

# THE HARVARD FOREST, 1975-76

Harvard University



Frontispiece: Root nodule on a lateral root of a young seedling of the sweet fern, *Comptonia peregrina* (L.) Coult., grown in an aeroponic tank. The swollen nodule lobes (each marked with a dark papilla) are infected with an actinomycete-like endophyte; nodule roots develop from these lobes. The symbiosis results in the fixation of atmospheric nitrogen. Photograph by Dale Callahan; magnification X 20. (see p. 11)

ANNUAL REPORT OF HARVARD UNIVERSITY ACTIVITIES  
AT THE HARVARD FOREST 1975-76

STAFF

The staff during the year 1975-76 consisted of the following persons:

William R. Bentley, Bullard Fellow (September 13, 1975 - June 2, 1976)  
Bryan Bowes, Cabot Research Fellow (from January 1, 1976)  
Susan Sovonick Dunford, Cabot Research Fellow  
Ernest M. Gould, Jr., Forest Economist  
Jack J. Karnig, Forest Manager  
Haviva Langenauer, Cabot Research Fellow  
D. Roger Lee, Cabot Research Fellow  
Walter H. Lyford, Soil Scientist  
Usher Posluszny, Cabot Research Fellow (from August 1, 1975)  
Hugh M. Raup, Charles Bullard Professor of Forestry, *Emeritus*  
P. Barry Tomlinson, Professor of Botany  
John G. Torrey, Professor of Botany and Director of Cabot Foundation  
Wayne H. Weidlich, Atkins Research Fellow  
Martin H. Zimmermann, Charles Bullard Professor of Forestry and  
Director of the Harvard Forest

Supporting personnel included:

Dale Callahan, Laboratory Technician  
Catherine M. Danahar, Business Secretary and Librarian  
Peter J. Del Tredici, Research Assistant  
Wayne E. Elliott, Custodian  
Anne Faulkner, Laboratory Technician  
Patricia L. Goforth, Research Assistant  
Vibeke Holm, Assistant to the Librarian  
Edward H. Hyde, Woods Crew  
George T. Kenney, Woods Crew  
Shirley P. LaPointe, Greenhouse Assistant  
Monica R. Mattmüller, Laboratory Technician  
Donald C. Mitchell, Assistant to the Manager of the Black Rock Forest  
Gordon B. Mitchell, Woods Superintendent  
Frances E. O'Brien, Secretary  
Theresa A. St. Helaire, Clerk-Typist  
Lisa Scola, Laboratory Assistant (September 22, 1975 - May 19, 1976)  
Dorothy R. Smith, Clerk-Typist  
Charles F. Upham, Woods Crew, retired (working part-time)  
Sandra K. Weidlich, Secretary



Photograph by  
Donald Skene  
May 1970

Walter Lyford, Soil Scientist at the Harvard Forest and Senior Lecturer in Biology, retired on June 30, 1976 from University duties, after 16 years of service. Even before he joined the Harvard Forest staff in 1960, while Senior Soils Correlator of the U. S. Soil Conservation Service, he had collaborated with the late John Goodlett, then Forest Geographer at the Harvard Forest. There are few persons in the world who know as well as Walter how the roots of mature trees grow in the forest soil. An excellent teacher, scores of students learned to appreciate the complex nature of the forest floor during his 16 years at the Harvard Forest. All of us at the Forest will miss his cheerful presence and his wisdom. We wish him many years of stimulating activities during his retirement in Sturbridge, Massachusetts and hope to see him often in Petersham.

Three of our present post-doctoral Fellows have accepted Assistant Professorships and will leave during this summer. Susan (Sovonick) Dunford is moving to the University of Cincinnati, Ohio; Roger Lee to the Memorial University of Newfoundland in St. John's; and Dutch Weidlich to the Michigan State University in East Lansing.

## STUDENTS

The following courses were offered in Cambridge by our staff members. John Torrey taught Biol. 165, *Plant Growth and Development*. Also in the fall term, Barry Tomlinson, in collaboration with four other members of the department, gave the course Biol. 18, *Diversity in the Plant Kingdom*. This course includes a survey of the life cycles and morphology of the major plant groups, with laboratory studies and field trips. It is intended to provide a foundation for continuing studies in the plant sciences. Martin Zimmermann gave again two guest lectures on forests and wood in Biol. 104, *Plants and Human Affairs*, a course given by Dr. Schultes. In the spring term, John Torrey taught, in collaboration with Drs. Bogorad and Ausubel, Biol. 11, *Plant Physiology*. Also in the spring, John Torrey taught his Freshman Seminar on *Plant Propagation*. Many of these and other courses had scheduled field trips to the Harvard Forest.

As during the past year, three courses were entirely Harvard Forest based. Biol. S-146, *Plants in Relation to their Environment* was given in the summer of 1975, Biol. 298, *Soil, Land and Human Environment* in the fall, and the Freshman Seminar on the Harvard Forest in the spring. These courses are discussed in more detail in last year's report.

Biol. S-105, *Plants of the Tropics* was taught by Barry Tomlinson at the Fairchild Tropical Garden in June-July 1975. Such was the demand that the normal limitation of enrollment to ten students was raised to 15. This proved rather burdensome, but the enthusiasm and responsiveness of the group provided the necessary compensation.

The Department of Landscape Architecture again brought their graduate students to the Harvard Forest for a few days prior to registration in September, 1975.

Sandra F. Simpson obtained her Ph.D. degree in June 1976, after having completed her work on DNA synthesis, protein synthesis and cell division in cultured pea root cortical explants undergoing cytodifferentiation.

The following students took units of undergraduate and graduate research. Biol. 90 (formerly 96r): Debbie Gregory (Soils in relation to land use), Betsy Gross (Phloem longevity of *Tilia americana*), Bruce Larson (Environmental stimulation for the release of epicormic branches) and David Adams (A study of the vascular system of the tree fern *Cyathea fulva*). The last three wrote undergraduate honors theses on these topics. Geology 96r: John F. Coburn (Soils in relation to land use). Biol. 299: Anne Leavitt (The history of the Forest Service and how it



Students of the Freshman Seminar 1976 playing the Forest Management Game. Above (from left to right): Craig Taylor (white shirt), Kerstin Gorham, Charlie Hirschhorn (standing), Ernie Gould, Rock Moulton, Carol Nilson, Anne Leavitt (a Senior, foreground), Cindy Herbig, Susan Vasallo. Below: Carol Nilson, Charlie Hirschhorn, Cindy Herbig, Eric Jorgensen, Rock Moulton.

parallels the development of the American conservation movement), Clark Binkley (Testing mathematical models descriptive of distribution of trees in stands), and David Raphael (Review of National Forest planning systems). Independent work: Mark Zielinski (Practical aspects of forestry on small tracts in New England).

Kalane Wong (Radcliffe '79) who had taken the Freshman Seminar on the Harvard Forest in the spring of 1976, assisted in the research of Susan Dunford and Roger Lee during parts of the summer 1976. Anitra Fagre (Radcliffe '79) and Dennis Rinehart (Harvard '78) cooked for the summer students during the summer of 1976.

## BULLARD FELLOW

*William R. Bentley* had been with the University of Michigan for several years, and his work there had focused on the resource management problems of public forestry. The year at Harvard provided an opportunity to bring together a number of experiences and integrate them with a variety of literature areas. The conceptual results represent a sort of political economy of public forestry which may be useful to agencies like the U. S. Forest Service. Related activities during the year included working with Ernie Gould on a number of issues, particularly the 1974 Resources Planning Act. Also, Bill Bentley worked on a cooperative effort with Utah State University on cost and value of wildland management information. He and his wife, Margaret Esplin, conducted some inquiries into the relationships among agriculture, food and human nutrition in New England. Ms. Esplin issued one report on this work through Michigan State University. After leaving Petersham, Dr. Bentley assumed the management of forestry research with the Crown Zellerbach Corporation.

## MEETINGS AND VISITORS

The Fourth Cabot Symposium was held April 26-30, with 28 speakers from 13 countries considering the subject, "Tropical Trees as Living Systems", from widely differing points of view. Emphasis was given to the construction of trees in relation to their vegetative and reproductive functions, leading to a consideration of the tropical forest as a collection of interacting individuals. The proceedings are to be published by the Cambridge University Press and should make available a body of information which will stimulate continuing research in the tropics.

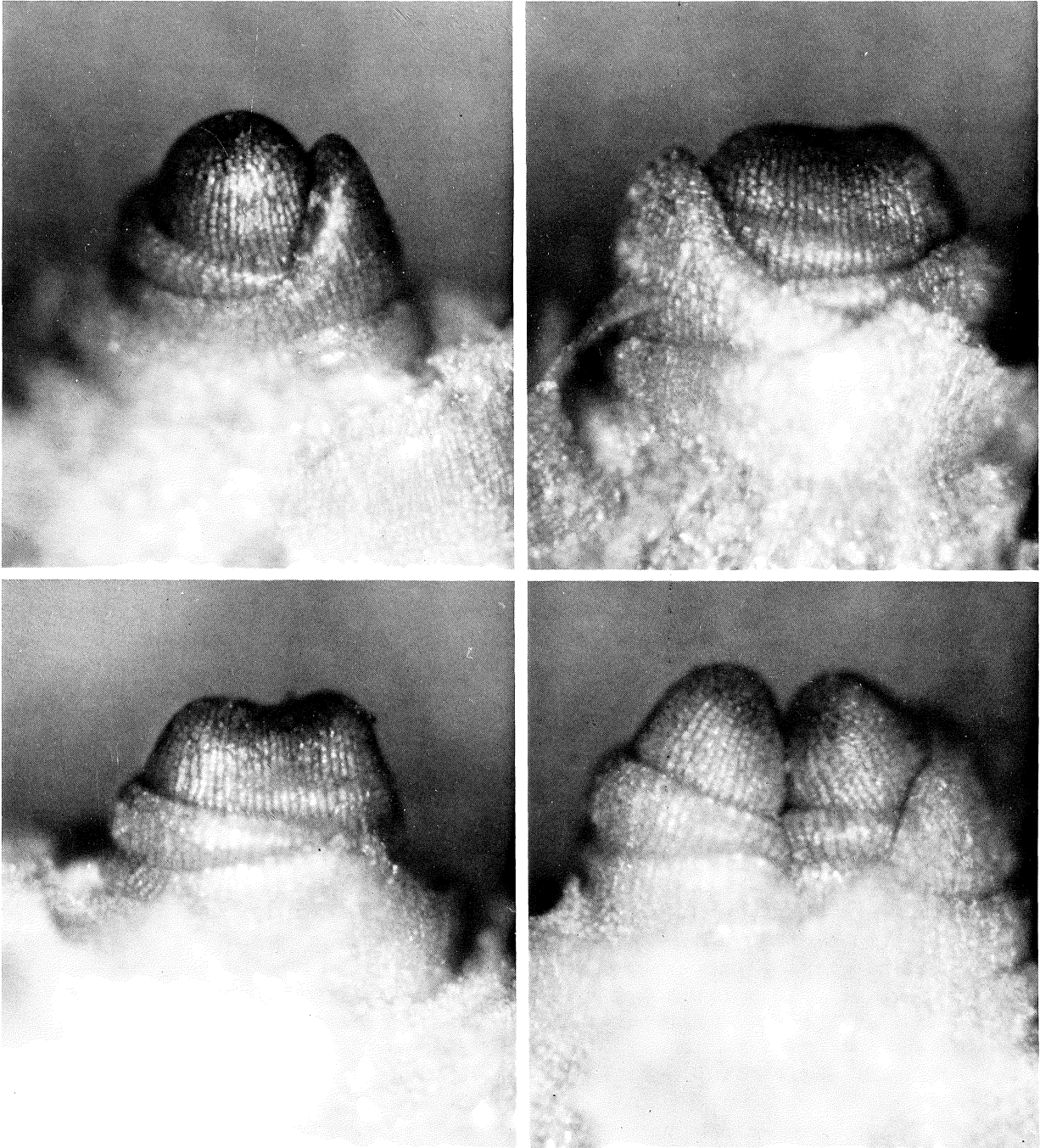
The seventh New England Fern Conference was held here May 21-23. It was the sixth meeting of the group at the Forest, only one year was missed when the meeting had to be held in Amherst because of the reconstruction of the museum a few years ago. — Numerous other groups met at the Forest, we had again many visitors, and the Fisher Museum continues to attract many groups and individuals.

## RESEARCH

Along with many other foresters, Ernie Gould was involved in the eleven-university consortium studying the U. S. Forest Service reports made under the recent Resource Planning Act. This act establishes a new process for planning the activity of the Forest Service based on an assessment each decade and a program for action covering 5 and 10 years into the future. This continuing process is open at all stages for public input and promises to become a new and dynamic forest-land-use planning process. — Ernie's work on town land-use planning continued with a new look at conservation needs in Petersham. Bill Bentley's presence as a Bullard Fellow also stimulated further work on models for scheduling woodland practices on a forest-operating unit, and on forest-management gaming. — Walter Lyford's time during his last year before retirement was mostly spent with the preparation of progress reports and articles for publication. As mentioned before, a considerable amount of his effort went into teaching.

During another trip to the South Pacific, Barry Tomlinson continued his field work on mangroves, primarily on the morphology, floral biology and systematics. The existence of hybrids in the genus *Rhizophora* is now strongly substantiated. A possible hybrid in the genus *Lumnitzera* (Combretaceae) was also located. In continuing studies of sea-grass communities, a survey of the gross aspects of leaf anatomy has been completed and floral morphology is being examined by Usher Posluszny. In other work on aquatic monocotyledons, also in collaboration with him, the family Zannichelliaceae has been surveyed anatomically and morphologically, sufficient to appreciate more precisely generic limits. This work is part of the final stages in the preparation of a volume on aquatic families in the series *Anatomy of the Monocotyledons*. — Also in collaboration with Usher Posluszny, branching of woody plants of the tropics has been investigated in material collected in the South Pacific, Florida, or grown in our greenhouses. Dichotomous branching in the woody monocotyledon *Flagellaria indica* has now been well documented (see illustration, p. 9). This is the first unequivocal demonstration of this type of branching in flowering plants. It is common in lower and fossil plants and usually considered a "primitive" character. The work on other branching patterns in trees ("tree architecture") was continued. — A survey of the vascular anatomy of woody monocotyledons is being brought to a close with an investigation of the Xanthorrhoeaceae





Sequence of pictures showing dichotomous branching of the vegetative shoot apex of *Flagellaria indica*, a woody monocotyledon of New Guinea. See text on p. 8. Photomicrograph by Usher Posluszny. Magnification X 140.

(to which Australian grass trees belong), certain members of the Iridaceae, Agavaceae and Cyclanthaceae.

Dutch Weidlich's research on the vascular anatomy of the Nymphaeaceae (the family of water lilies) continued. Many of the results are now in various stages of publication. — Research initiated last summer on a "cure" for chestnut blight has been expanded to include the inoculation technique developed by a group of investigators at the Connecticut Agricultural Experiment Station. A hypovirulent strain of fungus *Endothia parasitica* (originally discovered by researchers in northern Italy and southern France) is introduced into the infested area of the tree where it affects the virulence of the present strain. Twenty-five American chestnuts in the Harvard Forest and the Petersham area have been inoculated and it will be interesting to see how long these trees will survive.

My own work on the pattern of differentiation of the vascular system of arborescent monocotyledons continues. During the past year, we continued our investigation of the origin of the fibrous bundles in the cortical area of large palm stems (the "outer system"). Although these bundles are non-functional in the mature stem, they seem to play an important role during the development of the vascular system in the apical region.

Susan Dunford continued her work on the interrelationship between the xylem (the wood, where water and soil nutrients move from roots to leaves) and the phloem (the inner bark where sugars move from leaves to places of sugar consumption and storage), and the movement of water between them. She spent most of the winter months analyzing the previous summer's data and preparing new techniques for the summer 1976. During the present summer, she is working in collaboration with Roger Lee. The main effort concerns the direct measurement of phloem pressures with pressure transducers. This direct measurement turned out to be very difficult. Sieve-tube pressures can be as high as 20 bar (approximately 300 psi); this makes a proper seal between the probing needle and the bark very uncertain. Once phloem pressures can be measured, it will be possible to obtain a better understanding of the movement of water and sugars in trees.

Much of Roger Lee's time was spent with the collaboration effort described above, but in addition he did some experimental work on the hydraulic conductivity of wood.

A good deal of my time last fall was devoted to the proofreading and indexing of the first volume, on phloem transport, of the Encyclopedia of Plant Physiology, New Series. The book appeared in December 1975 (see bibliography).

Much effort of John Torrey's group over the past year has centered on the problem of the initial infection of roots of several non-leguminous woody species by an actinomycete-like organism, leading to root nodules capable of fixing

atmospheric nitrogen. Woody brush species studied include the common sweet fern, *Comptonia peregrina*; sweet gale, *Myrica gale*; the closely related bayberry, *Myrica pensylvanica*; the wax myrtle, *Myrica cerifera*; the autumn olive, *Elaeagnus umbellata* and the tree species from Australia, *Casuarina cunninghamiana*. Seedlings are grown with their roots in nutrient mist in aeroponic tanks, their roots are infected with a suspension prepared from nodules of mature plants. Initiation and development of nodules is followed photographically and through the use of light and electron microscopy.

Bryan Bowes from the University of Glasgow in England worked on this problem, centering his work in cooperation with Dale Callaham on *Comptonia peregrina*. Their time-lapse photographs, which served to monitor the development of the nodules, confirmed that nodule development in this woody brush species, unlike that in legume nodule development, involves repeated lateral root branchings forming an elaborate witches' broom-type of structure which is perennial, reaching several centimeters in diameter (see the frontispiece). The proximal portion of the root to which the nodule is attached undergoes rapid secondary thickening which assures the retention of the nodule.

From light microscopy using serial plastic sections and electron micrographs taken in cooperation with William Newcomb, former Cabot Fellow now at the University of Guelph, Dale Callaham has obtained unequivocal evidence for the existence of root-hair infection by the actinomycete-like endophyte observed both in *Casuarina* and in *Comptonia*. In both species the endophyte "thread" in the root hair is surrounded by the host plant cell-wall, paralleling the situation found in infection threads in root hairs of legumes produced by the soil bacterium *Rhizobium*. In this work, the use of the aeroponic tanks has proved to be an invaluable method for studying nodule development. Roots are totally available for periodic examination in large numbers. Peter Del Tredici has so improved the conditions that regular nodulation in *Comptonia* seedlings is achieved as early as two weeks after inoculation. An improved version of the tank allows the frame holding the plants to be lifted and clamped above the tank during observation.

In related studies, the problem of seed dormancy in *Comptonia* has now been resolved. The seeds contain an inhibitor which resides in the thin inner seed coats of the fruit. Isolation of the embryo leads to prompt germination. Alternatively, one can soak the whole fruits in a solution of gibberellic acid (500 ppm for 24 hr) and then plant the seeds and get germination of 50% or more.

From isolated embryos of *Comptonia* growing *in vitro* sterile root tips can be isolated for study in culture. Patt Goforth has followed these cultured roots in histological preparations. They show the formation of root buds in culture and also the roots themselves undergo secondary thickening, forming woody structures as they do in the field.

Haviva Langenauer focused her attention on changes and manipulation of the primary vascular patterns in cultured *Convolvulus* roots. She studied the role

of carbohydrate concentration in the medium on pattern formation and has been able to demonstrate a relationship between quiescent center dimensions and the complexity of the vascular pattern in roots subjected to different "starvation" regimes.

## FOREST OPERATIONS

Forest operations were slightly increased this year, and cordwood sold to local customers went from 15 to 33.25 cords. — Much of the crew time was again devoted to maintenance work such as plowing roads, mowing lawns, construction of a bridge over the Swift River, interior painting and miscellaneous repairs.

## HARVARD BLACK ROCK FOREST

A tree-planting experiment was initiated in the wildlife clearcuts in Compartments XXIII and XXV. Coniferous species including white pine (*Pinus strobus*), Scotch pine (*P. sylvestris*), white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*) were planted in April. About 10% of the seedlings were fenced to protect them from possible deer browsing. The seedling survival was 90% after six weeks. There is no evidence of deer browsing so far.

Approximately 90,000 board feet of timber was marked and cut in the former Peck & DeWitt tract adjacent to Route 9W. Miscellaneous maintenance work was done along borders, roads and trails. Several permanent sample plots for long-term tree-growth investigations were remeasured. Much of this work was done during the summer 1975 with the aid of two students from SUNY College of Environmental Science and Forestry at Syracuse; they were D. Jensen Bissell and Spencer Jarrett.

As Chairman of the Cornwall Conservation Commission, Jack Karnig got involved with a program to locate and publicize bicentennial trees within the Town of Cornwall. Twenty-eight such trees were located including the well-known white oak of the Black Rock Forest at the junction of White Oak and Continental Road (see opposite page).



Left: The white oak at the junction of White Oak and Continental Road.  
Right: Michelle Karnig standing beside a black walnut tree planted in October 1969. This picture may be compared with the one that appeared in the Annual Report 1972-73.

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This is a list of publications which have appeared in print between July 1, 1975 and June 30, 1976. Naturally, publication always 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 authors or to the Harvard Forest, Petersham, Massachusetts 01366.

Petersham, Massachusetts  
August, 1976

Martin H. Zimmermann  
Director