

# THE HARVARD FOREST 1993 - 94

Harvard University





**Cover photograph**

**Available light: one of many dynamic variables in forest ecology.**



# ANNUAL REPORT OF THE HARVARD FOREST 1993-1994

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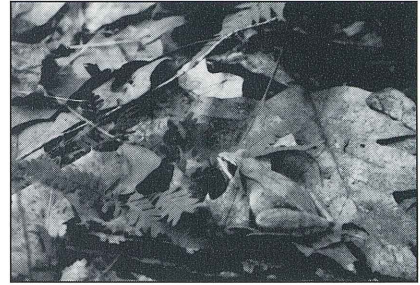
*Photography by Marcheterre Fluet*



# PERSONNEL AT THE HARVARD FOREST 1993-94

Arthur Allen	Research Assistant
Taber D. Allison	Paleoecologist
Richard D. Boone	Soil Ecologist
Emery R. Boose	Computer Scientist
Richard D. Bowden	REU Coordinator (part-time)
Jeannette M. Bowlen	Accountant
Jana D. Canary	Research Assistant
Gary C. Carlton	PhD Candidate, OEB
Evan H. DeLucia	Charles Bullard Fellow
Sean M. Divoll	Woods Crew (part-time)
Elaine D. Doughty	Laboratory Assistant (part-time)
Natalie Drake	Palynologist (part-time)
John A. Edwards	Forest Manager
Marcheterre Fluet	Research Assistant
Barbara J. Flye	Librarian/Secretary
David R. Foster	Director of the Harvard Forest
Lisa George	PhD Candidate, OEB
Fritz Gerhardt	MFS Candidate
Alisa Golodetz	Research Assistant (part-time)
Julian L. Hadley	Charles Bullard Fellow
Deborah Y. Hebert	Summer Cook, 1993
Donald E. Hesselton	Woods Crew
Dai P. Huynh	Woods Crew (part-time)
Jason P. Kaye	Research Assistant
Kathleen M. Keith	Research Assistant
Gong Wooi Khoon	Charles Bullard Fellow
Oscar P. Lacwasan	Custodian
Richard A. Lent	Data Manager/Ecologist
Ann L. Lezberg	Research Assistant
Anita Locke	Summer Cook, 1994
Catherine M. Mabry	Research Assistant
Glenn R. Matlack	Charles Bullard Fellow
Patricia Micks	Research Assistant
Ellen G. Moriarty	Graphic Artist (part-time)
Glenn H. Motzkin	Research Assistant
John F. O'Keefe	Museum Coordinator
Gloria Rapalee	GIS Assistant (part-time)
Hugh M. Raup	Charles Bullard Professor, <i>Emeritus</i>
Juan F. Silva	Charles Bullard Fellow
Timothy W. Sipe	Charles Bullard Fellow
Dorothy R. Smith	Secretary
Thomas A. Spies	Charles Bullard Fellow
Charles C. Spooner	Woods Crew
Lynne E. Stopen	Woods Crew (part-time)
Mark Thibault	Woods Crew (part-time)
C. Dana Tomlin	Associate of the Harvard Forest
P. Barry Tomlinson	E. C. Jeffrey Professor of Biology
Carlos Vazquez-Yanes	Charles Bullard Fellow
Craig Whiting	Research Assistant (part-time)
Margot Wilkinson	Research Assistant (part-time)
Paul S. Wilson	Research Associate
John S. Wisniewski	Woods Crew
Steven C. Wofsy	Associate of the Harvard Forest





## INTRODUCTION TO THE HARVARD FOREST

Since its establishment in 1907 the Harvard Forest has served as a base for research and education and in forest biology. Through the years researchers at the Forest have focussed on silviculture and forest management, soils and the development of forest site concepts, the biology of temperate and tropical trees, forest ecology and economics and ecosystem dynamics. Today, this research and educational legacy continues as the faculty, staff and students seek to understand historical and modern changes in the forests of central New England resulting from human and natural disturbance processes. This research activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 through funding by the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 3000 acres of land in Petersham, Massachusetts that include mixed hardwood and conifer forests, ponds, extensive spruce and maple swamps, and diverse plantations. Additional land holdings include the 25-acre Pisgah Forest in southwestern New Hampshire, a virgin forest of white pine and hemlock that was 300 years old when it blew down in the 1938 Hurricane; the 100-acre Matthews Plantation in Hamilton, Massachusetts, which is largely comprised of conifer plantations; and the 90-acre Tall Timbers Forest in Royalston, Massachusetts. In Petersham a complex of buildings that includes Shaler Hall, the Fisher Museum and Torrey Laboratories provide office and laboratory space, computer and greenhouse facilities, and a lecture room and lodging for seminars and conferences. An additional six houses and apartments provide housing for staff, visiting researchers and students. Extensive records of plant research, long-term data sets and historical information are maintained in the Harvard Forest archives.

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences (FAS) of Harvard

University, with the Director reporting to the Dean of FAS. The Harvard Forest administers the Graduate Program in Forestry that awards a Masters degree in Forest Science. Faculty at the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), which awards the PhD degree, and through the Freshman Seminar Program. Close association is maintained with the Department of Earth and Planetary Sciences (EPS) and the Graduate School of Design (GSD) at Harvard and with the Department of Forestry and Wildlife Management at the University of Massachusetts, the Ecosystems Center (Marine Biological Laboratory, Woods Hole), and the Complex Systems Research Center at the University of New Hampshire.

The staff of approximately 40 work collaboratively to achieve the research, educational and management objectives of the Harvard Forest. A sub-group of researchers meet monthly to discuss current activities and to plan future programs. Regular meetings with the HF LTER science team and with the Harvard Forest Advisory Committee provide for an infusion of outside perspectives. Forest management and physical plant activities are undertaken by our three-man Woods Crew and directed by the Forest Manager. The Coordinator of the Fisher Museum oversees many of our educational and outreach programs.

Funding for the base operation and staff at the Harvard Forest is derived from endowments, whereas research activities are supported with grants primarily from the federal government. Major research support comes from the National Science Foundation, Department of Energy (National Institute for Global Environmental Change), U.S. Department of Agriculture, and the Andrew W. Mellon Foundation. Our Summer Program for Student Research is supported by the National Science Foundation, the Northeastern Consortium for Undergraduate Science Education (Pew Charitable Trust), the A. W. Mellon Foundation and the R. T. Fisher Fund of Harvard Forest.



## RESEARCH ACTIVITIES

Research at the Harvard Forest addresses basic questions concerning the development and dynamics of all components of forest ecosystems, with an emphasis on eastern North America. These studies use the excellent facilities and detailed histories of the 3000-acre Harvard Forest for site-based research and experimental manipulations and then scale up to landscape and regional studies across central Massachusetts and much of New England. We involve scientists and students from other institutions to bring additional perspectives to our research program, and we place results from studies in New England into a broader context through regional and comparative investigations in other ecosystems.

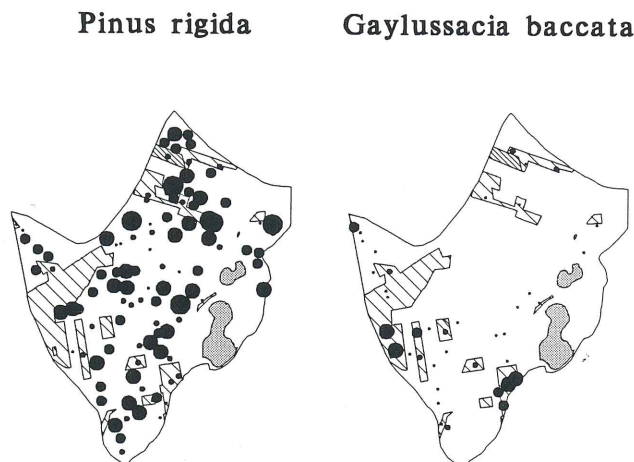
### Land-use History and Forest Ecosystem Dynamics

Human activity directly and indirectly controls forest ecosystem structure, composition and function across broad areas of the globe. A major focus of numerous studies at the Harvard Forest is to reconstruct and to describe historical patterns of land-use activity and to interpret the resulting forest dynamics. Of particular interest is the evaluation of the duration of land-use impacts on ecosystem function and the implication of these effects for forest management and conservation. This research emphasis continues a long tradition of study at the Harvard Forest and is coordinated by D.R. Foster with funding from the A. W. Mellon Foundation, National Science Foundation, and National Aeronautic and Space Administration.

### Community and Landscape Studies

Ultimately our ability to interpret the effects of human activity on forest composition, structure and process will depend on site studies that combine intensive environmental and vegetation analysis and detailed historical information with an intimate understanding of basic biological and ecological processes. Many Harvard Forest studies continue to develop such detailed site information. On sand plains in the Connecticut River Valley Glenn Motzkin and David Foster are coordinating a study of the vegetation dynamics and disturbance history of pitch-pine/scrub oak communities, relatively uncommon vegetation that is of considerable conservation interest. During the past year Glenn mapped 50 years of forest change from aerial photographs, compiled fire and land-use histories, sampled the vegetation with the assistance of Jon Harrod, and analyzed the relationships between species distribution and vegetation composition and land-use history (Fig. 1). Art Allen undertook detailed soils sampling in this project and worked with Glenn on all aspects of the field studies. Jon will present the results of the study at the Ecological Society of America conference this summer and Glenn, David and Art are currently preparing two manuscripts for publication.

On a landscape level D. Foster, G. Motzkin and J. O'Keefe have initiated a study of the changing distribution of white pine and hemlock in the township of Petersham. This study seeks to contrast the response of two abundant and important conifer species which have very different biologies, to the regime of land clearance, forest cutting, and agricultural abandonment that occurred in central New



**Fig. 1.** The effect of land-use history on the modern distribution of pitch pine (*Pinus rigida*) and huckleberry (*Gaylussacia baccata*) on a sand plain in the Connecticut River Valley. Within the 2000-acre sand plain two distinct types of land-use were prevalent during the 19th C: tillage for agricultural crops such as corn (unshaded areas) and woodlot (shaded areas). Despite 60-100 years of reforestation, the current distribution of these species exhibits very tight relationships to historical activities. Evidently huckleberry expands outward very slowly from residual woodlot areas whereas pitch pine establishes prolifically onto exposed mineral soils following agricultural abandonment.



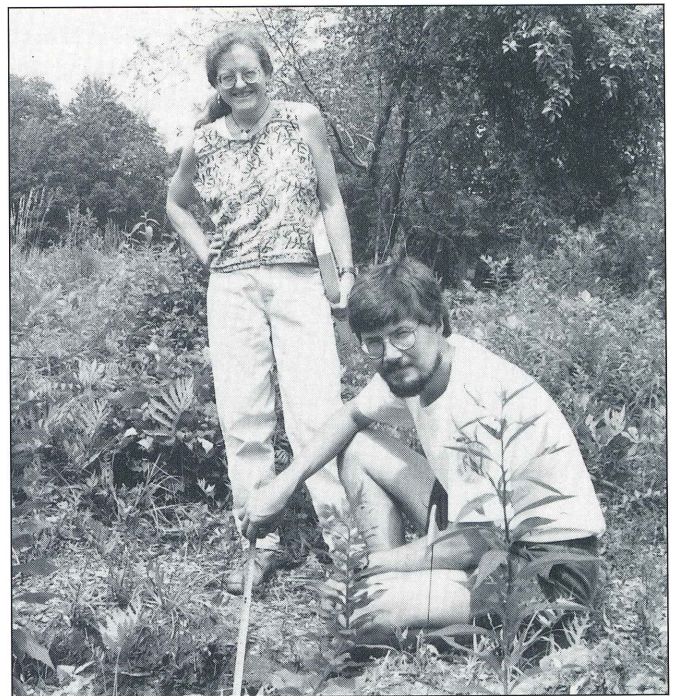
**Joel Carlson and Don Strauss looking for hemlock and white pine in Petersham**

England. The first phase of the study involves mapping the modern distribution of these species from aerial photographs and field sampling, which is being undertaken by summer assistants Joel Carlson and Don Strauss. Subsequent work will focus on comparisons with historical maps and analysis of historical data on the abundance and human use of these species.

*Land-use and Soils Relationships*

In parallel with the vegetation studies an extensive survey and sampling of soils on Prospect Hill and sand plains in the Connecticut River Valley was completed to evaluate the relationships between land-use, vegetation and soils. The work included description of soil profiles and soil sampling of 172 sites on Prospect Hill and 121 sites on the sand plains. Prior land-use (tillage, pasturage, permanent woodlot) was determined by the presence or absence of a plow ( $A_p$ ) layer and other soil profile characteristics. Laboratory analyses included characterization of organic matter content, pH, texture, coarse fragment content and bulk density. The field and laboratory work involved Art Allen on the sand plains and Art, Melinda McCall, Jason Kaye, Rachel Byard, Margot Wilkinson, Craig Whiting, and Rich Boone on Prospect Hill.

Cation content and potentially mineralizable nitrogen were measured for a subset of samples from both sites. The data suggest that prior land-use influences current soil properties as evidenced by: (1) significantly higher calcium on formerly plowed Prospect Hill sites, (2) significantly lower potassium on formerly plowed sand plain sites, (3) both higher (Prospect Hill) and lower (sand plain) potentially mineralizable N on sites that were formerly plowed. Field-based determinations of prior land-use on Prospect Hill, as interpreted by Art from soil profile characteristics, has compared favorably with historical analysis by Stephen Spurr in the 1950's, and D. Foster recently. As part of a collaborative effort with the NSF LTER program, the Soil Conservation Service (SCS) has agreed to characterize the cation content and texture of soil samples from both sites. Ongoing work on soil/land-use legacies includes a soil moisture retention study conducted by Art on sand plain soils and a study of mineralizable nitrogen on the two sites undertaken by R. Boone and J. Compton in conjunction with Art, Glenn and David.



**Cathy Mabry and Art Allen preparing soil pits on the Prospect Hill tract before a summer field trip**



Although detailed site studies at the Harvard Forest describe the long-term development of vegetation in response to environmental change, natural disturbance and human activity there is great need to evaluate these results within a regional context and to assess forest development in areas of contrasting land-use and environmental conditions. One major study at the Harvard Forest examines the 2000-year history of upland and aquatic ecosystems across the cultural and environmental gradients that stretch from the Connecticut River Valley across the Central Uplands of Massachusetts into the Eastern Lowlands (Fig. 2). This work is coordinated by D.R. Foster and involves M. Binford, N. Drake, J. McLachlan, E. Doughty, G. Motzkin and C. Mabry at Harvard University, Emily Russell at Rutgers University and Mitch Mulholland at the University of Massachusetts.

Fundamental questions that are addressed include: What were the composition and dynamics of forests before European settlement; what impacts did Indian populations have on the vegetation across this region; how did the timing, intensity and type of European agricultural and industrial activity vary; and how did the vegetation respond to broad-scale disturbance in the form of forest clearance and reforestation? Results from this study should enable us to interpret the developmental history of our modern forest landscape, compare modern forest composition and structure to those during the past 2000 years, and provide an historical context for current ecological studies and conservation efforts.

The research involves the use of numerous historical and field techniques: pollen, charcoal, physical and nutrient analysis of lake sediments, compilation and interpretation of archival documents and records, analysis of historical maps and aerial photographs, and sampling of the modern vegetation on a regional basis. Results from the

paleoecological research suggest that fire and Indian activity may have followed patterns of greater frequency and abundance at lower elevations in the Connecticut Valley and towards the coast, that regional vegetation change resulting from European activity included a major decline in the abundance of beech and hemlock and increase in oak, birch, pine and red maple, and that sub-regional differences in vegetation and forest dynamics can be explained by environmental factors and variations in land-use (Fig. 3).

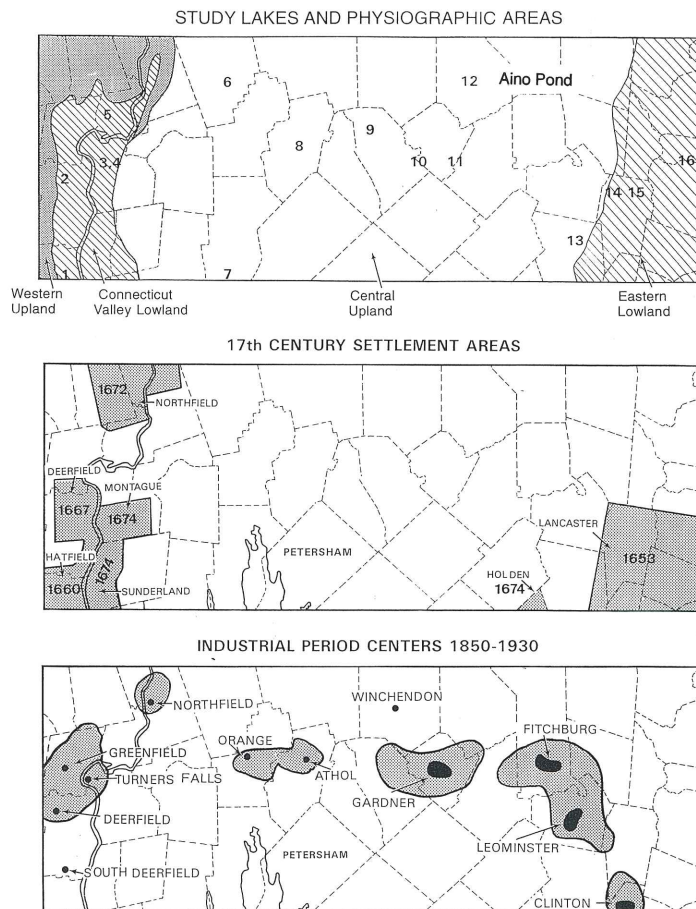
Paleoecological studies have been complemented by analysis of historical and modern data on forest composition. D. Foster completed an analysis of proprietor's data, boundary tree records compiled by early settlers when surveying township and lot boundaries in the 17th and 18th C. These records provide an estimate of tree species abundance in each township at the time of European settlement and reveal broad geographical trends in forest type and distribution. Results from central Massachusetts indicate pronounced trends in species distribution and significant relationships between species abundance and elevation.

D. Foster and G. Rapalee completed the analysis of forest cover maps for 1830 compiled by C. Mabry and G. Motzkin. These maps depict forest areas and cultural features at a time near the peak of agricultural clearance in central New England and thus provide an important indication of land-use intensity and distribution at a local and regional level. Analysis of these maps indicates striking geographic patterns: locally, agriculture within a township was strongly controlled by soil drainage, topography and distance from roads and houses; regionally, broad-scale variation in physiography led to distinctive patterns of land-use and residual forest areas in the Connecticut River Valley, Central Uplands and intervening Pelham Hills. This work has been aided by the substantial efforts of undergraduate assistants Jamie DeNormandie and George Landman in the analysis of historical census data.

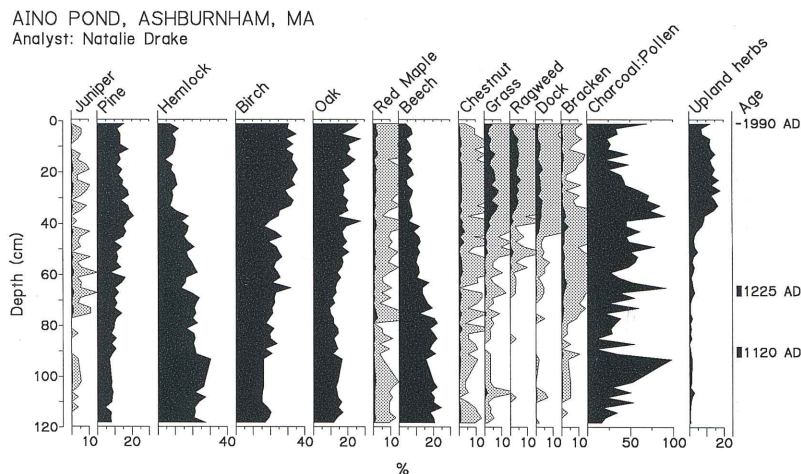


**Mike Binford discusses LTER research with Ann Sakai from the Systematic and Population Biology Program at the National Science Foundation**





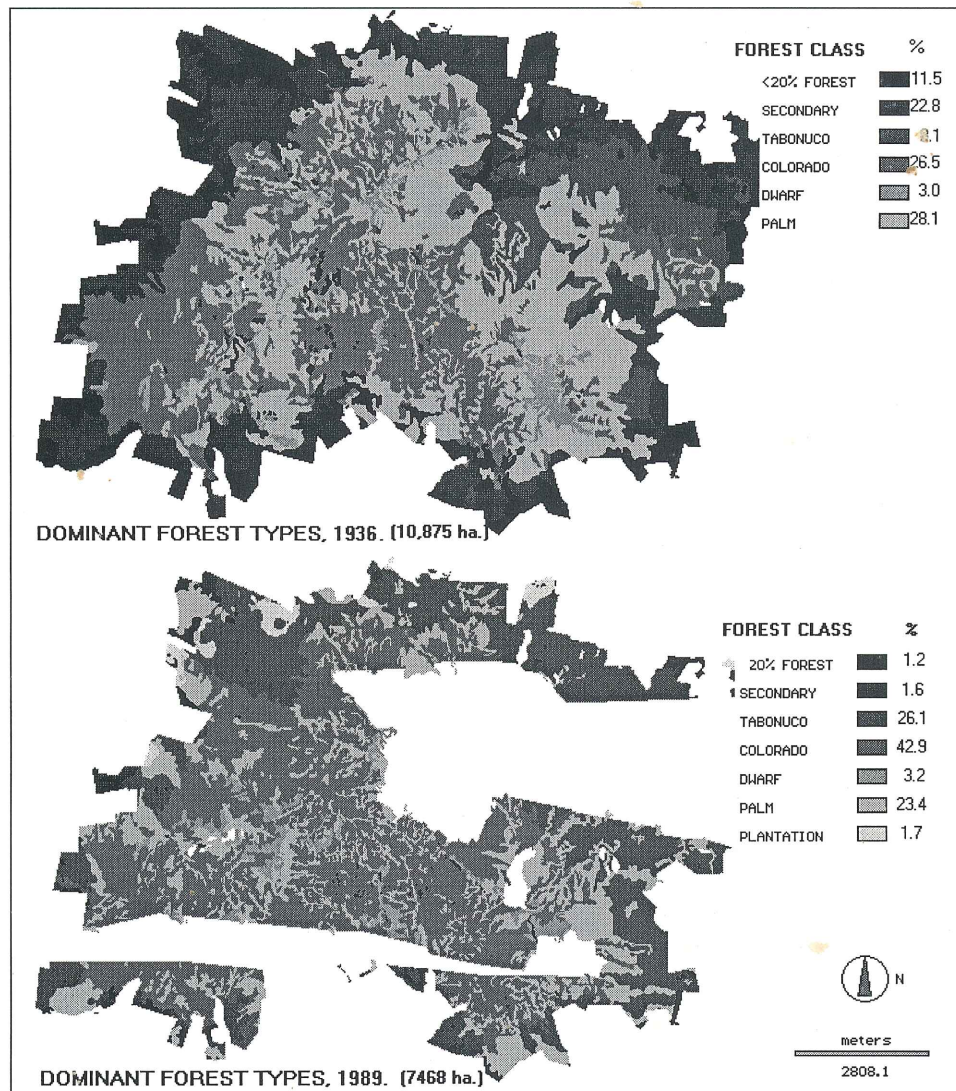
**Fig. 2.** The study area for paleoecological, historical, and modern analysis of vegetation and land-use patterns showing the broad physiographic areas, lakes that are being analyzed for pollen to reconstruct the vegetation over the past 2000 years, and some aspects of human activity. The area stretches from the Connecticut River Valley eastward across the Central Upland to the Eastern Lowlands and northward from the town of Petersham to the New Hampshire border. The location of Aino Pond in Ashburnham is identified in the upper map and the resulting pollen diagram is presented below.



**Fig. 3.** Pollen diagram showing the changes in the vegetation and fire history in north central Massachusetts over the past 1500 years. The major transformation of the landscape by European land clearance and agriculture from the early 18th C to present is indicated by the great increase in grass, weeds and total upland herb species. This land-use activity caused a profound change in forest composition as indicated by the great decrease in beech and hemlock and increase in pine, birch, oak, red maple and chestnut. The 20th C decline in chestnut due to the introduced chestnut blight is noted at the very top of the diagram. The gray shading is a 10x magnification of the % abundance scale.

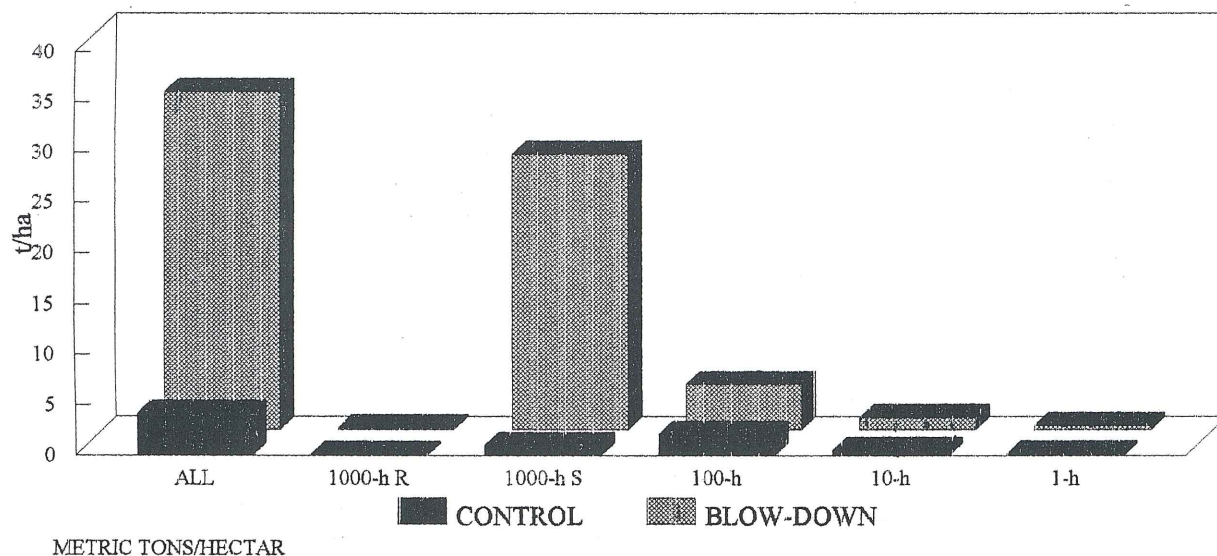
Cathy Mabry, working with summer research assistants D. Holland, C. Collier and R. Saveer provided data on modern forest patterns across north central Massachusetts by sampling 359 randomly located plots for composition of trees, shrubs and herbs. Cathy analyzed these data in relation to site environmental factors and history and is working with David to analyze regional trends in forest composition that will be related to the proprietor's and paleoecological records. It will be interesting and challenging to compare vegetation samples taken some 300 years apart.

The analysis of forest landscape dynamics in Puerto Rico as controlled by land-use history, environmental gradients and hurricane impacts involves M. Fluet, D. Foster and E. Boose. Similarities in the history of deforestation, agriculture and abandonment provide an interesting basis for comparison with central New England, despite the major differences in climate, topography and vegetation (Fig. 4). Marcheterre completed the photo interpretation and GIS analysis of forest vegetation maps from 1936 and 1989 and is currently analyzing historical data on land-use and vegetation with David.



**Fig. 4.** Forest type distribution in the Luquillo Experimental Forest, Puerto Rico, as mapped from the most complete aerial photographic coverage available for 1936 and 1989. Marginal regions of < 20% forest and secondary forest in 1936 are largely replaced by tabonuco forest in 1989, reflecting the elimination of most agriculture after the 1940s. Physiographic relationships consistent with both time periods include the association of palm growth with drainage patterns, and the association of dwarf forest with high and exposed elevations.





**Fig. 5.** Estimates of the mass of downed wood (in tons per hectare) on the experimental hurricane blowdown and an untreated adjacent hardwood forest. Downed wood is divided into five time-lag classes ranging from one hour to 1000 hours that indicate the length of time required to dry the material to a combustible condition. The results indicate that hurricanes do generate substantial fuel loadings that increase the potential for fires, but that much of the fuel is in size classes that require lengthy drought in order to burn.

## Hurricane Disturbance to New England Forests

### *Hurricane modeling*

Hurricanes are an important natural disturbance affecting forest areas in eastern North America and the Caribbean. E. Boose, D. Foster, and M. Fluet are investigating the long-term impacts of hurricanes on the forests of New England and Puerto Rico through a combination of computer modeling and historical studies. Emery has developed a simple meteorological model (HURRECON) that reconstructs wind conditions during a hurricane, and a simple topographic exposure model (EXPOS) that identifies areas exposed to peak winds on a landscape scale. This approach has been tested against actual forest damage in Hurricane Hugo in Puerto Rico and in the 1938 New England Hurricane. This project was continued by Joel Carlson, an REU student who studied treefall orientation across central New England resulting from the 1938 Hurricane. Preliminary results suggest that regional-scale (~100 km) variation in treefall is linked to the broad-scale meteorology of the

storm, while landscape scale (~10 km) variation is a result of air turbulence that is difficult to model. A detailed reconstruction and analysis of the 1815 New England Hurricane is underway by Sherry Baker, an REU student working with Emery. This storm, though similar to the 1938 Hurricane in its track and intensity, had a rather different impact on the landscape because of the widespread clearing for agriculture throughout central New England in 1815.

### *Effects of Hurricane Blowdown on Community Dynamics*

Ann Lezberg continued to assess forest response to the experimental hurricane blowdown on the Tom Swamp tract, with assistance from E. Doughty and Amy Miller. The major findings indicate that nearly 50% of windthrown trees continue to survive and leaf-out three years after blowdown and that saplings and sprouts rather than seedlings dominate the regeneration. Joel Carlson completed an analysis of fuel loading and potential fire characteristics on the blowdown and is preparing a final manuscript for publication with W. A. Patterson at the University of Massachusetts (Fig. 5).

G. Carlton and F. Bazzaz explored the impact of disturbance on resource availability and on tree species by focussing on five microsites created by the experimental hurricane blowdown treatments: mounds, pits, undisturbed forest floor with and without herbaceous vegetation, and the vertical portion of forest floor created by uprooting. Climatic conditions were most extreme on mounds and least extreme in pits and in the undisturbed forest understory. Effects of blowdown on air temperature, light levels, and  $\text{CO}_2$  concentrations were more pronounced after three years than effects on soil resources. Spatial heterogeneity in light levels and nitrate supply rates was greater in the blowdown, but other soil resources were more heterogeneous in the undisturbed forest. Congruence among resource levels was generally greater in the undisturbed forest than in the experimental blowdown.

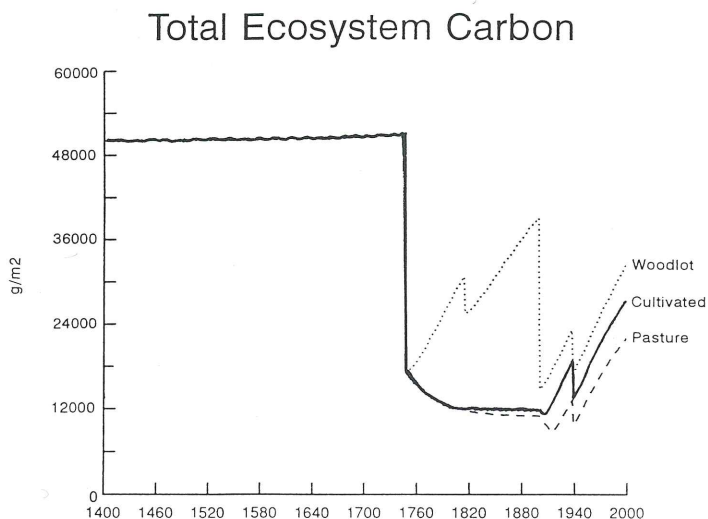
Seed dispersal onto the disturbed site was extremely patchy and seedling recruitment was greatest on exposed topsoil. White birch (*Betula papyrifera*) exhibited the greatest growth rates and most flexible photosynthetic response to changing light levels. Yellow birch (*B. alleghaniensis*) was least flexible and grew more slowly than the other species but was best able to survive on shaded microsites. Black birch (*B. lenta*) was intermediate in its response. To synthesize results of this project, Gary developed projection matrix models for five canopy tree species. The models show that all five species require disturbance to maintain positive population growth. White birch obtains the greatest benefit from the simulated blowdown and red oak the least.

## Soils and Ecosystem Studies

### Factors controlling carbon flux at the Harvard Forest

Measurement and evaluation of carbon flux is a major research focus examined by the soil warming, chronic N, long-term litter manipulation, and Environmental Measurement Site (EMS) studies in the LTER and NIGEC programs. Rich Boone and Emery Boose have added to these efforts by utilizing the CENTURY model to simulate the influence of Harvard Forest land-use history (1700-present) on net carbon flux, and by examining the factors that may determine the different  $\text{CO}_2$  fluxes measured around the EMS (Fig. 6). The CENTURY simulations predict that current carbon storage rates on Prospect Hill average  $2 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ , consistent with data from the EMS, and that storage rates are not influenced by type of prior land-use (tillage, pasturage, permanent woodlot) but are affected by stand age and major disturbances. Simulations were carried out by Roopal Shanghvi, an REU student.

The second study was carried out by Kris Chamberlin as a Master's degree project for Antioch College. Kris considered the influence of land-use history, soil drainage, and stand characteristics on soil respiration and the total  $\text{CO}_2$  flux around the EMS. S. Wofsy and colleagues have determined that net C storage is about  $2\text{--}4 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$  to the southwest and about  $1\text{--}2 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$  to the northwest. Kris' work suggests that soil drainage may be the important controlling factor. Within 100 m of the tower soils to the southwest are poorly drained, those to



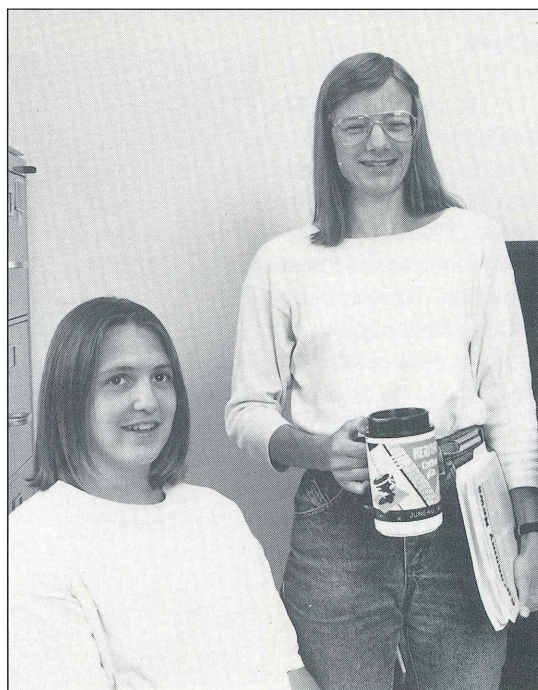
**Fig. 6.** Estimated total ecosystem carbon for the different land-use scenarios in the Harvard Forest dioramas using the CENTURY model. Three generalized land-use sequences were modeled: (1) continuous forest (woodlot); (2) forest-pasture-forest (pasture); and (3) forest-cultivated-forest (cultivated). It was assumed that the forested area was heavily cut at the time of settlement (ca. 1750 A.D.), that agricultural areas were reforested commencing in the late 19th C. and that forest areas were damaged by the hurricanes of 1815 and 1938.



the northwest are well drained. Soil respiration within 100 m of the tower (M. Goulden, investigator) is also lower to the southwest. Kris' work suggests the need for more intensive examination of soil drainage and soil respiration around the tower and underscores the need to define the EMS footprint.

*Biological and physical controls on soil organic matter quantity and quality*

Soils are an important component of the global carbon cycle, yet the biological and physical controls on soil organic matter, especially the active fraction, are poorly understood. To address this topic Rich Boone and Knute Nadelhoffer have continued their long-term litter manipulation study. Over the last year instrumentation of the plots was completed through installation of an automated soil temperature array and soil moisture probes, measurements of soil respiration and soil solution chemistry have continued, and a portable IRGA-based system for measuring CO<sub>2</sub> efflux was developed. The data continue to show treatment effects on soil respiration, soil solution nitrate concentrations, and soil moisture. Jason Kaye was responsible for development of much of the new instrumentation and for chemical analyses. Outside collaborators include Rich Bowden (Allegheny College) and Eric Sundquist (USGS, Woods Hole).



**Jana Canary and Pat Micks**



**Rich Boone and Jana Compton (newly appointed Research Associate)**



### *Carbon controls on nitrogen retention by temperate forest ecosystems*

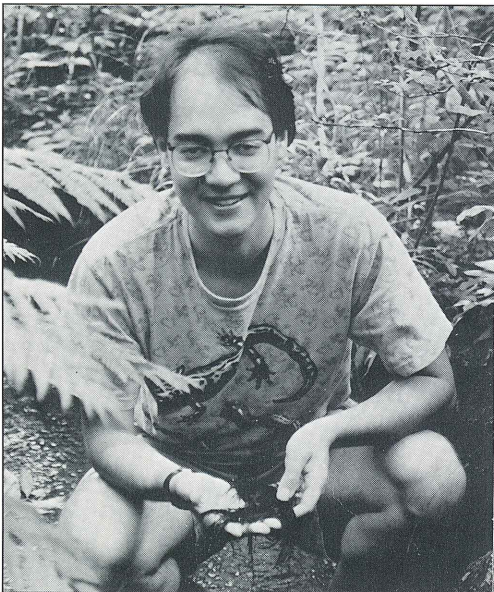
As part of a USDA project with J. Aber and W. McDowell at the University of New Hampshire, Rich Boone and Pat Micks investigated the potential for abiotic N fixation in forest floor material from a hardwood and red pine stand. These stands have received additions of  $\text{NH}_4\text{NO}_3$  since 1988 to examine forest ecosystem responses to chronic N deposition. Results indicate that 82-92% of the added N was retained in the soil as non-extractable N; both biotic and abiotic N immobilization have been suggested as mechanisms for the large N storage. In the new experiment forest floor samples were sterilized with propylene oxide, then treated with  $^{15}\text{N}$ -labelled ammonium sulfate. After a two-day incubation nearly all the added  $^{15}\text{N}$  was still in salt-extractable form, indicating that abiotic N immobilization by the forest floor is minimal and is not a major mechanism for N retention.

### **Animal Ecology**

Studies of bird and butterfly ecology were continued by Richard Lent. At a local scale, the surveyed grid of over 300 permanent points located throughout the Prospect Hill Tract serves as a spatial reference system for a breeding bird census that was initiated by Richard and Jessica Green, an Amherst College student. Studies of the landscape ecology and population biology of butterflies were conducted by two Amherst students, Martha Schumann and

James Chen as part of senior honors research. Each is studying phenotypic variation in a different species of Satyrid butterfly in twenty grassland sites arranged in a transect running from Petersham to the Vermont-Canada border. This study includes intensive field work and greenhouse rearing studies to examine environmental and genetic influences on the morphology of individual butterflies that exist as isolated populations in the patchy New England landscape.

Melissa Stine and Paul Wilson are studying pollination by bumblebees visiting mixed fields of red clover, white clover, and cow vetch. Individual bees specialize to varying degrees on one of the plant species. For instance, bees foraging on red clover, when given an equal choice of red versus white will choose red 88% of the time, and bees foraging on white clover, when given the same choice, will choose white clover 68% of the time. It is interesting that this constancy is unequal and need not be hierarchic. For instance, bees coming off of white clover choose red versus white only 32% of the time; they choose vetch versus white 45% of the time, but they choose red versus vetch 60% of the time. Another major finding is that constancy is not necessarily greater when the plants involved are more similar. The two clovers have a nearly identical architecture, whereas vetch is relatively distinct; yet bees on one of the clovers are more likely to choose vetch than the other clover when given a choice. These results argue against the commonly held belief that floral constancy is the result of individual bees specializing so that they will become particularly efficient in handling one type of flower.



**Paul Wilson**



**Missy Stine and Mike Donoghue challenging bees to forage on clover**





**Barry Tomlinson  
with hand-lens**

### **Developmental and Reproductive Biology**

A survey of cone structure in Cupressaceae by Barry Tomlinson was completed to show distinctive developmental characters of the family and trends in their morphological variation. Continued comparative study of the seed cone of Podocarpaceae has had the objective of showing that late changes in seed morphology are conditioned by early differences in vasculature. Material of all 17 genera in the family is being studied. The Podocarpaceae is probably the largest family of conifers in terms of species number but is neglected by most botanists because of its tropical/southern temperate (i.e. Gondwanan) distribution. The common misconception of conifers as "pines with a north-temperate distribution" is being challenged.

In order to complete an understanding of seed-cone characters in all conifers, attention has been turned to the "taxads" (Cephalotaxaceae and Taxaceae) a small and rather isolated group, familiar largely as *Taxus* ("yews"). *Taxus* can be shown to be highly derived in its morphology by comparison with the less familiar genera in these families, all rather difficult of access because of their divergent but restricted distributions. Material of three genera at the Arnold Arboretum is an important resource.

The elucidation of pollination processes in conifers leads to an appreciation of its diversity and the subtlety of many of its mechanisms. A functional relationship between pollen morphology, ultrastructure and the pollination process is very complete. We may soon be in a position to demonstrate how pollen morphological variation actually "works." This information is of value to paleobotanists since fossil pollen is widely used in the identification of extinct gymnosperms and a discussion of their relationships.

Paul Wilson and Michael Donoghue have initiated a study of the floral biology of hobblebush, *Viburnum lantanoides*. This forest shrub has two types of flowers: those in the center of the inflorescence have small petals, fertile stamens (male parts), and a fertile gynoecium (female organ); the flowers at the margins of the inflorescences have enormously enlarged showy petals, merely vestigial stamens, and a gynoecium that is structurally normal but nevertheless fails to set fruit. This display has been hypothesized to aid in attracting pollinators. Our experiments aim to test this hypothesis under a variety of ecological situations - in the shade, in the sun, in isolated lowland populations, and in montane areas where hobblebush is a prominent component of the vegetation. In 108 patches, the showy flowers were either clipped off of the inflorescence or not. Fruit set will be followed for the rest of the season.

Michelle Buonopane, an REU student is studying reproduction, growth, and nutrient limitation in Canada yew, *Taxus canadensis*. These plants have both male and female cones. However, Michelle has found that the distribution of gender in the forests of Petersham is bimodal - plants tend to be either mostly male or mostly female. Michelle has also found that the number of ovules produced on a plant of a given size is positively correlated with the amount of new growth. This finding is contrary to the frequent assumption that there should be a tradeoff between growth and reproduction. In a final study Michelle is providing nutrient fertilizer to half her plants and following the fate of maturing seeds. Her hypothesis is that fertilizer will lower the rate of seed abortion.



## Harvard Forest LTER Program

The Harvard Forest is one of eighteen sites forming the Long Term Ecological Research (LTER) program sponsored by the National Science Foundation. Each site addresses ecological questions of a long-term nature; collectively the sites undertake comparative studies across ecosystems. Representatives from the LTER sites, U.S. funding agencies and international research groups meet twice annually to develop collaborative studies.

The central theme of the Harvard Forest LTER is a comparison of historically-important, physical disturbances and modern, chemical disturbance in terms of their effects on forest ecosystem structure and function. One fundamental question is whether chronic, low-level additions of pollutants can result in more long-lasting alterations of ecosystem functions than does the historical regime of disturbance.

The research project involves soil scientists, atmospheric chemists, and ecologists studying physiological, population, community and ecosystem processes. Principal investigators represent the Departments of Biology (F.

Bazzaz), Earth and Planetary Sciences (S. Wofsy), and Harvard Forest (D. Foster, R. Boone, E. Boose, R. Lent, B. Tomlinson) at Harvard University as well as the Ecosystems Center-MBL, Woods Hole (J. Melillo, K. Nadelhoffer, P. Steudler), the Complex Systems Research Center at the University of New Hampshire (J. Aber) and the University of Massachusetts (W. Patterson III). The research is organized to maximize the interactions and exchanges among scientists from different disciplines. Four core experiments include: (1) recreation of physical disturbances, including catastrophic hurricane blowdown and smaller windthrows; (2) simulation of chronic chemical disturbance by altering inputs of important pollutants; (3) interactions between physical and chemical disturbances; and (4) repetition of treatments to assess the range of variation in response.

The LTER science group meets approximately monthly. The annual Harvard Forest Ecology Symposium is held to present current research. Abstracts from this meeting are published annually. The program for the 1994 Symposium is shown on the following page.



**Knut Nadelhoffer with Tom Callahan, NSF Director of the Long Term Studies Program, and Mike Binford during an LTER Site visit**



## Harvard Forest Ecology Symposium 1994

### Titles of Abstracts and Presentations

- J. Aber. Predicting Long-term Carbon Balance at the Harvard Forest
- A. Allen *et al.* The Relationship of Soil Properties to Land-Use History on the Montague Sand Plain
- Allison, T., D. Foster *et al.* Regional Vegetation Response to Human Disturbance in New England
- Amthor, J. Development and Testing of a Mechanistic Model of Forest Mass, Energy, and Momentum Exchange
- S. Bassow and F. Bazzaz. Canopy Photosynthesis: Eco-physiology of Forest Carbon Cycles
- G. Bernston and F. Bazzaz. Using *In Situ* Observations of Root Growth to Determine Root Production and Turnover
- R. Boone, K. Nadelhoffer, J. Kaye and R. Bowden. Biological and Physical Controls on Soil Organic Matter Storage
- R. Boone, E. Boose and R. Shanghui. Modeling Effects of Land-use on Ecosystem Carbon at Harvard Forest
- E. Boose, D. Foster and M. Fluet. Hurricane Impacts to Tropical and Temperate Forest Landscapes
- R. Bowden *et al.* Effects of Soil Moisture and Temperature on Fluxes of Carbon Dioxide and Methane in Forest Soils
- R. Bowden *et al.* Soil Respiration: Contributions of Aboveground Litter, Belowground Litter, and Root Respiration
- J. Carlson. Effects of a Simulated Hurricane on Downed Woody Fuel Loading in a Central MA Hardwood Stand
- J. Carlson and E. Boose. Treefall Orientation Across Central New England During the 1938 Hurricane
- G. Carlton, F. Bazzaz and W. Bossert. A Multiple-Resource Model of Seedling Growth in an Experimental Blowdown
- G. Carlton, W. Bossert and F. Bazzaz. Matrix Models of Simulated Hurricane Effects on Tree Population Dynamics
- M. Castro, P. Steudler *et al.* Methane Consumption: Scaling from Chambers to Global Scales
- C. Catricala *et al.* The Harvard Forest Soil Warming Experiment: 1993 Update
- K. Chamberlin, R. Boone *et al.* Impacts of Land-use History, Soil Drainage, and Soil Respiration on Carbon Flux
- W. Currie and J. Aber. Modeling Litter Decomposition and N Dynamics Across LTER Sites
- W. Currie *et al.* The Roles of Dissolved Organic C and N on Responses to Chronic N Additions
- E. Farnsworth, S. Careaga, J. Nunez-Farfan and F. Bazzaz. Plant Phenology and Growth on Warming Plots
- D. Fitzjarrald, K. Moore and R. Sakai. Forest-Atmosphere Exchange: Report on the Period 1992-1993
- M. Fluet, D. Foster and E. Boose. Disturbance and Vegetation Changes in eastern Puerto Rico, 1936 - 1989
- D. Foster. Legacies of Human Land-Use: Paleoecological and Historical Insights into Modern Ecological Processes
- D. Foster and G. Motzkin. The Post-settlement History of White Pine and Hemlock in Central New England
- L. George and F. Bazzaz. The Understory as an Ecological Filter; its Influence on the Distribution of Tree Seedlings
- A. Goldstein, S. Fan, M. Goulden, J. Munger and S. Wofsy. Olefin Emissions from Harvard Forest
- A. Golodetz and D. Foster. History, Ecology, and Conservation Value of Protected Lands in Central New England
- M. Goulden, S. Fan, A. Goldstein, J. Munger and S. Wofsy. Controls in Inter-annual Variation in Carbon Storage
- J. Hadley. Cold Tolerance and Winter Survival of Red Spruce Foliage at Harvard Forest
- R. Harriss, P. Crill, K. Bartlett, D. Blaha and P. Czepiel. Sources of Atmospheric Methane in the Eastern U.S.
- J. Hendricks and J. Aber. The Effect of Nitrogen Availability on Fine Root Chemistry
- B. Lefer and R. Talbot. The Atmosphere-Biosphere Exchange of Nitric Acid ( $\text{HNO}_3$ ) in Mid-latitude Forests
- A. Lezberg, G. Carlton, E. Doughty and D. Foster. Response of Tree Saplings to Simulated Hurricane Blowdown
- C. Mabry and D. Foster. The Relationship Between Forest Vegetation and Regional Physiography and Disturbance
- A. Magill and J. Aber. Plant and Soil Response of Forests to Chronic Nitrogen Additions
- M. Martin and J. Aber. Predicting Net Carbon Balance Through the Use of Remotely Sensed Foliar Chemistry
- G. Matlack. Mixed-history Landscapes as a "Special Case" for Stochastic Models of Forest Community Structure
- C. McClaugherty and G. Hoffman. Three-year Decay of Pine and Maple Wood
- P. Micks, R. Boone and S. Scott. Abiotic N Fixation by Forest Floor Material from the Chronic N Plots
- G. Motzkin, D. Foster, A. Allen and J. Harrod. Vegetation Dynamics and Disturbance on a Pine-Scrub Oak Sand Plain
- G. Motzkin. Rarity of the Modern Landscape: Studies on Uncommon Plant Communities in the Conn. Valley, MA
- J. Munger, M. Goulden, S. Fan, A. Goldstein and S. Wofsy. Deposition of  $\text{O}_3$  and Nitrogen Oxides to Forest Canopies
- K. Newkirk, F. Bowles, J. Melillo and C. Catricala. Time Domain Reflectometry: Results from Soil Warming
- J. O'Keefe and K. Chamberlin. Woody Species Phenology, Prospect Hill Tract, Harvard Forest - 1993
- J. O'Keefe, K. Chamberlin and J. Reed. Regeneration Following Clearcutting of Red Pine Overstory - Year 4
- S. Ollinger, J. Aber and C. Federer. A GIS Modeling Approach to Estimating Regional Carbon and Water Balances
- G. Rapalee, D. Foster, C. Mabry and G. Motzkin. Topographical Influences on the Patterns of Forested Land in 1830
- J. Reed, K. Chamberlin, J. O'Keefe and A. Lezberg. Assessment of Winter (92-93) Storm Damage
- P. Voss and F. Bazzaz.  $\text{CO}_2$  Heterogeneity at the Harvard Forest
- P. Wilson and M. Donoghue. The Pollination of Hobblebush
- P. Yao, A. Lewis and J. Cermak. Comparison of Three Sapflow Measurement Techniques in Canopy Red Oak

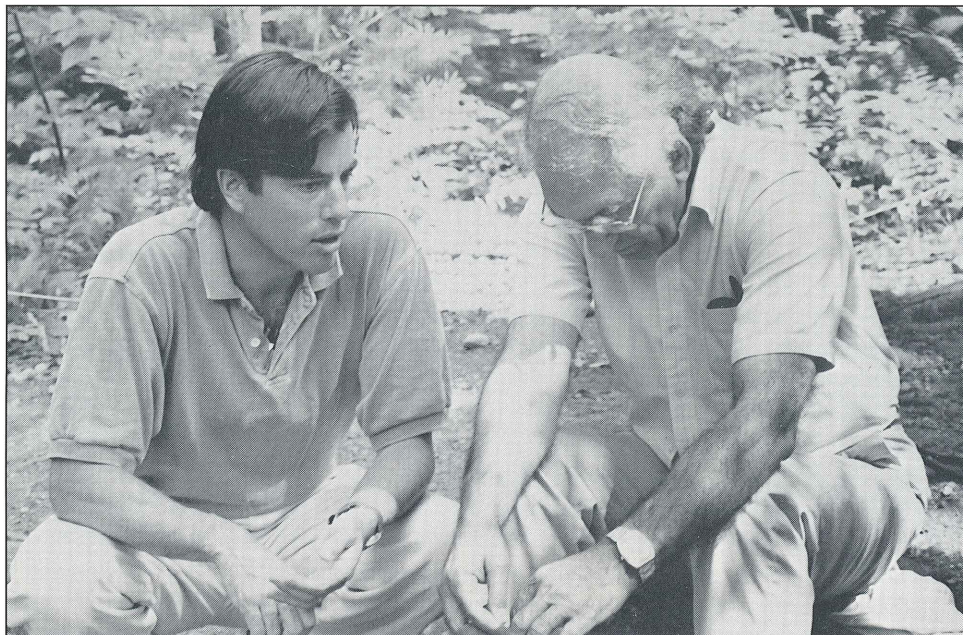


**National Institute of Global Environmental Change  
(NIGEC)**

Harvard University serves as the Northeastern Regional Center for the NIGEC program sponsored by the Department of Energy. The purpose of NIGEC research is to improve the understanding of mechanisms of global environmental change, to develop innovative experimental and observational programs that enhance the understanding of ecosystem and regional scale processes contributing to global change, and to provide educational opportunities in global environmental change research. The Center is administered by the Division of Applied Sciences and a large proportion of the field studies are conducted at the Harvard Forest. Researchers include many of the LTER scientists (Aber, Bazzaz, Boone, Melillo, Wofsy) in addition to faculty from the University of New Hampshire (P. Crill, R. Harris, R. Talbot), State University of New York (D. Fitzjarrald, K. Moore) and Oregon State University (R. Waring and R. McCreight).

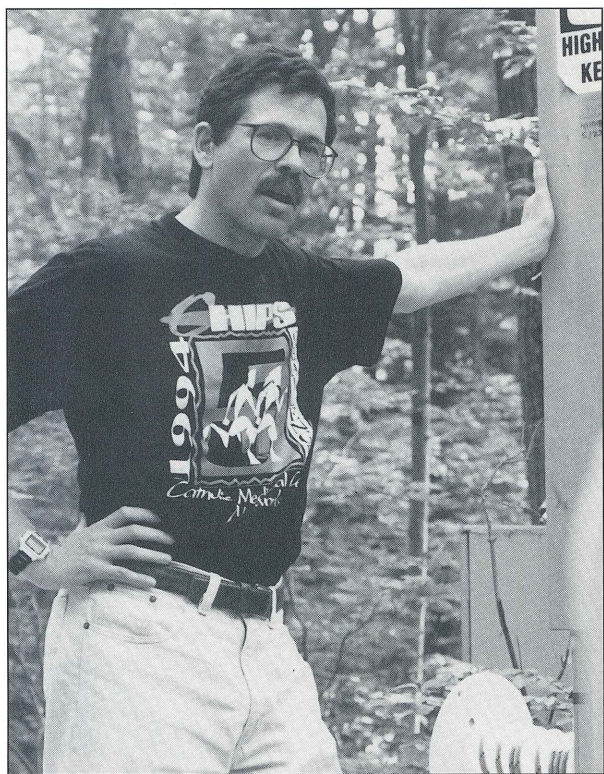


**Jerry Melillo trenching soil plots**

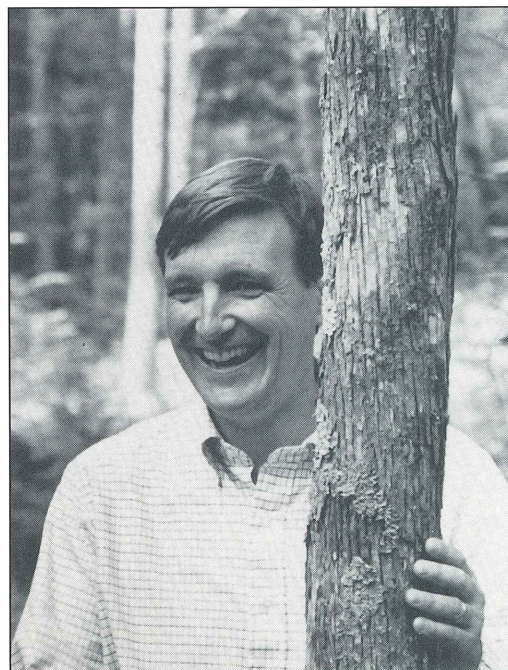


**David Foster and Fakhri Bazzaz**

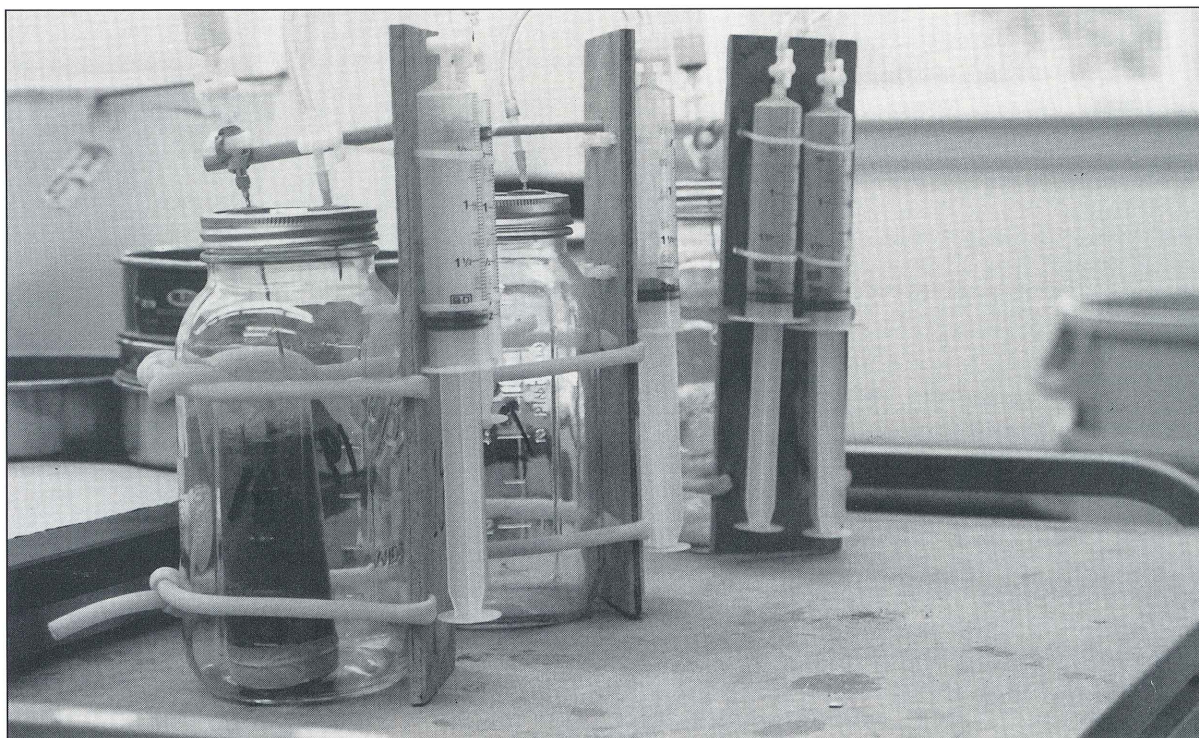




**Steve Wofsy**



**John Aber**



**Analyzing trace gases**



## BULLARD FELLOWS

The Bullard Fellowship Program in Forest Studies supported seven visiting faculty this year: Drs. Evan DeLucia, Julian Hadley, Gong Wooi Khoon, Juan Silva, Timothy Sipe, Thomas Spies and Carlos Vazquez-Yanes.

Evan DeLucia and Tim Sipe investigated biomass allocation in several species of hardwood saplings that vary in shade tolerance: cherry < white ash < red maple < sugar maple. This research is aimed at understanding how juvenile trees allocate resources to above- and belowground structures in the field, where there is competition for light, water and nutrients. Most existing data on root:shoot allocation patterns for trees comes from greenhouse or common garden studies, where the controlled conditions may yield substantially different allocation patterns. Two hundred small, naturally-established trees were carefully excavated and the root systems were washed and measurements were made of biomass allocation to fine roots, storage roots, primary stem axis, branches, and leaves, and concentrations of nitrogen and total non-structural carbohydrates in all plant components. These data were supplemented by measurements of light environments and photosynthetic performance in the field.

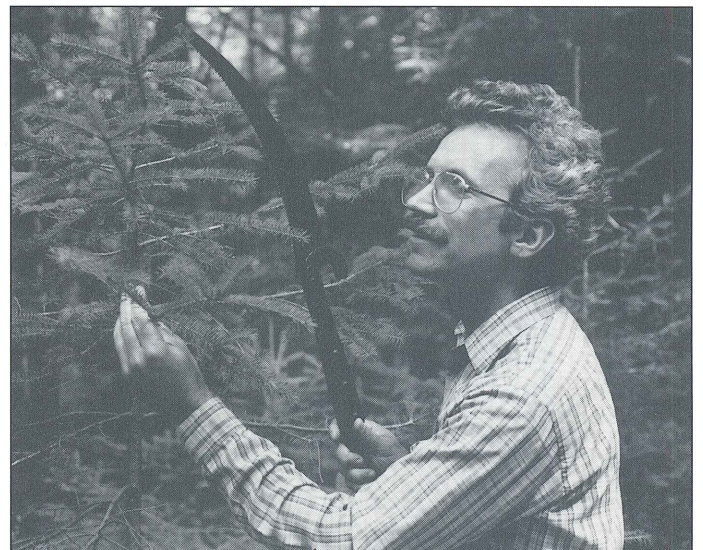
In collaboration with Fakhri Bazzaz, Evan is studying the effects of elevated atmospheric CO<sub>2</sub> on the optical properties of leaves of three *Betula* species. Increasing levels of atmospheric CO<sub>2</sub>, resulting from human activity, are expected to alter many physiological and anatomical leaf features. These changes may alter the ability of the photosynthetic apparatus to acclimate to low irradiances and will impact the ability to use remotely sensed data for estimation of global productivity.

Julian Hadley investigated the climatological causes of red spruce winter injury and decline at high elevations in New England. The cold tolerance of red spruce on four mountains in New York, Massachusetts, Vermont and New Hampshire, as well as at Harvard Forest, was monitored from January to March 1994. In May and June 1994 Julian conducted a survey of winter injury to red spruce on mountains from eastern New York to northern Maine. Julian attended the ESA meeting in Madison, a workshop in Lyndonville, Vermont on the Ecology of the Northern Forest and presented a paper at a NATO Advanced Research Workshop on Air Pollutants and the Leaf Cuticle in Fredericton, New Brunswick.

Gong Wooi Khoon conducted experiments in the laboratory of F. Bazzaz on the effects of elevated CO<sub>2</sub> on tropical forest seedling growth, biomass allocation, net photosynthesis, respiration and fluorescence. She also analyzed data from Peter Ashton's long term plots to study the growth characteristics and mortality of four families of emergent trees in the Malaysian rain forest. Gong presented a poster at the First Global Change in Terrestrial Ecosystems conference and a paper at the VI International Congress of Ecology at Manchester, U.K.



**Evan DeLucia**



**Julian Hadley**



Juan Silva analyzed the population structure and dynamics of several plant species from tropical savannas while working in the laboratory of Otto Solbrig. Juan gave seminars at the Center for Evolutionary and Functional Ecology (CRNS) in Montpellier, France, the Laboratory of Ecology at the Ecole Normale in Paris, the Gray Herbarium and the Harvard Forest.

Tim Sipe's research focuses on forest microenvironmental patterns and the physiological ecology of trees. Tim returned to two experimental sites that he had established during his dissertation work at the Harvard Forest (1984-90) and remeasured survival and growth of juvenile trees in the understory and in canopy gaps. In addition he collaborated extensively with E. DeLucia on the study of biomass allocation in trees and worked with the LTER team to outline future studies. He will be returning to Petersham regularly in the future to study forest microenvironmental heterogeneity and the impacts of microenvironmental heterogeneity on forest regeneration.

Tom Spies analyzed environmental and successional patterns of Douglas-fir/western hemlock forests at landscape to regional scales in the Pacific Northwest. He studied how the variance in forest composition and structure was explained by age and physical environment changes along regional gradients of climate, fire, and stand age. Tom received funding to study patterns and dynamics of vegetation in relation to land use and environment and to analyze the biological and economic consequences of different forest policies for the Oregon Coast Range. He gave seminars at Harvard University, the University of Massachusetts, the University of Maine and the Institute for Ecosystem Studies.

Carlos Yanes worked in the laboratory of F. Bazzaz on a study of the effect of CO<sub>2</sub> concentration on seed response to the quality of light during germination. Carlos wrote papers on induction of seed germination in woody legumes from deciduous tropical forests, the changes in moisture content and respiration rate of fleshy tropical rain forest seed species, and on the role of seed size on seedling survival and growth in the forest understory.

Glenn Matlack completed manuscripts on the history and impact of land use in the southeastern Pennsylvania and northern Delaware Piedmont zone. Glenn presented seminars at the University of Maine, Sewanee College, Trenton and Glassboro State Colleges, University of Southern Mississippi, and SUNY at Buffalo. Work done at Harvard Forest was featured on two National Public Radio shows dealing with environmental issues.

Bullard Fellows for 1994-95 include Drs. David Bowman of the Conservation Commission of the Northern Territories, Australia; John Connolly, University College, Dublin, Ireland; E. David Ford, University of Washington; David Janos, University of Miami; David Kittredge, University of Massachusetts; Sharachandra Lele of the Pacific Institute in Development, Environment and Security; and Jacob Weiner, Swarthmore College.



**Students Jeff Herrick and Hafiz Maherali with Tim Sipe in front of the new Torrey laboratory**

## EDUCATIONAL ACTIVITIES

In conjunction with Dr. C. H. W. Foster, David Foster taught ENR 522, "Topics in Environmental Policy," in the Kennedy School of Government. This course focussed on issues of natural resource management at the Quabbin Reservoir, which provides drinking water for the city of Boston and adjacent municipalities and is managed by the Metropolitan District Commission. A series of outside experts on issues related to natural resources, conservation, government, and science provided course context and assisted in a weekend fieldtrip to Quabbin. The course culminated in the production of student papers and a synthetic white paper by the two faculty members.

Dr. Tomlinson taught Biology 24, Introductory Plant Biology, and Biology 102, Biology of Gymnosperms, in Cambridge during the fall semester. In Biology 102 a class project analyzed the geographic distribution of conifers to test the hypothesis that this group of plants is an exception to the generalization that biodiversity increases towards the tropics. The project was extended into the spring semester as a senior undergraduate Biology 90r paper. It was demonstrated that conifers are not less diverse in the tropics compared with their temperate distribution, if biodiversity is measured as species per unit area. Dr. Tomlinson and Dr. Foster with the assistance of various members of the Harvard Forest Staff led the Harvard Forest Freshman Seminar program which meets at the Harvard Forest over four weekends during the spring term. Both also participated in Biology 220, Topics in Organismic and Evolutionary Biology.



## Summer Research Program

The Harvard Forest summer undergraduate research program, coordinated by Rich Bowden of Allegheny College, brought a diverse group of students to the Forest to receive training in ecological research; 15 undergraduates participated. In addition there were two recent graduates and 4 graduate students in the program which included research with faculty and scientists, independent student projects, field trips, and weekly discussion groups and seminars. The program culminates with student research presentations at the Annual Summer Student Symposium.

Ilse Ackerman  
Sherry Baker  
Lori Biederman  
Michelle Buonopane  
Amy Boyd  
Joel Carlson  
James Chen  
James DeNormandie  
Jessica Green  
Jeffrey Herrick  
George Landman  
Hafiz Maherali  
Amy Miller  
Michael Pine  
Meghan Riley  
Martha Schumann  
Melissa Stine  
Gwen Stevens  
Kaelyn Stiles  
Don Strauss  
Nancy Werdin

Antioch College  
Allegheny College  
Gustavus Adolphus College  
Bates College  
Antioch New England College  
University of Massachusetts  
Amherst College  
Harvard University  
Amherst College  
State University of New York  
Holy Cross College  
University of Illinois  
University of Massachusetts  
Harvard University  
Trinity College  
Amherst College  
CA Polytechnic State University  
Allegheny College  
Oberlin College  
University of Massachusetts  
University of Wisconsin



**Jessica Green**



**Susan Bassow, PhD candidate under  
Fakhri Bazzaz**

**Michelle Buonopane and Nan Werdin**



## ACTIVITIES OF THE FISHER MUSEUM

The Fisher Museum plays an important role in the educational mission of the Harvard Forest by providing a public outlet for information related to research in forest biology and management. The Museum also provides a unique setting for conferences sponsored by the Forest and outside organizations. Dr. John O'Keefe has primary responsibility for the development of activities and coordination of use of the Museum.

The enthusiasm of our growing group of volunteers ensured another successful weekend schedule during the summer and fall of 1993, welcoming approximately one thousand visitors during the period. The Third Annual Volunteer Recognition Dinner was held on November 10th. Bob Lane and Mary Ann Walker shared honors as the most active volunteers and Helen Gronich was recognized for her continuing work as volunteer coordinator.

A new exhibit with maps depicting the extent of forest cover in 1830 and 1985 across central Massachusetts was completed in time for Friends Day in September. The exhibit's location, opposite the land-use history dioramas, provides a different view of the dramatic changes in our landscape. This exhibit, developed by John O'Keefe, produced by Rick Riccio and the exhibit design staff at the Peabody Museum of Anthropology in Cambridge and installed by Don Hesselton of the woods crew, drew on the land-use history research of staff scientists working with D. Foster.

The Museum continued its collaborative programs with the Petersham Craft Center. John O'Keefe led a children's walk in July and a tree identification workshop in October and Dr. Elio Schecter of Tufts University taught a mushroom collection and identification workshop at the Forest in September. In our ongoing work with the Rainforest Collaboration group, Harvard Forest hosted 40 inner-city,

middle-school children, their teachers and a number of UMASS faculty and students over two weekends in the fall. The trip to the Forest provided an opportunity to study a temperate forest ecosystem as part of this joint UMASS-Boston Public Schools program designed to excite students about careers in the biological sciences.

### Meetings, Seminars, Conferences

In October, the Fisher Museum hosted a Forestry Forum sponsored by the Massachusetts Forestry Association with a grant from the Wharton Conservation Trust. This two day conference brought representatives of the forestry and environmental communities together to identify shared interests and to start working toward common goals. In November the Museum hosted the Massachusetts Forestry Association, in December the Millers River Watershed Council and in May the New England Fern Conference. Other meetings at Harvard Forest included the Massachusetts Cooperative Extension Service Coverts Project, Massachusetts Project Learning Tree, New England Chapter of the Wildlife Society, University of Massachusetts Forestry Faculty retreat, Board of Directors of Mount Grace Conservation Land Trust, and the U.S. Forest Service Forest Health Monitoring Training Workshop. In August, we hosted scientists attending a Gordon Conference on forest soils organized by Charlie Driscoll from the Hubbard Brook LTER and also a group of Spanish environmental scientists attending Real Colegio Complutense, a collaborative program between Spanish universities and Harvard. Both groups were guided through our LTER experiments by various members of the staff.

Speakers in the Harvard Forest Seminar series included Bullard Fellows Julian Hadley, Glenn Matlack, Juan Silva and Tom Spies; David Janos, University of Miami; Jess Zimmermann, University of Puerto Rico; George Peterken, England; Frank Lowenstein and Kathy Corish, the Nature Conservancy; Jana Compton, University of Washington; Donald Leopold and Peter Smallidge, SUNY Syracuse; Sara Webb, Drew University; Rick Boyce, Dartmouth College; Aaron Ellison, Mount Holyoke College; Mary Martin, University of New Hampshire; Jorge Morello, University of Buenos Aires; Salle Nor, Forest Research Institute of Malaysia; and Rich Boone, Gary Carlton, Alisa Golodetz, Art Allen, Barry Tomlinson, Cathy Mabry and Glenn Motzkin of Harvard University.



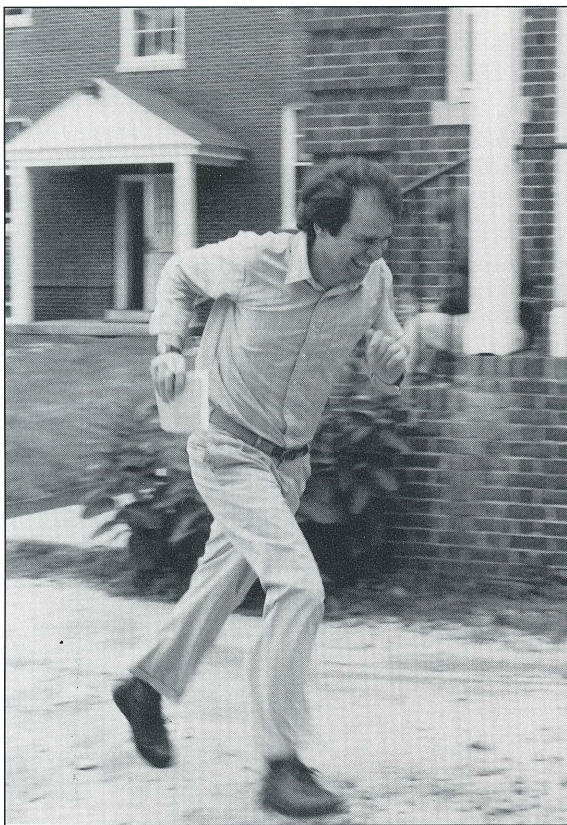
**John O'Keefe sampling deer browse  
with Amy Boyd and Amy Miller**



## FOREST AND MAINTENANCE ACTIVITIES

This year's silvicultural activity centered on the 100-acre Matthew's Plantation located in Hamilton, Massachusetts. Most stands were planted in the early 1900s by Mr. Nathan Matthews, a Boston lawyer who became interested in testing the survival and growth of exotic species for forestry. To reduce the cost of planting stock, he started a commercial nursery on the Hamilton estate in 1901 that operated successfully for over 20 years. In 1923, R. T. Fisher visited with Matthews to help map the 300 recognizable planted groups. From this meeting an interest built up that eventually led Mr. Matthews to donate part of this land to the Harvard Forest for future study.

Beginning in January part of the woods crew commuted 200 miles daily to conduct thinnings on the property. Approximately 200,000 board feet of softwood was harvested and shipped to Canadian markets. The majority of the volume was white pine but stands of Douglas fir, white fir, Norway spruce, red pine, and larch were improved. The cooperation of the Myopia Hunt Club and local residents provided access to part of the property. Logs were handled from the schooling field at the Myopia Hunt Club, which greatly increased the efficiency of the operation. We are quite grateful for all the cooperation received in Hamilton.



**Jack Edwards on the move**

The growth chambers that were housed in the Torrey Labs were moved to one bay of the Shaler garages to establish a cooler room consisting of two walk-in refrigerators and a freezer. The adjacent bay is being converted to establish a new soil archive facility. Other improvements include the installation of asphalt drives at the Higginson, Director's and Highway houses, a new well at the Highway House and the purchase of a 1993 4-W drive 1-ton dump truck and a 1994 4-W drive pick-up. The mail and copying area of Shaler Hall has received much improvement with new bench space and storage.

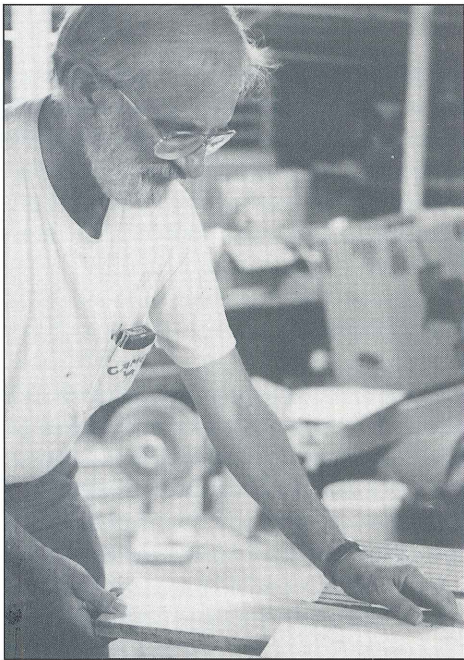
### *Renovation of J. G. Torrey Laboratory*

The J.G. Torrey Laboratory has been extensively renovated with support from the National Science Foundation and the Faculty of Arts and Sciences at Harvard. The right wing has been converted to a nutrient analysis laboratory with two new offices, new laboratory benches and cabinets, a six-foot wide chemical hood, and a separate heating and air conditioning system. Renovation of the headhouse space adjacent to the greenhouse involved creation of a small adjoining lab and installation of new benches, cabinets and sinks. The renovated facility will provide 1048 ft<sup>2</sup> of new laboratory space and 1102 ft<sup>2</sup> of new office space that will serve staff, students and visiting researchers.

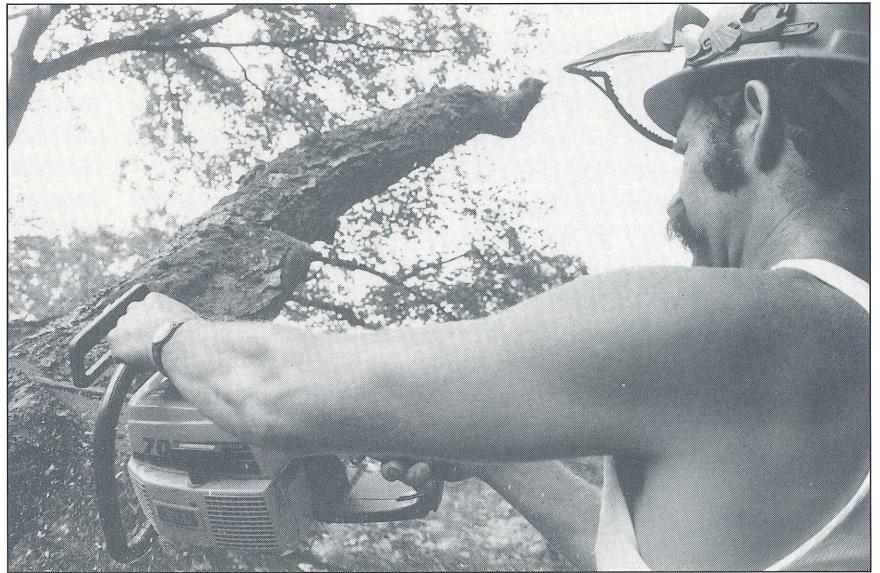


**Pete Spooner**





**Don Hesselton - measure twice**



**John Wisnewski - cut once**

## ACTIVITIES OF THE HARVARD FOREST STAFF

Art Allen completed the New England Regional Certificate of Soil Studies at the University of New Hampshire and became a registered Soil Scientist through the Soil Science Society of Southern New England. He attended the annual meeting of the Soil Science Society of America in Cincinnati.

Rich Boone collaborated with Phil Sollins (Oregon State University) on a survey to determine the availability of soil information and archived soil samples across the LTER network. The survey is available on LTERnet and was summarized in the LTER publication Network News. Rich hosted a Harvard Forest field trip for 100 attendees of the August 1993 Gordon Conference "Hydrologic, Geochemical and Biological Processes in Forested Catchments" to many of the major Harvard Forest LTER experiments. He also presented the Harvard Forest "Site Bite", a brief overview of site activities, at the LTER All Scientists Meeting held at Estes Park, Colorado in September 1993.

Emery Boose served on the GIS Working Group and Climate Committee of the LTER program and attended the LTER All Scientists Meeting and CENTURY Modeling Workshop.

At an awards ceremony in New London in September, David Foster received the College Medal from President Claire Gaudiani of Connecticut College in recognition of his scientific, educational and public activity in ecological sciences. David continued to serve on the editorial boards of *Ecology* and *Journal of Ecology*, board of directors of the Mount Grace Land Conservation Trust, science advisory committee of the Massachusetts Audubon Society, advisory board of the Highstead Arboretum, management

board of the National Institute for Global Environmental Change (northeastern center), and member of the Temperate Directorate of the Man and the Biosphere Program administered by the United Nations. He was appointed chairman of the Technology Committee of the Long Term Ecological Research program and member of the Publications Committee and represented the Harvard Forest as Principal Investigator on the LTER project at national Coordinating Committee meetings. David served on the Young Investigators Award panel at the National Science Foundation and presented seminars at the University of North Carolina, University of Connecticut, University of California, Santa Cruz, and at an IUFRO conference on wind disturbance to temperate forest ecosystems in Edinburgh. David served as the undergraduate thesis advisor of Peter Adler (Harvard College) and on the graduate committees of Gary Carlton (OEB) and Kristina Hill (GSD).

Richard Lent attended the LTER Data Manager's Meeting in Madison and the LTER All Scientist's Meeting in Estes Park. He gave talks at the ESA meeting in Madison, at the Massachusetts Audubon Society's Conference on Native Grasslands and Heathlands of the Northeast, at the annual meeting of the Population Biologists of New England at the University of Rhode Island, and at Mt. Holyoke College. He represented the Association of Field Ornithologists at a semi-annual meeting of the International Council for Bird Preservation at the American Museum of Natural History, gave a talk at the Athol Bird and Nature Club, and attended meetings of the Massachusetts Butterfly Club and the Cambridge Entomological Club. Richard serves on the research committee of the Massachusetts Division of Fisheries and Wildlife Partners in Flight Working Group, con-



cerned with conservation of neotropical migrant birds. Rich led four, guided, public bird/nature walks at the Harvard Forest, lectured on bird-habitat relationships to the Freshman Seminar, and worked with Naomi Pierce's entomology class to make field collections of insects.

John O'Keefe attended a conference on Conservation Biology in the Northern Forest Lands Region at Lyndonville State College, Vermont and a conference on Eastern Old Growth Forests at the University of North Carolina in Asheville. John presented seminars on forest history to the Garden History Section of the Massachusetts Horticultural Society, the University of Massachusetts/Boston and Fruitlands Museum in Harvard, Massachusetts. He attended the annual conference of the New England Society of American Foresters (NESAF), a spatial information workshop sponsored by NESAF and the Cooperative Extension Service and served as a judge at the Mahar Regional High School Science Fair.

Barry Tomlinson was an invited speaker at the Linnean Society Symposium "Monocotyledons: Classification and Evolution" at the Royal Botanic Gardens, Kew, England. A seminar presentation of recent ideas on conifer pollination was also given at the Department of Botany, University of Georgia.

Cathy Mabry attended the ESA meeting and presented a poster "Life history variation in a mixed hardwood forest in New England." She accompanied Steve Hamburg of the University of Kansas to Taiwan to meet with Taiwanese ecologists to evaluate opportunities for international col-

laboration. Glenn Motzkin attended the conference on Ecological Restoration and Management sponsored by the New England Wildflower Society and Native Grasslands and Heathlands of the Northeast organized by the Massachusetts Audubon Society. He participated in a course on bryophyte identification at the Eagle Hill Wildlife Research Station in Maine.

## GIFTS AND NEW FUNDING

Generous gifts and new grants have enabled the Harvard Forest to expand many research and educational activities. Mrs. Ethel Lewis and Dr. Richard Groat donated eleven acres of land to the Forest, abutting the Prospect Hill tract along Route 32 and Leighton Road. The land includes the western portion of the French lot donated by the Fisher family last year. John Delong, a student in the Freshmen Seminar undertook an independent study of the history of this interesting tract of land.

David Foster was principal investigator on several new grants from the National Science Foundation: "Hurricane disturbance regimes in tropical and temperate forests" from the Ecosystems program (\$225,000; with Emery Boose); "Regional vegetation response to human disturbance in central New England" from the Ecology program (\$290,000; with Michael Binford); "Establishment of a nutrient analysis laboratory and sample archive at the Harvard Forest" from the program for Field Station and Marine Laboratory Improvement (\$150,000; with Richard Boone); and "Harvard Forest Long-Term Ecological Re-



**Jeannette Bowlen and Barbara Flye**



search Program - Forest ecosystem dynamics in central New England" from the Long Term Studies Program (\$3,700,000). This last grant represents six years of renewed funding for the Harvard Forest Long Term Ecological Research Program, an effort that includes collaborators from the Harvard Forest, the University of New Hampshire, MBL Ecosystem Center, Mount Union College and Harvard University departments of Organismic and Evolutionary Biology, Earth and Planetary Science and Graduate School of Design. As part of the LTER program the Harvard Forest also received \$58,700 to improve computer facilities, electronic networking and archival and systematic collections.

Two awards were made from the A. W. Mellon Foundation towards new educational and research programs coordinated by D. R. Foster. A program for Minority Undergraduate Research in Ecology was established with a three-year grant of \$85,000. This effort will support 4-6 students annually at the Forest as an expansion of our existing summer undergraduate research program. In June, the Mellon Foundation announced an award of \$350,000 to establish a five-year program in land-use history and forest ecosystem dynamics. This funding will be matched by Harvard University to provide support for graduate students, post-doctoral fellows and research assistants working at the Harvard Forest. Continued support for research on forest dynamics in Puerto Rico came through two new subcontract awards from the University of Puerto Rico to D. R. Foster: "Integrated remote sensing of tropical forests" from NASA (\$40,000) and "LTER Program in Puerto Rico" from NSF (\$117,000).

In collaboration with K. Nadelhoffer at the MBL Ecosystems Center, Rich Boone received \$83,000 from the National Institute for Global Environmental Change to con-

tinue the ongoing study of organic matter dynamics in temperate forest soils. Glenn Motzkin will continue his efforts of inventorying uncommon plant communities in Massachusetts with a grant for \$4,000 from the Massachusetts Natural Heritage and Endangered Species program. Glenn's studies this year focus on calcareous wetlands and riverine and sandplain communities. Julian Hadley received two years of funding (\$120,000) from the Competitive Grants program at the U.S. Department of Agriculture for a project titled "Effects of altitude on cold tolerance and bud and needle mortality in red spruce."

Our efforts to expand the library have benefited greatly from the largest series of donations in Harvard Forest history. Mrs. Henry Morss, Jr., donated the new E.O. Wilson book "The Diversity of Life." Mr. Joseph Galloway of Montserrat, West Indies sent a copy of "Hugo versus Montserrat" to add to our material on Hurricane Hugo and Dr. Ann Lewis of the University of Massachusetts added volumes of American Journal of Botany and Plant Physiology. Mr. James Baird of Petersham gave a complete set of "The Auk." Dr. James W. Hardin of North Carolina State University donated Bulletin of the Torrey Botanical Club from 1973-1993 and Eleanor Winslow at Manomet Observatory traded copies of Bird Banding for surplus issues of the Jack Pine Warbler journal. Jack Pine Warbler, Wilson Bulletin and Bird Banding were included in eight boxes of journals received from Carolyn Hammarskjold, librarian at the W.K. Kellogg Biological Station. We received a series of Biological Conservation and American Midland Naturalist from Dr. Robert Burgess at the State University of New York. Dr. Carol Augspurger at the University of Illinois donated 3 volumes of The American Naturalist to complete our series.





## Visiting Research Scientists at the Harvard Forest 1993-94

In addition to Harvard Forest researchers a large number of outside scientists made use of Harvard Forest facilities and research sites. Many of these scientists were involved in the HF LTER program or in Harvard University's Northeast Regional Center of NIGEC (National Institute for Global Environmental Change) project.

John Aber	University of New Hampshire	Shoichi Kawano	Kyoto University
David Ackerly	Harvard University	C. Kerfoot	Ecosystems Center - MBL
Jeff Amthor	Lawrence Livermore Lab	Dave Kicklighter	Ecosystems Center - MBL
Peter Bakwin	Harvard University	Christina Kilday	Rhode Island School of Design
Susan Bassow	Harvard University	Otto Klemm	University of New Hampshire
Fakhri Bazzaz	Harvard University	B. Lefer	University of New Hampshire
Glenn Berntson	Harvard University	Alison Magill	University of New Hampshire
Mike Binford	Harvard University	Mary Martin	University of New Hampshire
K. Boering	Harvard University	Charles McClaugherty	Mount Union College
Rich Bowden	Allegheny College	Ernesto Medina	Centro de Ecologia y Ciencias
Frank Bowles	Ecosystems Center - MBL		Venezuela
Mark Castro	Ecosystems Center - MBL	Jerry Melillo	Ecosystems Center - MBL
Chris Catricala	Ecosystems Center - MBL	Shi-Li Miao	Ecosystems Center - MBL
Chaur-Fong Chen	Oregon State University	Kathleen Moore	State University of New York
A. Coleman	Harvard University	Mitch Mulholland	University of Massachusetts
Patrick Crill	University of New Hampshire	J. William Munger	Harvard University
William Currie	University of New Hampshire	Knute Nadelhoffer	Ecosystems Center - MBL
Bruce Daube	Harvard University	Kathy Newkirk	Ecosystems Center - MBL
Peter Del Tredici	Arnold Arboretum	Fred Paillet	U.S. Geological Survey
Mike Donoghue	Harvard University	William Patterson	University of Massachusetts
Marty Downs	Ecosystems Center - MBL	Bob Percy	University of California, Davis
Brian Drayton	Boston University	Richard Primack	Boston University
Todd Drummey	Ecosystems Center - MBL	Andrea Ricca	Ecosystems Center - MBL
Joseph Elkinton	University of Massachusetts	Michael Rogers	GA Institute of Technology
Aaron Ellison	Mount Holyoke College	Emily Russell	Rutgers University
Elizabeth Farnsworth	Harvard University	Paul Rygielwicz	Environmental Protection
David Fitzjarrald	State University of New York		Agency
Son-Miao Fan	Harvard University	Paul Steudler	Ecosystem Center - MBL
Alan Goldstein	Harvard University	Britt Stephens	U.S. Geological Survey
Alisa Golodetz	Hampshire College	Robert Talbot	University of New Hampshire
Michael Goulden	Harvard University	S. Thomas	Harvard University
Robert Harriss	University of New Hampshire	Brayton Wilson	University of Massachusetts
Joseph Hendricks	University of New Hampshire	Greg Winston	U. S. Geological Survey
Doug Karpa	Harvard University		



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Gary and Maggie Carlton



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Petersham, Massachusetts  
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