinator. In the afternoon the crowd of more than 200 gathered in the completed pole barn which had been transformed into an outdoor auditorium with our vintage 1942 GMC truck serving as a stage, to hear Professor E. O. Wilson, Frank B. Baird, Jr. Professor of Science of Harvard University present an address on biodiversity and the environment. His speech highlighted our celebration of the establishment of the Harvard Forest as a site for Long-Term Ecological Research (LTER) under the National Science Foundation's LTER Program.



(l. to r.) D. Foster, J. Karnig, J. Torrey, E. Wilson  
(Photo by D. Phillips)

The occasion also marked the termination of 30 years of dedicated service to Harvard University by Jack J. Karnig, Forest Manager of the Black Rock Forest in Cornwall, New York. Jack was presented a clock to commemorate his long service both to the Harvard Forest and to Harvard University.

Professor P. B. Tomlinson was on leave for the fall term conducting field research in New Zealand, New Caledonia, New South Wales and Tasmania from August 1989 to January 1990. He was back in Petersham in time to celebrate the publication of his new book entitled "The Structural Biology of Palms" produced by Oxford University Press. In May 1990 he and his family attended the 25-Year Recognition Program in Cambridge to receive the award of a Harvard chair, presented by President Bok.

David R. Foster has been appointed Director of the Harvard Forest effective July 1, 1990 for a five-year term in the place of Professor Torrey who steps down from the directorship after six years in service. In relation to the restructuring of the Harvard Forest administration, Dean Spence has appointed a Faculty Advisory Committee, chaired by Professor Andrew H. Knoll, Department of Organismic and Evolutionary Biology and including several faculty members from other University departments with interests and activities at the Harvard Forest.

Professor Torrey was honored by appointment as Storer Life Science Lecturer at the University of California at Davis. He presented three public lectures and consulted widely among the faculty during his week stay in October 1989.

In May 1990 Dr. Torrey was recognized for his research in *Frankia*-actinorhizal research by a group of colleagues and students who met at the Harvard Forest for an all-day workshop in *Frankia* biology. The occasion was organized by Dr. Torrey's former student Dr. D. Baker at Yale University.

Dr. Torrey's research laboratory in the Controlled Environment Facility has been closed but he will continue as Professor until his mandatory retirement June 1991.

Frances O'Brien completed eighteen years as Secretary at the Harvard Forest, sixteen of them as Secretary of the Cabot Foundation. A retirement reception was held in the Fisher Museum in October.

Jeannette Bowlen joined the staff of the Harvard Forest to fill a new position as Accountant.



(l. to r.) D. Smith, F. Phillips, B. Flye, J. Bowlen (Photo by M. Fluet)

In September we received word of the death of Georgina (Paine) Howland at the age of 101. Mrs. Howland was the wife of the late Llewellyn Howland and of Richard T. Fisher, founding director of the Harvard Forest.

Marion S. Hambleton, Secretary at the Harvard Forest from September 1941 until her retirement in June 1963, died in May 1990.

We have been informed that Dr. Ruhama Berliner was one of the victims of a guerrilla attack on February 4, 1990 on a tour bus travelling from Israel to the cities of ancient Egypt south of Cairo. Dr. Berliner was a Bullard Fellow at the Harvard Forest in 1986-87 and stayed on as a post-doctoral fellow for a second year with support from the Mellon Foundation. The death of Dr. Berliner is a sad loss to her many friends and a loss to the scientific community.

Stephen H. Spurr, former Assistant Director and staff member (1940 - 1950) at the Harvard Forest, died this June in Austin, Texas at the age of 72. While in Petersham, Spurr published major articles on vegetation distribution, the role of disturbance in New England forests, forest development, silviculture, soils, microclimate and aerial photography interpretation. After leaving the Forest, he taught at Minnesota and Michigan before moving to the University of Texas, where he was president and professor.

#### COURSES AND STUDENTS

Dr. Tomlinson taught Biology 24 (*Introduction to Plant Biology*) and Biology 102 (*Biology of Gymnosperms*) during the spring term 1990 and participated in the Harvard Forest Freshman Seminar. In June-July 1990 he taught Biology S-105 (*Plants of the Tropics*) at Fairchild Tropical Garden, Miami, Florida. In Cambridge he participated in organizing the Harvard University Herbaria Seminar series during the spring semester.

Sixteen students participated in Biology 160 (*Forest Ecology*) offered by Dr. Foster in the fall term. In addition to the regular lecture schedule in Cambridge, the students spent three weekends at the Harvard Forest with a final weekend devoted to independent projects. The class accomplishments included: a spatial analysis of regeneration patterns of birch species at the Pisgah Forest ranging from microsite differences to tract-wide distribution assessed using Geographic Information Systems; damage patterns, disturbance history and regeneration of the wind-thrown Cathedral Pines in NW Connecticut; analysis of the damage patterns on the simulated windthrow created on the Prospect Hill tract (see front cover); and a dendrochronological analysis of the old-growth hemlock stand on the Prospect Hill tract.

Biology 299 (*Forest Practice and Research*) was under the direction of Dr. Foster. This course of independent study is intended for advanced undergraduate and graduate students who wish to apply their strong background in forest biology or related fields to specific research questions. Three students from the Graduate School of Design, two biology undergraduate majors and one biology graduate student took this course this year. Projects included: paleolimnology and restoration ecology of a lake in northern New York; policy and practice of wetland replication; forest history reconstruction; and landscape-level analysis of forest disturbance patterns.

The Harvard Forest Freshman Seminar provides each year an opportunity for first-year students to learn about the landscape, history and biology of plants in central New England and more specifically about research activities at the Harvard Forest. Most of the staff get involved in this informal instruction during the four weekends students spend in Petersham. Highlights of the independent projects undertaken by the class this past spring include: the discovery that the Townline Swamp on the Prospect Hill tract has over 8 meters of sediment beneath it, dating back 13,000 years; creation of a new design for the John Sanderson Farm exhibit in the Fisher Museum; an architectural analysis of *Fagus grandifolia*; and a study of tree regeneration patterns within and outside deer exclosures at the Quabbin Reservoir where deer populations are very high.

In addition to regular teaching responsibilities, Dr. Foster supervised two undergraduate student theses: Kathy Hocker undertook a study of gap dynamics in Sitka spruce forests of southeastern Alaska and Leslie Bargbagello made a comparative study of present-day tropical deforestation and historical deforestation of northeastern U.S. in the 18th and 19th centuries.

With support from the REU (Research Experience for Undergraduates) program of the National Science Foundation, Jonathan Harrod (Harvard College) and Marcheterre Fluett (Smith College) worked with Dr. Takaso and Dr. Tomlinson on the conifer cone project June-September 1989. The objective was for students to experience field collection, specimen fixation, processing, microscopic examination and presentation in publishable form. Each student was assigned a given genus (*Chamaecyparis*, *Juniperus*) on which he or she worked for the summer.

T. Sipe completed his PhD thesis research under the direction of Professor F. Bazzaz of the Department of Organismic and Evolutionary Biology, (OEB) Harvard University, and submitted his thesis (see Bibliography). He made a seminar presentation of part of this work in Petersham. Tim and his family left Petersham after six years in residence, moving to Saint Peter, Minnesota. Tim will assume a tenure-track faculty position in the Department of Biology at Gustavus Adolphus College.

Ms. S. R. Mansour completed her PhD thesis research at the Harvard Forest under the joint direction of Professor Torrey and Dr. A. Dewedar and returned in June 1990 to submit the thesis to the Department of Botany, Suez Canal University, Ismailia, Egypt.

P. Schoonmaker is nearing completion of his thesis research for the PhD degree in Biology at Harvard University under Professor D. Foster. Peter's research has centered on disturbance effects at the Pisgah tract originating during the 1938 hurricane.

Three PhD students working under the supervision of Professor F. Bazzaz (OEB) spend part of their research time, especially during the summer months, at the Harvard Forest and have their primary base in Cambridge. Rosie Crabtree, Gary Carlton and Peter Wayne are all regular participants in summer research programs in Petersham. Their work is described in a later section under LTER Research.





Mr. R. A. Moustafa continues to work on his PhD thesis locally under the supervision of Professor D. Foster in collaboration with university faculty members in Egypt. His study of the environmental factors influencing plant distribution in the South Sinai, Egypt has been facilitated by statistical analyses using computer facilities available at the Harvard Forest. His thesis will be submitted to the faculty of the Suez Canal University in Ismailia, Egypt.

*(Photo by M. Fluet)*

#### MEETINGS AND VISITORS

In October the Harvard Forest hosted a meeting of the Coordinating Committee of the LTER Program of the National Science Foundation (NSF). Some fifty scientists representing the seventeen LTER sites across the United States that form a network for ecological research met together with NSF administrators to exchange information and coordinate plans for intersite activities over the next decade. Two half-days were spent in the field at study sites devoted to regeneration in forest gaps, atmosphere/biosphere exchanges especially involving trace gas fluxes, and vegetational changes following a simulated windstorm.

In January 1990 the principal investigators and co-principal investigators of the HF-LTER held their all-day annual meeting in the Fisher Museum in Petersham for scientific exchange and for planning. In the morning progress reports were made by leaders of each of the research groups (Foster, Bazzaz, Aber, Nadelhoffer, Melillo and Wofsy) and in the afternoon plans for the ensuing third year were developed with new research activities and proposals presented and discussed. About thirty-five scientists attended.

Other meetings held at the Harvard Forest included the New England Forest Economists, Massachusetts Cooperative Extension Service Coverts Project, Massachusetts Project Learning Tree, and the Massachusetts Association of Conservation Commissions Wetlands/Wildlife Workshop.

The Harvard Forest seminar series was a mixture of research presentations, many highlighting the work of our local scientists, and reviews of forestry-related videotapes to evaluate their appropriateness for inclusion in the Gould Audio-Visual Center Library. The video review process enabled our staff to continue to develop their critical thinking with respect to a wide range of subjects and presentation styles.



Seminar presenters included: Mr. Bruce Spencer, Head Forester, Metropolitan District Commission; Dr. George Peterken, Charles Bullard Fellow on leave from the Nature Conservancy Council, UK; Mr. Robert Leverett, who has done extensive research on remaining old-growth forest areas in Massachusetts; Dr. Gregory Insarov, Senior Research Scientist, Natural Environment and Climate Monitoring Laboratory, Moscow, USSR; Mr. Michael Bell, doctoral candidate, Yale University; Mr. Glenn Motzkin, graduate student in forestry at the University of Massachusetts, Amherst; as well as Dr. Robin Scribailo, Dr. David Foster, Dr. Barry Tomlinson, Dr. John Torrey, Dr. Isabelle Louis, Dr. Gordon Whitney, Dr. Denise Gaudreau, Ms. Ann Lezberg, Ms. Rosie Crabtree and Dr. Timothy Sipe all of the Harvard Forest, reviewing their current work.

Dr. Tomlinson and Dr. Takaso participated in a symposium on "Modern evidence in the systematics of conifers" at the A.I.B.S. meetings held in Toronto, Canada, August 7-10, 1989. The meeting was organized by Dr. Tomlinson and sponsored by the American Society of Plant Taxonomists and the Systematics Section of the Botanical Society of America.

### FISHER MUSEUM

The highlight of the year in the Fisher Museum was the dedication of the Gould Audio-Visual Education Center at the Harvard Forest Gala in September. Mrs. John Fiske cut the ceremonial ribbon with a machete once used by Professor Fisher to weed out undesirable saplings and Mrs. Ernest Gould unveiled a bronze plaque dedicated in Ernie's memory. A capacity crowd of close to two hundred then viewed the premier of our first multi-media presentation, "The Harvard Forest."

Generous grants from the Wharton Conservation Trust and the George I. Alden Trust, together with gifts given in memory of Ernie Gould, permitted construction of the Gould Audio-Visual Education Center, purchase of the necessary equipment and production of this show. The completed facility consists of a visitor-operated VCR/television monitor system which features a different selection from our expanding videotape library each month, and the multi-media complex which allows production and presentation of slide shows using up to three projectors synchronized to narration and music.



Our show, "The Harvard Forest," has seen extensive use as an introduction to the Forest for many groups, ranging from elementary school through university and professional associations, who visited the Forest. In January John O'Keefe was the featured speaker and presented the show at the annual meeting of the Massachusetts Forestry Association held in Sturbridge. Recently, the AV show has been transferred to videotape.

The weekend hours for the Museum (Saturdays from 10 am - 4 pm, May through October) have been continued in 1990. An expanding group of dedicated volunteers make these weekend openings possible and should permit expansion to Sunday hours in 1991. The Museum hosted special weekend programs for the Harvard Neighbors and Massachusetts Forest Products week in October and for Earth Day 1990 in April. This spring a shelter created by Donald Hesselton to hold trail maps and brochures was installed on the lawn in front of the Museum.



Sarah Sheldon, a recent graduate in forestry from the University of Massachusetts, was employed as Museum intern to assist with the revision of the Natural History Trail through John Sanderson's Farm (Red Trail). New features include interpretations of the recent tree harvesting activity and the new deer enclosure. The LTER demonstration pulldown along the Black Gum Trail is one of several features being incorporated into that self-guided trail.

J. O'Keefe, S. Sheldon and D. Hesselton viewing a marker on the Red Trail. (Photo by M. Fluet)

#### COMPUTERS AND DATA MANAGEMENT

Computer facilities at the Harvard Forest have been greatly expanded this year. The old North Star computers were retired and replaced by new IBM PS/2s. The recently renovated computer lab and office now contain six computers (including four new model 70-A21s) for research and data management. Their primary use is GIS (Geographic Information Systems), spatial statistics and data analysis. Our three secretaries and accountant each have a new computer (model 30-286) with HP LaserJet printer for word processing, accounting, and data entry. An IBM XT and clone are available for general use.

Software developed at the Harvard Forest has included a major revision of the Harvard Forest accounting program. GIS programs, developed over the last several years by E. Boose to supplement the Map Analysis Package (MAP) of C. D. Tomlin, were revised, expanded and distributed, along with the PC version of MAP, to other LTER sites. A new series of programs was created to yield accurate maps of tree stems (and other point objects) from field measurements of inter-tree distances: coordinates are calculated by triangulation, likely errors are identified, and GIS maps are produced from the coordinate data.

Computer networks are becoming increasingly important for scientific communication and collaboration. Electronic mail, acquired by the Forest in December, has proven to be a valuable communications link with our collaborators and other research sites. Next fall we plan to set up a local area network (LAN) connecting our six research computers: the LAN should make it easier to share files, peripheral devices, and electronic mail. We plan to connect our LAN to the Harvard University campus network and thus to international networks such as the Internet. Valuable advice on networking was received from the LTER Connectivity Committee that visited the Forest in October.

For more than 80 years the Harvard Forest has kept careful records on paper of research and forest management activities. We plan to convert some of our archival data to electronic form, and virtually all of our new data will be collected or entered on a computer. The role of data management will thus grow in importance, especially in light of our commitment as an LTER site to store and make accessible to others the results of our long-term ecological experiments. This year we have outlined long-term plans for data management at the Harvard Forest, and have contributed information on our core experiments for inclusion in the LTER Core Data Set Catalog.

One of the benefits of the LTER program is the chance to learn from and work with scientists and computer experts from other LTER sites. This year ("the year of the workshop") offered many such opportunities. As a representative of the Harvard Forest LTER, E. Boose attended the LTER Data Managers Meeting (Toronto), the LTER GIS Workshop (Ft. Collins, CO), the LTER Remote Sensing Workshop (Durham, NH), the Workshop on Data Management at Inland and Coastal Field Stations (Kellogg Biological Station, MI), and the spring LTER Coordinating Committee Meeting (San Juan, Puerto Rico).

Dr. C. D. Tomlin, Harvard Forest Associate, continues a direct involvement in research activities in Petersham, especially in relation to HF-LTER projects and development of computer software. His presentations have taken him to many different departments and schools in Ohio and to meetings in New Haven, CT; Denver, CO; Ames, IA; Detroit, MI; Champaign, IL; and Fort Collins, CO. He serves on the National Workshop Committee of the American Society for Photogrammetry and Remote Sensing. His current research involves work with agencies of NASA and the U.S. Army Corps of Engineers as well as with the Harvard Forest.

#### BULLARD FELLOWS

Dr. George F. Peterken arrived with his wife, Susan, in September. Dr. Peterken came from the Nature Conservancy Council in Great Britain, where he specializes in woodland conservation, a role which has involved commissioning and applying research; developing policies for woodland assessment and management; and advising on the impact of national forestry policies. His research interests have centered on the classification and long-term history of native British forests.

At Harvard Forest Dr. Peterken divided his time between two projects. In collaboration with Professor Richard Forman of the Graduate School of Design, he examined the landscape-scale issues in redesigning British upland conifer plantations. He also prepared material for a book on natural wood-

lands, to bring the knowledge gained from research on natural forests in North America and central Europe to bear on various conservation issues in British woodlands. He travelled to virgin forest remnants throughout the United States. He also prepared a paper on "old-growth" forests in Europe for a North American audience and gave lectures at Cornell University, University of Massachusetts at Amherst, and the Institute of Ecosystems Studies in Millbrook, New York.

G. Peterken (Photo by M. Fluet)



#### HARVARD FOREST RESEARCH

**Comparative morphology of plants.** Dr. Tomlinson spent six months in the South Pacific collecting material for the study of cone development in southern hemisphere conifers, mainly the family Podocarpaceae.

Field work involved closely monitoring populations over extended periods, complemented by dissection of samples to assess developmental stages. Adequate material for developmental study of eight genera was obtained. In addition, field observations at the time of pollination suggested that there is a distinctive method of pollen capture, related to the distinctive structure of the cone in most members of the family, and seemingly also to the breeding mechanism and seeding strategy.

Dr. Tokushiro Takaso working with Dr. Tomlinson, continued a survey of cone development in Taxodiaceae and Cupressaceae with support from the National Science Foundation. All ten genera in the Taxodiaceae have been examined as well as eight genera in the Cupressaceae. In Taxodiaceae there is remarkable diversity in the timing of initiation of the ovuliferous scale, while in Cupressaceae most genera lack this structure altogether. The generally accepted idea that the coniferous cone is always a compound structure is thus being challenged. Dr. Takaso left Harvard Forest in May 1990 to take an appointment at the University of Victoria, British Columbia.

Dr. Robin Scribailo continued work on floral development of aroids, with initial emphasis on taxa with perfect flowers. Despite the seemingly simple structure, there is considerable diversity in developmental pathways. The ultimate objective is to study mechanisms controlling floral development within the family since on a single inflorescence staminate, pistillate and sterile flowers based on a common structural plan, may occur.

**Roots and Rhizosphere.** Studies continued in Dr. Torrey's laboratory of the *Frankia*-actinorhizal plant symbiotic associations that result in fixation of nitrogen from the atmosphere, benefitting the host plants and ultimately the soil and the environment. The focus this year has been on sporulation by *Frankia* both in culture and in the host root nodules and spore behavior following sporangial release. Several strains of *Frankia* that characteristically show spontaneous spore release in culture have been shown by Suzanne Racette to nodulate a range of actinorhizal host plants where sporulation in the nodule occurs with low frequency. These strains are the first pure-cultured isolates known to cause sporulation in the host.

Samira Mansour studied the role of germinating spores in the infection process using *Casuarina glauca* as the host plant and two *Frankia* isolates from *Casuarina*, including one strain HFPCgI4 isolated by Samira from *C. glauca* nodules collected in Egypt. Ms. Mansour found that spores from both strains showed increased percentage germination in response to root exudates, aseptically prepared from roots either of *C. glauca* or *Gymnostoma papuanum* (Casuarinaceae).

Inoculation with spore suspensions of CgI4 of seedlings of *C. glauca* grown in water culture resulted in prompt (3 day) germination of the spores in the vicinity of the seedling roots, followed by infection of root hairs by *Frankia* hyphae from germinated spores, and subsequent development of effective root nodules. This research presents clear evidence that spores alone can be infective particles for nodulation in actinorhizal plants. The assumption is made that root exudates facilitate the infection process.



Dr. Torrey's research group in May 1990. (l. to r. front) E. Doughty, D. Barker-Berlo with Zachary; (center) I. Louis, S. Racette, A. Hachey, L. Ellsworth, S. Mansour; (back) R. Lundquist. (Photo by M. Fluet)

Dr. Isabelle Louis of the Department of Botany, National University of Singapore continued her second year at the Harvard Forest. Dr. Louis' research, supported by the Mellon Foundation and a grant from the USDA Competitive Grants Program to Dr. Torrey and performed in collaboration with S. Racette, focussed on the physiology of cluster-root formation in several actinorhizal plants, especially in the Myricaceae. Cluster roots are elicited in several species by deficiency of phosphate in nutrient solution or in soils. Dr. Louis also developed methods for the axenic micro-propagation of the actinorhizal plant *Comptonia peregrina*.

**Studies of Bog Development in Sweden.** With support from the NSF Ecology Program and Swedish National Research Council, D. Foster is continuing to study the initiation and development of raised bogs in central Sweden in conjunction with H. Jacobson (University of Maine; University of Lund, Sweden), J. Almendinger, and H. Wright, Jr. (both of the U. of Minnesota). Research to date has documented the centrifugal expansion of bogs in conformance with an autogenic model of development and independent of exogenous factors such as climate change. Hydrological studies involving placement of a transect of piezometers beneath the bog Hammarmossen have documented that the mire is perched above the regional groundwater table. This result greatly alters our conception of the hydrological setting of raised bogs. H. Jacobson's PhD research is focussed on paleolimnological and paleohydrological changes in central Sweden and will greatly augment the understanding of the regional and local environment. The research program should contribute to an integrated knowledge of landscape development involving climatic, hydrological and vegetational change on upland and wetland areas.

**Forest dynamics and historical studies in New England.** Dr. G. Whitney, Research Associate, has extended an earlier study by John Goodlett on vegetation-site relationships in the Harvard Forest area. With the help of several student assistants, he extended the study to a wider range of sites and species. He developed several software programs for assessing the significance of site factors on the distribution of the vegetation.

Numerous related studies are tied together under the common theme of vegetation, disturbance and land-use history. These studies seek to establish the nature of the pre-settlement forests and environment and to evaluate the effects of spatially and temporally varying disturbance regimes and land-use practices. The work integrates the fields of paleoecology, biogeography, climate dynamics, agricultural history and related social sciences.

D. Foster, E. Boose, D. Gaudreau and G. Whitney are looking at spatial variation in vegetation and land use across Worcester County and the adjoining Connecticut Valley Lowland and temporal variation in forest patterns from the late Holocene to the present. For each of the more than 100 townships in this region historical data being collected include early land surveys, decadal land-use and agricultural statistics, and forest surveys. These data, which will extend back into the 18th and late 17th centuries, will be encoded and analyzed on Geographic Information Systems. Paleoecological studies of selected small lake basins across the region will extend this historical information back into the Holocene. The region incorporates significant environmental and cultural gradients; sites will be positioned to sample the resulting vegetation history across these gradients.

Denise Gaudreau will coordinate the paleoecology studies in a newly developed pollen laboratory and will link the results with those from her prior studies in western New England.

At the Pisgah Forest in SW New Hampshire, Peter Schoonmaker is finishing his detailed forest reconstruction and paleoecological analysis of late Holocene vegetation and disturbance history. He has finished analyzing the pollen in five humus soils and small wetlands, has counted tree ring chronologies from more than 300 trees and has reconstructed the vegetation history along two transects across the forest and in two large plots.

Results from a related study on the Prospect Hill tract have been recently submitted for publication by D. Foster and T. Zebryk. Detailed pollen studies of sediments in a small hollow and the Black Gum Swamp enable the reconstruction of the local and regional vegetation history over an 11,000-year period. During this period the forests, which were dominated by hemlock for the last 8,000 years, were affected by eleven fires, the hemlock blight 4,700 years ago, and extensive alteration by cutting, agriculture and fire by settlers 200 years ago. Following each disturbance the hemlock and northern hardwood species were replaced by pine, oak and birch or chestnut and then subsequently recovered.

Tad Zebryk is continuing to investigate the historical development of the Black Gum Swamp as part of a project for the Masters of Forest Science (MFS) degree. Russell Stafford, another MFS student, is examining the regeneration patterns of hemlock at the Pisgah tract.

**Related studies of wind damage.** D. Foster, A. Lezberg, M. Fluet and E. Boose travelled to Puerto Rico in May 1990 to investigate the damage to the Luquillo Experimental Forest as part of the Puerto Rico LTER project where David is a co-investigator. M. Fluet and D. Foster have been analyzing air photos of the damage to ascertain the relationship to specific landforms and forest-type. Field studies provided a good ground check of this analysis, which will be used to generate a GIS-based model of tropical forest response to catastrophic wind and rain.

M. Fluet and D. Foster presented results on a similar analysis of tornado damage to old-growth forests in the Tionesta Scenic Area (Allegheny National Forest), western Pennsylvania to a meeting of collaborators at the Institute of Ecosystems Studies, in Millbrook, NY.

#### **HARVARD FOREST LTER RESEARCH**

October 15, 1989 marked the beginning of the second year of a six-year grant from the National Science Foundation to the Harvard Forest in support of its Long Term Ecological Research (LTER) program, as one of 17 sites in the national LTER network. The HF-LTER is administered by a science team composed of D. Foster and J. Torrey, Harvard Forest; F. Bazzaz, Organismic and Evolutionary Biology; S. Wofsy, Earth and Planetary Sciences, Harvard University; J. Melillo, K. Nadelhoffer, P. Steudler, Marine Biological Laboratory, Woods Hole, MA; and J. Aber, University of New Hampshire who meet approximately every other month to plan and coordinate research activities based in Petersham.



The central focus of the HF-LTER program is a study of the effects of natural and man-made disturbances on forest vegetation and their effects on the functioning of the forest ecosystems. Experimentation includes simulation of atmospheric depositions by increased chronic nitrogen and sulfur applications to the soil, creation of small and large gaps in the forest by simulated wind storms or by selective deadening of overstory species, and long-term continuous monitoring of trace gas fluxes within and above the forest canopy. Experimental sites include Prospect Hill, Tom Swamp and Slab City tracts of the Harvard Forest. Efforts are made to achieve careful coordination and intense use of each experimental site through detailed mapping of the vegetation on the ground, the use of aerial photography and remote sensing (overflights by NASA), the application of Geographic Information Systems and modelling.

Upwards of fifty scientists including principal investigators, post-doctoral fellows, graduate and undergraduate students and technical help from a number of institutions are involved in the on-going research of the HF-LTER. Funding comes not only from the NSF HF-LTER grant but also from supplementary grants from NSF and from other government and private agencies in support of the broad ecological research program. Operations are year round but intensify during the spring, summer and fall each year.

Some of the highlights of the research are summarized below.

- In September, 1989, 0.5 hectare (ha) of a 50-year-old hardwood forest was pulled down, simulating windstorm damage. This site near Prospect Hill Road served as a trial run for a larger simulated hurricane area planned for the coming year. Researchers have been involved in a detailed analysis of the patterns of vegetation damage created by this disturbance.

- In the fall of 1990, a 1.0 ha area in a hardwood stand on the Tom Swamp tract will be pulled over to simulate the effect of hurricane winds. In addition, three 0.25 ha plots will have either red oak, red maple or all overstory species except red maple killed by girdling to simulate pathogen damage. This year prior to these treatments intensive work has been devoted to base-line data acquisition, mapping, sampling and measuring in the undisturbed forest.

Complete stem maps for all plots have been drawn, shrub and herb abundance in permanent plots have been compiled and additional data collected, including seedling density and distribution, seed rain, litter fall and nutrient analyses, micrometeorological characteristics, soil trace gas fluxes, and nitrification and mineralization information. Each of these parameters will be measured repeatedly after the blowdown.

The blowdown will be created by our woods crew working in conjunction with the forestry crew from the University of Massachusetts. On the Prospect Hill tract these crews developed a technique in which steel cable from a skidder equipped with a Hyster winch is attached to an individual tree 5 m above the ground and then pulled to bring the tree down. The technique does a very good job of simulating a natural windstorm as the equipment can be operated from a working area situated some distance from the experimental site and trees will either uproot or snap off depending on their inherent mechanical strength and rooting properties (see front cover).



•Data collection at the Environmental Monitoring Station (EMS) began in October 1989 under the direction of S. Wofsy with the help of post-doctoral fellows, W. Munger and P. Bakwin. Vertical profiles are acquired every 20 minutes from instrumentation installed on a 30-meter radio tower for temperature, water vapor, ozone, carbon dioxide and carbon monoxide. Also total oxides of nitrogen and nitrous oxide radicals are measured. Continuous records are obtained for net and photosynthetic radiation, for soil temperatures and the amount and chemical composition of precipitation. These data are archived on 8-mm videotape.

S. Wofsy (standing) and P. Bakwin examine the instrumentation at the EMS site. (Photo by M. Fluet)

The onset of net uptake of  $\text{CO}_2$  at Harvard Forest was observed in late April, indicating a contribution of evergreen species from a larger area than earlier anticipated. Measurements of dry deposition of total oxides of nitrogen ( $\text{NO}_y$ ) show an enormous influence of air borne pollutants from the New York metropolitan area. No significant deposition of  $\text{NO}_y$  was observed on snow and the hypothesis predicts deposition during the winter on tree boles and branches. The ozone uptake rates were relatively low in winter, providing base-line data for spring and summer and periods of active plant metabolism.

The data obtainable represent a rich and varied set, defining the inputs of nutrients and toxicants to Harvard Forest throughout the year.

•The research group from the Ecosystem Center, Marine Biological Laboratories and John Aber from the University of New Hampshire are undertaking a series of experiments to determine the responses of forest ecosystems to continuous low level additions of nitrogen and sulfur compounds, typically derived from the atmosphere as acid rain. Experimental treatments involve regular additions of nitrogen as ammonium nitrate and sulfur as sulfate.

Intensive samplings have been made of trace gases including nitrous oxides and methane based on short-term samplings of gases trapped in a chamber above the soil. The most intriguing result to date has been a significant reduction in methane consumption in soils amended with nitrogen compounds.

Other studies involve nitrogen mineralization, foliage litter decay, green foliage analysis and above-ground litter analyses with a view to developing understanding of C and N cycling in the forest ecosystem.



T. Sipe, G. Carlton, R. Crabtree, and A. Mallas (Photo by J. O'Keefe)

•F. Bazzaz and his graduate students (T. Sipe, R. Crabtree, G. Carlton and P. Wayne) have focussed on the process of forest regeneration after disturbances that produce gaps of different sizes in the forest and create distinctive microenvironmental patterns, especially of light and temperature. In his studies of regeneration of maple (*Acer*) species in gaps of different sizes at the Harvard Forest, T. Sipe found that *A. pensylvanicum* outperformed *A. rubrum* and *A. saccharum* in nearly all positions within the gaps. Patterns of survival and growth were supported by shoot-level photosynthesis measurements.

R. Crabtree is assessing the effects of the form and rate of nitrogen application on patterns of biomass accumulation among four species of birch (*Betula* spp.). In shadehouse experiments yellow and black birch (*B. alleghaniensis* and *B. lenta*) allocate relatively more biomass to roots when fed  $\text{NH}_4^+$ . Grey and white birch (*B. populifolia* and *B. papyrifera*) allocate more to leaves. Neither rate of application nor form of nitrogen affected total biomass production differently among the four species. Interactions with light were apparent with some species. Field trials have been established in plots on Prospect Hill tract to assess further the effects of nitrogen treatment on seedling performance.

G. Carlton has planned his research on regeneration of six tree species following disturbance by determining seedling success at microsites found after hurricane blowdowns, - i.e., tip-up mounds, pits, in open areas and under residual vegetation. Differences at each of these sites may be expected in nutrient availability, light, water and gaseous fluxes. His study will take advantage of the experimental blowdown planned on the Tom Swamp site. Preliminary baseline information on micrometeorological conditions at undisturbed sites will be followed by characterization of conditions at each microsite after the blowdown. Observations over two years are planned.

## FOREST OPERATIONS

Almost ninety experimental plantations, mostly of conifers, were established at the Harvard Forest from 1909 through 1940. During the current year discussions were intensified to determine the best management options for these areas. Clearly, some of our plantations provide fine examples of fully-stocked, vigorous trees of excellent form while others have been so damaged by pests and/or heavily invaded by competing hardwoods that they scarcely represent plantations.

In January 1990 plantations comprising twelve acres in the Prospect Hill tract were selected for cutting. Selective thinnings were completed on two plantations of mixed spruce and pine while two red pine plantations comprising six acres were clearcut. A one-acre white pine plantation still remains to be thinned next winter. The estimated 100,000 board feet of timber from the cut plantations were sold primarily to a local mill and to one in Winchester, New Hampshire. Some high quality poles were sold and trucked to Canada for use as utility poles while lesser quality poles sent to Canada were pressure-treated and shipped to Africa, for use as erosion-control stabilizers in the Sahara as part of a World Bank project. Several trailers of pulpwood were shipped to International Paper Company while several thousand board feet of smaller logs were sawn in Harvard Forest's own sawmill. Bill Laity, a forest management intern from Sterling College, Craftsbury Common, Vermont, assisted in the operation. This open area, although disturbed in the short run, provides outstanding wildlife habitat and will produce sapling stands for future research use (see back cover).

Our ongoing project to gate access roads and thereby restrict vehicle use continues this year. Four 14-foot swinging gates were installed through the efforts and skills of the woods crew. Signs will be added to inform the public of restrictions and acceptable activities. An estimate has been made that as many as 35 gates of different types may need to be installed over the next several years.

The sandpit on the eastern side of Harvard Pond has been exhausted of useful gravel and sand and has been closed. Its regrading and planting with red oak, alder and autumn olive seedlings will accelerate its revegetation and aesthetic appearance. Other plantings include two hundred Christmas tree seedlings on the grounds near Shaler Hall.

With the help of an anonymous donation we were able to purchase and install a 100-horsepower 371 GMC Diesel power unit in the sawmill. This improvement coupled with the addition of a Belsaw edger has made our milling capability much more efficient, in time for us to saw the large quantity of small diameter sawlogs produced by the timber harvest previously described. Our building maintenance always requires finish and dimension lumber. We are thankful to have the means to supply our own lumber in-house.

Shaler Garage has been improved with the installation of a new roof. New storm windows were placed on the second floor of Shaler Hall as well as a new roof on the Fisher Museum. The Director's house has received much attention including complete interior painting and refinishing of the floors.

A new central electric well-control system was installed for a reliable water supply. A compressed-air system for the vehicle maintenance shop in the garage improves our capacity for in-house repairs. Roadwork improvement behind Shaler Hall along Locust Opening, Pierce Farm and Prospect Hill Roads, designed to facilitate 12-month access, is nearing completion.

#### HARVARD BLACK ROCK FOREST

On September 14, 1989 the sale of the Black Rock Forest to the Golden Family Foundation of New York City was consummated by Harvard University after many years of negotiation and planning. Mr. William Golden, head of the Foundation, transferred the management of the Black Rock Forest to the BRF Preserve and a Consortium of fifteen scientific and educational member institutions. The member institutions include: American Museum of Natural History, Bard College, Barnard College, Brearley School, Brookhaven National Laboratory, Brooklyn Botanic Garden, City College of New York, Columbia University, Dalton School, Friends Seminary, Lehman College, New York Academy of Sciences, New York University, Storm King School and the United Nations International School.

According to Mr. Golden, each of these institutions will conduct their own research in biology, botany, geology and ecology and they will be encouraged to develop joint research projects at the Forest in the future. The Consortium is led by an executive committee with Dr. Philip Ammirato of Barnard College, President and Dr. Dwight Kincaid of Lehman College, Secretary. Mr. Jack J. Karnig, formerly Manager of the Black Rock Forest with Harvard University, has been appointed Director with John Brady as Forest Manager under the Consortium.

The Consortium now publishes the Black Rock Forest Newsletter with regular reports on the activities there. Anyone interested in being placed on the mailing list should write Jack Karnig, Black Rock Forest, Box 483, Cornwall, NY 12518.

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The foregoing is a list of publications which have appeared in print between July 1, 1989 and June 30, 1990. 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  
June 1990

John G. Torrey  
Director



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A view looking north across Locust Opening Road into Plantation 24-C before it was thinned early in 1990 (see Forest Operations). Alternating blocks of sixteen white pine and sixteen white spruce seedlings from the Forest nursery were planted (in checkerboard fashion) on this old mowing in 1924. Seedlings that died were replaced in 1927. Competing hardwoods were weeded out in 1933 and 1935. The stand was lightly thinned in 1943 and again in 1951. The white pine grew faster but was of poor quality due to severe weevil damage and the thinnings favored the spruce.

The lack of any treatment for nearly forty years is clearly evident in this photograph. The 1990 thinning removed nearly 60% of the stems and just over 50% of the volume in this stand. Numerous hardwood saplings, which are well suited to this site and will eventually form the replacement stand, can be seen in the understory. The present condition of the stand can be seen by looking north across Locust Opening Road from the site of the harvest landing on the Red Trail. (Photo by M. Fluet)