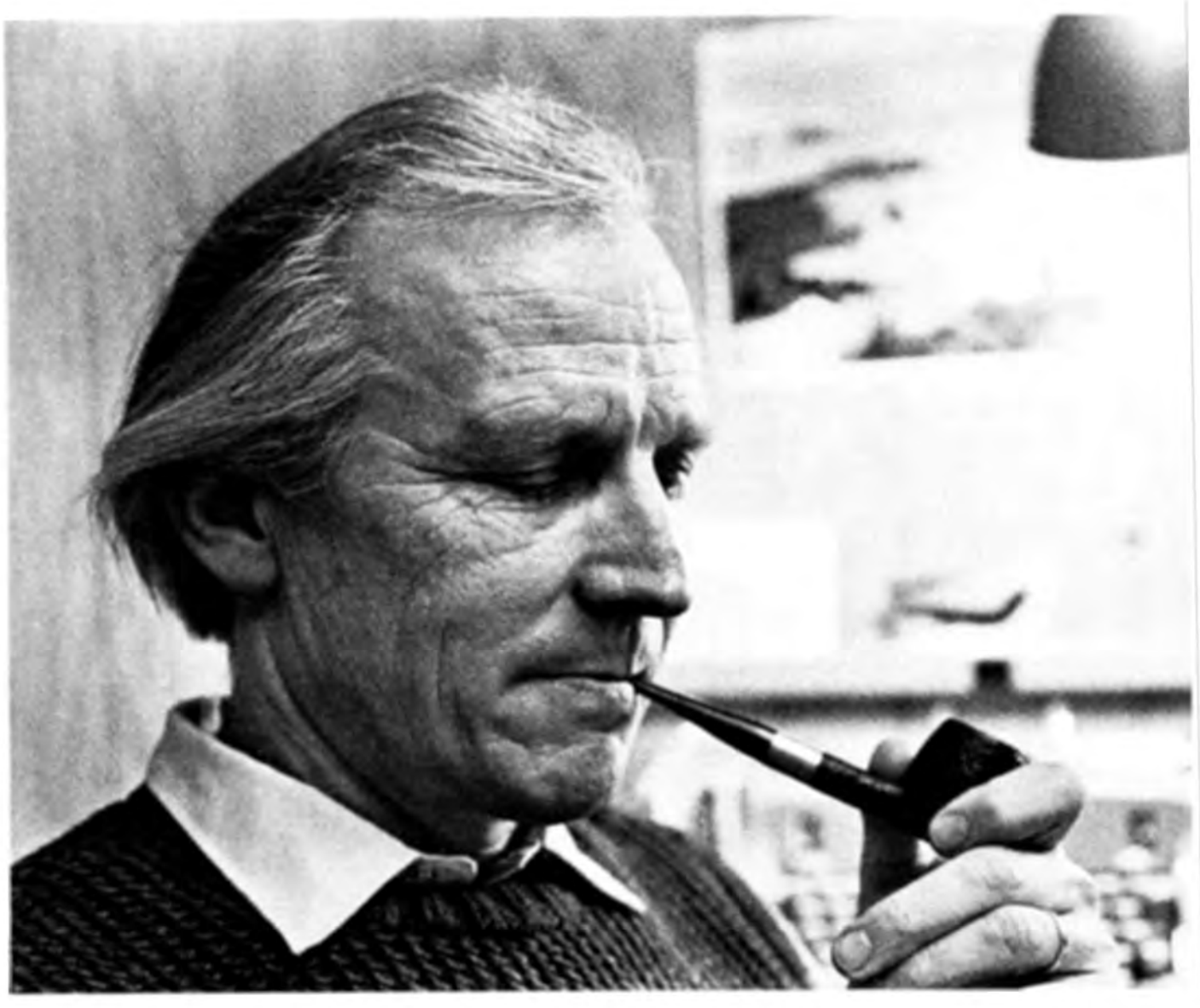
THE HARVARD FOREST, 1983-84

Harvard University



Martin Huldrych Zimmermann

November 27, 1926 — March 7, 1984

To commemorate Martin's lifelong interest in students and research a special fund has been established. Interest from the "Martin H. Zimmermann Fund to Assist Students at the Harvard Forest" will be used to help with their educational and research expenses. Those who wish to join in this venture can send their contributions to the Harvard Forest, designated for the Zimmermann Fund.

Martin Zimmermann was the most recent of the five men to direct the Harvard Forest over the last 75 years. Significantly, each of these has been acquainted with his predecessor and this has brought a remarkable degree of continuity to the development of research and teaching at the Forest. Few institutions have been so lucky in the men chosen to lead.

I've known four of these people, three of them quite well, so I realize that each one has had a consuming passion to understand the true nature of things in the world around us. Each has had his own special interest, but each has also had a concern for affairs beyond his research area.

Martin was certainly an expert in his field and a major source of innovative thought who was able to bring a new and deeper understanding to others through discussions, teaching and publications. But in addition, Martin was a kind of renaissance man. A skilled artist able to capture the spirit and beauty of a scene with a pen or watercolors, an artisan of no mean stature when working with stained glass or building a harpsichord and finally a fine musician who stimulated others to play together and excel.

The forest inspired Martin not only to do many of his physiological experiments on trees growing in the the woods, but also to have an unusually broad interest in the technical and social problems of forest resource use and development. He never forgot what he learned as a young man in Switzerland when he worked summers for the local forester. Consequently, he came to take a special interest in the design and conduct of the long-term silvicultural experiments at the Forest. In recent years, when he began heating his house with wood, he laid out and himself cut several experimental areas. Typically, each tree he removed had a purpose and he intended that the growth of the remaining trees be followed over the years.

I think that my most vivid and fond memories will be of Martin as a teacher. We gave a course together so I had a good chance for a close look. Because he was a master of his subject, he had a real knack for stimulating students to learn. Although skill and competence are important to any teacher, perhaps more central to Martin's success was his compassionate concern for each of his students. He worried about their progress and welfare and always took whatever time was needed to insure a full understanding and confidence on the part of the student. It was a major pleasure for him to get letters from old students telling of their doings after graduation.

Harvard students benefited immensely from his years of service as did all of us who counted Martin as a friend. And now the leadership has passed again, and John Torrey will see that Harvard's scholars in the woods continue to explore and illuminate the world around them.

DIRECTORS OF THE HARVARD FOREST

Upper left: Richard Fisher, director from 1908 to 1934, and Austin Cary whose Woodsman's Handbook, was the first success of the Harvard University Press. We haven't been able to find a picture of Ward Shepard, director from 1937 to 1939. Upper right: Albert Cline was assistant director to both Fisher and Shepard and director from 1939 to 1946. Al arranged hurricane cleanup after 1938. Lower left: Earl Stephens listens to Hugh Raup who knew all three of the previous directors and was himself director from 1946 to 1967. Lower right: Ernie Gould, Martin Zimmermann and Pete Hannah. Martin started work at the Forest in 1954 and became director in 1969, serving until his untimely death in 1984.

ANNUAL REPORT OF ACTIVITIES AT THE HARVARD FOREST

1983 - 1984

STAFF

Gerald M. Allen, Bullard Fellow (from September 1, 1983 through May 31, 1984)
Emery Boose, Computer Assistant
John Brady, Assistant to the Manager of the Black Rock Forest
Marcia Brightman, Laboratory Aide (from May 1, 1984)
Robert O. Brush, Bullard Fellow (from July 1, 1983 through June 30, 1984)
Catherine M. Danahar, Business Secretary and Librarian
Wayne E. Elliott, Custodian
Frank W. Ewers, Cabot Research Fellow
Mark S. Fontaine, Research Assistant
David R. Foster, Assistant Professor of Biology
Ernest M. Gould, Jr., Forest Economist, Senior Lecturer on Biology
Acting Director of the Harvard Forest (from July 1, 1983)
Anne K. Hachey, Greenhouse Assistant (from May 15, 1984)
Edward H. Hyde, Woods Crew
Adrian M. Juncosa, Post-doctoral Fellow (from April 15, 1984)
Jack J. Karnig, Forest Manager
Susan Lancelle, Research Assistant
Ralph L. Lundquist, Head of Greenhouse
Monica R. Mattmuller, Research Assistant
Gordon B. Mitchell, Woods Crew Superintendent
Susan P. Moriarty, Laboratory Aide (part-time until May 1, 1984)
Marcia A. Murry, Post-doctoral Fellow (NIH)
Frances E. O'Brien, Secretary
Frances N. Phillips, Secretary
Hugh M. Raup, Charles Bullard Professor of Forestry, Emeritus
Jorg Sauter, Bullard Fellow (from July 1, 1983 through October 1, 1983)
Dorothy R. Smith, Secretary
Charles C. Spooner, Woods Crew
C. Dana Tomlin, Assistant Professor of Landscape Architecture, Associate of the Harvard Forest (from January 1, 1984)
P. Barry Tomlinson, Professor of Botany
John G. Torrey, Professor of Botany
George J. Wilder, Cabot Research Associate (NSF)
Patricia H. Young, Laboratory Technician
Zhang Zhongze, Visiting Scholar
Martin H. Zimmermann, Charles Bullard Professor of Forestry
Director of the Harvard Forest (until June 30, 1983)

On September 5, 1983 Martin Zimmermann was elected an Honorary Member of the Polish Botanical Society. This is the highest award of the Society and was given to pay tribute to Martin's achievements in plant physiology and anatomy and for help to Polish botanists.

John Torrey was appointed Fulbright Senior Scholar at the University of Aberdeen in Scotland for the first half of 1984. In addition to his research which is described later in this report, while in Great Britain he gave the Mary Snow Memorial Lecture in the Botany School of Oxford University.

We are pleased to announce that Dana Tomlin, Assistant Professor in the Department of Landscape Architecture, Graduate School of Design has been appointed an Associate of the Harvard Forest. Dana is Associate Chairman of that Department and Assistant Director of the Laboratory for Computer Graphics and Spatial Analysis. His appointment represents another step to improve collaboration between these two Harvard institutions.

This spring Ernie Gould was given the first Distinguished Alumnus Award by the Department of Forest Resources at the University of New Hampshire. It was a pleasure to see how much activities had expanded since my graduation in 1940.

STUDENTS

Members of the staff continued their normal teaching activities. In the fall semester Barry Tomlinson taught in Biology 18, Diversity in the Plant Kingdom; Ernie Gould and David Foster gave Biology 101, Trees, Forests and Man. In the spring semester David Foster and Andrew Knoll gave Biology 210, Topics in Paleobotany and Plant Evolution. Dana Tomlin taught the Landscape Planning and Design Studio, LA 211b, with Carl Steinitz and assisted with the Fall Workshop at the Harvard Forest.

The Harvard Forest Freshman Seminar again brought students to Petersham on weekends scattered throughout the spring semester. Ernie Gould and David Foster arranged the schedule of events. This continues to be a useful way of making students aware of study possibilities at the Harvard Forest.

David Black took two independent study courses with Ernie Gould in the spring term. He wrote two reports "An Analysis of the Area Around the Quabbin Reservoir for its Potential as Mountain Lion Habitat" (Biol. 91r). Dana Tomlin helped David with the computer mapping aspects of this study and provided computer facilities. The second paper concerned the "Management of Forest Land for Black Bears" (Biol. 299r). Ashrenazi-Kimmel also took a unit of Biol. 299r with David Foster to study ecology.

Dana Tomlin had Andy Mitchell do an independent study of a micro-computer-based mapping project which laid groundwork that will be very

useful to the Forest. Ernie Gould helped review the work.

In June, Barry Tomlinson gave Biology S-105, Plants of the Tropics, at the Fairchild Tropical Garden in Miami, Florida. Eleven students from ten institutions ranging from Canada to Puerto Rico took the course. An international flavor was provided by a student from West Germany (via Tufts University) and a Swiss post-doctoral student from McGill University.

Kathleen Walker, a Harvard sophomore, assisted by Dawna Smith, with the aid of a grant from the Tozier Fund of Harvard University and a work-study grant, made several movies of common anatomical subjects for teaching purposes during the summer of 1983. Problems encountered during this work suggested that a large scale operation making teaching films would be considerably handicapped by methods which, though suitable for research, are not very adaptable for the precision needed in making demonstration movies. Perhaps video methods of information storage might be better and this possibility is to be explored.

Before he left in June, 1983 to begin a M.Sc. program at Michigan State University, Jeff Vincent completed an architectural analysis of the tropical treelet Anisophyllea disticha (Rhizophoraceae) which Barry Tomlinson ushered through the publication process. Plagiotropic axes in this species were shown to have a phyllotaxis which seems unique for flowering plants.

During the fall term, from August 1 to December 16, 1983, Nathaniel Potter worked on the in vitro culture of excised roots of members of the Casuarinaceae, especially Allocasuarina, providing the background information necessary for research pursued by John Torrey during his stay in Aberdeen. Nathan was on the cooperative work program from Antioch College.

Ann Lewis completed her class work in Cambridge so that her thesis can now be pursued full time. She continued the study of water storage mechanisms in Sphagnum hyaline cells in the summer of 1984 testing the "air-seeding" of embolism, a hypothesis suggested by Martin Zimmermann in Xylem Structure and the Ascent of Sap. This work is being supported by the Northeastern Forest Experiment Station, U. S. Forest Service, USDA.

Ann's husband, Emery Boose, has continued to help us with our many computer problems while he is working on his thesis. Expert assistance such as his is essential to maintaining and using the system of computers we now operate.

Matt Kelty finished his PhD at Yale this spring but stayed on with the support of the Yale-Harvard Joint Fund. He analyzed the results of our 1956 experiment in Tom Swamp I which showed that the removal of all understory trees and shrubs had no effect on the growth rate of the remaining overstory in a mixed-species hardwood stand. He compared this study with others done in the eastern United States and found a consistent geographical pattern: understory removals have no effect in areas of fairly high rainfall near the east coast, but the same treatment noticeably improves overstory growth in Missouri and Arkansas, where rainfall is more limited, especially late in the growing season.

from fourteen American universities or research centers plus five European, Australian and South American universities.

- The fall season began in September with the usual four-day visit of about fifty students from the Graduate School of Design, Department of Landscape Architecture. This method of introducing new Harvard Students to the region and each other is always a stimulating occasion.
- In October the Northeastern Forest Economists held their annual three-day meeting at the Forest.

  In November we had the sixth Northeast Paleobotanical Conference here for three days. The New England Forestry Foundation held its annual training program here for another three days. Pete Hannah's silviculture class from the University of Vermont was also here overnight.
- In December we helped with a day of training for the nature staff of the Northfield Pumped Storage Facility. The botany students from the OEB in Cambridge visited the forest for a weekend. The Massachusetts Department of Environmental Management held a two-day Acid Rain Forum. This brought together seven experts in the field with the senior staff of the Harvard Forest to advise Commissioner Gutensohn about a proper departmental role in light of the present state of our knowledge on acid precipitation.
- The spring season started in March when Clark Binkley brought his management class here from Yale for two days.
- In May students from the Landscape Architecture Department got Phil Craul, from Syracuse, to give them a four-day crash course in soils at the Forest. Barry Tomlinson organized a Workshop on Aroid Systematics over the Memorial Day weekend. This brought eighteen people from the United States, Canada and England together to discuss research on the family Araceae (the Jack-in-the Pulpit family).

Among the many individual visitors, Dr. Yehia Ishac, Director of the Unit of Bio-fertilizers at Ain Shams University, Cairo, Egypt visited the Harvard Forest last July while on a tour of the United States to learn about Frankia research. He gave a seminar on nitrogen fixation in arid soils.

John Pierre Chiron, a student at the Pons Lycee Technique, Emile Combe in Cognac, France spent the month of July at the Harvard Forest assisting Frank Ewers and Marcia Murry with data collection and computational analysis.

People at the Harvard Forest also made visits. Barry Tomlinson gave seminars at the University of Maine in Orono, in October; was the invited graduate student speaker at the New York Botanical Gardens in March, and was the invited lead speaker at a symposium organized during the annual meetings of the Canadian Botanical Association in New Brunswick, Canada in June. On these occasions he spoke about recent research on vascular anatomy of monocotyledons and about tree form as a process.

John Torrey gave numerous talks and seminars on his research while he was in Great Britain. He attended the IUFRO Conference on "Trees as Crop Plants" and chaired a session on "The Vegetative Structure".

Ernie Gould was invited speaker at the Annual Meeting of the New England Society of American Foresters, at the New England Workshop on Environmental Affairs at Tufts University and at the Conference on Fees for Outdoor Recreation on Lands Open to the Public at the University of New Hampshire. Ernie also spoke at the Annual Meeting of the Massachusetts Association of Conservation Commissions. At the latter he received a 1984 Environmental Services Award.

Dana Tomlin gave invited lectures on computer cartography at the Universities of Oregon and Alaska, Salem State College and at Yale and Purdue.

The trustees of the Fred Harris Daniels Foundation provided a generous gift to the Harvard Forest for improvement of the Fisher Museum. These funds have been used to modernize the second floor to benefit visitors. A student from the School of Design was hired to lay out the concept and execute it under Dana Tomlin's supervision. Dana, himself did the cartoons.

BULLARD FELLOWS

The Gunnatillekes finished their tenure as Bullard Fellows in Cambridge and returned to Sri Lanka. The three Fellows this year were all centered at the Harvard Forest.

Gerald Allen, Associate Professor of Forestry, Humboldt State University, developed a first draft of "Operations Research in Forestry: A Collection of Problems" during his nine-month stay at the Forest. This work is designed as an aid to teaching quantitative decision-making in professional forestry programs. A unique format is used to focus on the development of problem-solving skills rather than the traditional methods-oriented approach. Classroom testing and further development will be done by Jerry at Humboldt State during the 1984-85 academic year.

Between trips to the libraries at Cambridge and Amherst, Jerry also gave several presentations and seminars throughout New England on redwood management. He collaborated with Ernie Gould to produce an article on solving "wicked problems" which has been submitted to the Journal of Forestry.

Jörg J. Sauter, Professor of Botany at the University of Kiel, spent three months at the Harvard Forest doing research in hydrophysiology. He concentrated on two questions. First, can the exclusion of air during the cutting of holes for the subsequent infusion of liquids into trees improve the uptake of solutions. Normally boring a hole in a tree lets air into a cell the instant its wall is broken, causing an air embolism. However, using a specially constructed steel tub, holes were drilled under water so air was excluded. Then a potentiometer connected to a water tank measured the uptake from holes bored with and without the air embolism protection. This comparison was studied in several tree species and all unprotected

trees had uptake reduced to only 10 to 60 percent of the protected ones. However, considerable variation was noted among species which was related to differences in their hydrosystems as well as in their capacity to recover from air embolisms.

The second problem was demonstrating unequivocally that air embolism is caused by freezing the vessels in a tree. A new double staining procedure was developed for tracing embolized vessels under the microscope. One dye stained vessels that were functioning before the freeze/thaw treatment, while the second dye applied afterward showed the embolized vessels. When the second dye solution was supplied under vacuum the greatest number of embolized cells appeared. If the second dye was administered at normal atmospheric pressure Jörg observed that the microporous vessels of red maple essentially recovered from water vapor embolization within 30 to 90 minutes.

Robert Brush, from Amherst, focused his attention primarily on the potential microcomputers have for mapping geographical data bases. Because manipulating geographic information is central to so many forest planning operations it is important to do it as efficiently as possible. Bob consulted with Emery Boose and Dana Tomlin and then designed a program that can produce distinctive maps of large data bases despite the limited memory of our microcomputer.

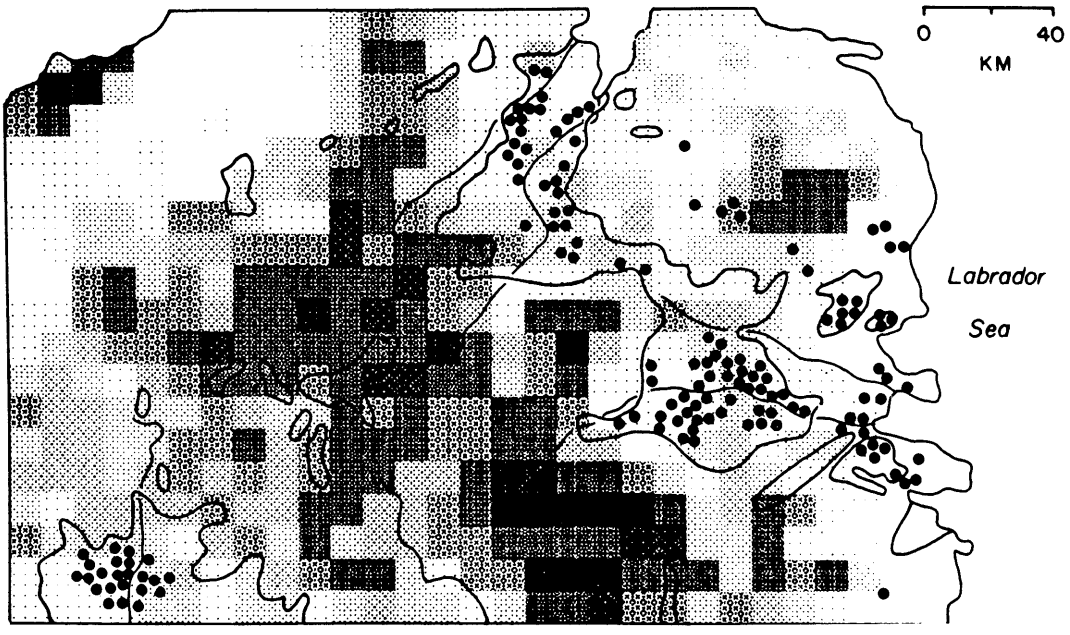
Bob used the potential of our dot matrix printer to generate a myriad of gray tones, fine and coarse textures and bold patterns, using basic units of one-twelfth of an inch. Symbols for many computer generated maps have been limited to keyboard symbols and characters. The pattern making program, however, offers a wide assortment of tones and textures from our dot matrix printer. David Foster was able to use Bob's software to map the distribution of vegetation following fire disturbance on his study area in Labrador.

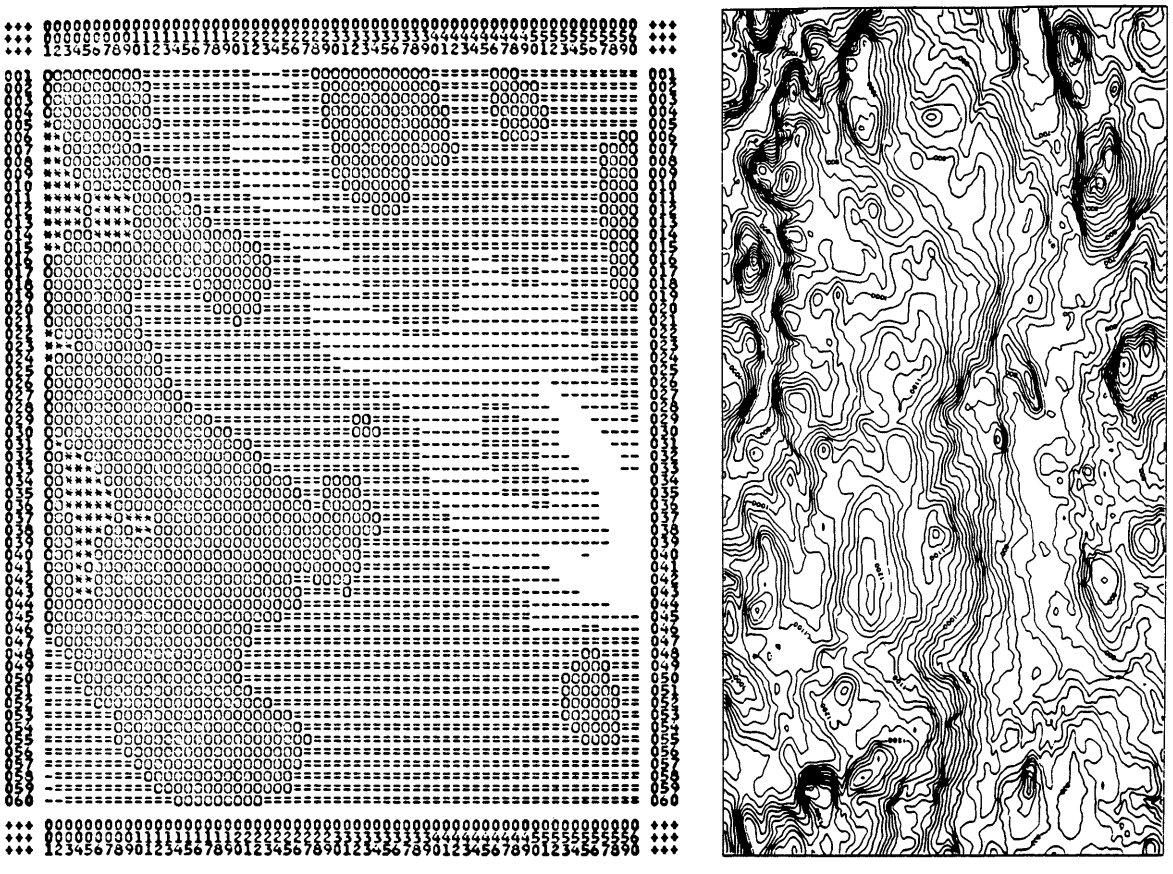
Bob also completed an article published in Landscape Architecture magazine which urged foresters and landscape architects to work together in shaping forest spaces that are both productive and interesting to look at.

RESEARCH

Growth of the Richard Thornton Fisher Fund for Research this year was primarily from capitalized interest which added almost $900 to the fund.

Since the Forest Cutting Practices Regulations were promulgated in January the State Forestry Committee has absorbed less of Ernie Gould's time. That activity is now in a monitoring, educational and research phase the success of which will determine whether the whole regulatory venture will be worthwhile. If we are successful, the whole institutional





Computer maps can take many forms depending on the printer and software available. At the top is the vegetation map that David Foster made with the shading technique developed by Bob Brush for a dot matrix printer. Below are two elevation maps in Petersham by Dana Tomlin. Left is a map using symbols found on a typewriter. Right is a more conventional appearing contour map drawn with a pen plotter.

setting for forestry in Massachusetts will be gradually transformed into a healthier state which will benefit landowners, loggers, industry and the public at large. The next few years will tell the story.

Ernie has also been spending time collaborating with the people at the White Mountain National Forest in appraising current planning processes and analytical schemes. Some simple analyses, using the Harvard Forest IRAM model (I'd Rather Allocate it Myself), produced long range harvest programs for the WMNF that were quite similar to those made by the much more elaborate and expensive FORPLAN model.

IRAM can be worked with paper, pencil and a pocket calculator or with software Ernie has developed for our microcomputer. Making a 200 year harvest schedule costs about 25 cents worth of computer time, a price that is just about what such long term forecasts are probably worth. These results have encouraged us to try to rationalize a new forest planning process to use simple tools which help take full advantage of participatory planning among foresters, interested lay people, administrators and legislators.

Dana Tomlin has started to develop the software needed to use the MAP package on a microcomputer. This involves a program in PASCAL which will be very efficient in its use of memory space. Heretofore most computer map work has had to be done on a main-frame, so being able to use a microcomputer will be a major advantage for foresters and other resource planners

David Foster has continued to collaborate with colleagues at the University of Minnesota and Lund University in Sweden on research into the origin and development of the peatlands that cover up to 40 percent of many boreal regions. These peatlands are an important component of northern ecosystems which have long baffled arctic ecologists. Hypotheses describing peatland formation were presented at conferences at McGill University and the University of Colorado. They are being tested by continuing research in Central Sweden. David was appointed Visiting Associate at the McGill Subarctic Research Station where more studies of boreal plant community dynamics will be made.

David spent part of the winter examining the Harvard Forest archives and organizing indices to the maps, unpublished manuscripts and published papers. The value of this historical information has been revealed in the extensive files on the old-growth Pisgah Forest in Winchester, N.H. First sampled in 1911 by Richard Fisher, it was later resurveyed by Neil Hosley and Al Cline in 1930, Steve Spurr in 1941, Earl Smith in the 1950's and David Henry and Mark Swan in 1968. This historical information provides the basis for a study initiated by David on the role of disturbance in central New England forests.

For some years a group of scientists from the Ecosystem Center in Woods Hole have been using the Harvard Forest as a research site. This work has been under the leadership of Dr. Jerry Mellilo. This summer Jerry has begun a new study to expand the depth of our knowledge about the various carbon-nitrogen interactions in ecosystems. Plant physiologists have shown that there is a close relationship between the nitrogen status

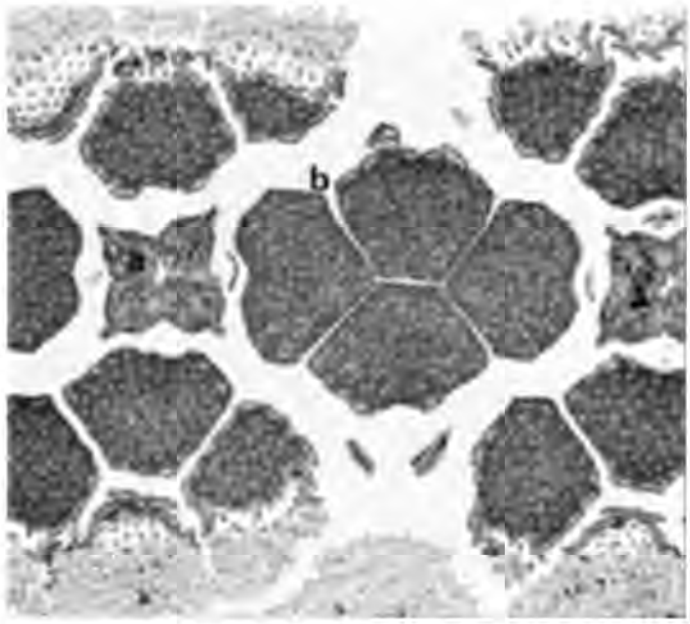
of a plant and its maximum net photosynthesis. However, we know little about how nutrient availability influences the allocation of fixed carbon to the growth of plant parts. Jerry hopes to find answers to the following questions: does nitrogen availability influence the relative allocation of carbon between perennial and deciduous plant parts? Is the allocation of fixed carbon between leaves and fine roots controlled by nitrogen availability? If nitrogen is an important controller of carbon allocation, does the form of available nitrogen (ammonium vs. nitrate) influence the allocation pattern?

Frank Ewers continued work that he started with Martin Zimmermann on the effect that winter freezing has on water-conducting tissue in trees. Frank and Martin found that trees with smaller vessels are more resistant to freezing-induced embolism (air blockage) than trees with larger vessels. This response might have an effect on the distribution of plants in nature.

Frank also worked with Roni Aloni, a former Bullard Fellow from Isreal, on the development of vascular tissue in pine needles. Leaves of white pine live for two, or rarely three, years. After the first year they produce additional food-conducting phloem but no additional water-conducting tissue.

Monica Mattmuller has assisted both Frank Ewers and Barry Tomlinson making and mounting sections of a variety of plant tissues for study. She has also helped several graduate students in the same way. Monica is our resident expert in such matters and also does most of our photographic work.

Barry Tomlinson has been working for a number of years on a book "The Botany of Mangroves" and he delivered the draft manuscript to the publisher in April, 1984. It will be the first of a new series Cambridge Studies in Tropical Biology to be produced by Cambridge University Press. The objective of this series is to treat biology in its broadest sense and make information on specialized topics more easily available to students and research workers in the tropics. This book should appear in 1985 and the series could make a major contribution to tropical studies.



Right-Carludovica palmata. Tangential section of a floral axis produces this regular pattern of (a) a single female flower with 4 carpels alternating with (b) groups of 4 male flowers with many stamens in transverse and oblique section. Barry Tomlinson is investigating this floral morphology.

Jim LaFrankie continued his work on Smilacina, investigating in great detail the method of vascular connection between successive segments in the sympodial rhizome system. The integrated nature of the system was demonstrated by using colored dyes to follow the pathway of water movement along axes of different order. He was able to visit marked populations of several Central American species during a visit to Mexico in May and June.

John Sperry continued his work on the hydraulic architecture of the palm Rhapis excelsa, both at the Harvard Forest, on greenhouse grown plants, and subsequently at the Fairchild Tropical Garden from March to July, using field grown plants. His research was continued with the aid of a pre-doctoral dissertation improvement grant awarded by the National Science Foundation. Preliminary results have tended to support the "air-seeding" hypothesis proposed by Martin Zimmermann to account for control of embolism in the xylem tissue of plants under stressed conditions.

Paul Rich continued his work at the LaSelva Field Station of the Organization for Tropical Studies (O.T.S.) in Costa Rica, with support from a Fulbright Fellowship and a grant from the Noyes Foundation (administered by O.T.S.). His research demonstrates that although palms have no capacity for increasing trunk tissue secondarily, the proportions of some stems are closer to those of trees with secondary growth than at first is apparent from theoretical considerations. Above all, many palms increase the mechanical strength of their trunks with age by continued late changes in tissue texture. This indicates how the palm habit of growth is highly adaptive in the conditions of the tropical rainforest and further emphasizes the mechanical diversity of tropical trees. The quantitative studies of palm species at LaSelva (which Barry Tomlinson was able to visit in March) are complemented by anatomical studies of palm stem tissues carried out here at the Harvard Forest.

Mary Lopez has continued her studies on carbon metabolism in cultured Frankia and in the actinorhizal symbiosis. Her collaborative work with Mark Fontaine on changing levels of trehalose and glycogen in Frankia were presented as a poster at the International Symposium on Nitrogen Fixation in Wageningen in the Netherlands. This work is a part of her research for her PhD thesis at the University of Massachusetts.

MEETINGS AND VISITORS

Last year the Forest hosted an unusually large number of meetings covering a wide array of subjects:

- In June of 1983 there was a one-day Management Planning Orientation Meeting for the Massachusetts Department of Environmental Management, Division of Forests and Parks. From August 21 to 25 a meeting on "Evolutionary Constraints on Primary Productivity: Adaptive Strategies of Energy Capture in Plants" was organized by Tom Givnish from the Department of Organismic and Evolutionary Biology (OEB) in Cambridge. This brought together about two dozen people

During the preparation of his book Barry has visited mangrove communities in South Florida, Central America, Australia, the South Pacific and South-east Asia.

Adrian Juncosa formally began his appointment as post-doctoral fellow in April with support from a National Science Foundation grant (Barry Tomlinson as principal investigator). We had a preview of him in the summer of 1983 when he spent some time at the Forest recovering from a broken ankle, the result of falling out of a tree in Colombia. While at the Forest his research will extend our knowledge of the processes of embryo and seedling development in the Rhizophoraceae, a group of plants in which the representatives in mangrove communities (tribe Rhizophoreae) show vivipary, i.e. development of the embryo to the seedling stage and its emergence from the fruit while still on the parent tree. Comparison will be made to terrestrial representatives of the family with the idea of understanding the evolutionary origin of this unusual condition and perhaps also why it should be so common a condition in trees of the intertidal zone in the tropics.

George Wilder continued his research into the leaf and root anatomy of the Cyclanthaceae. This work has revealed many of the differences and similarities between genera and between this and other plant families. These results have been embodied in eight manuscripts that will be published in the Botanical Gazette, the Canadian Journal of Botany and the Leaflets of the Botanical Museum at Harvard. George was an invited speaker at the meeting of the New York Microscopical Society, chaired a session of the meeting of the Development and Structural Section of the Botanical Society of America and won seventh place in Nikon's International Competition in Photomicrography.

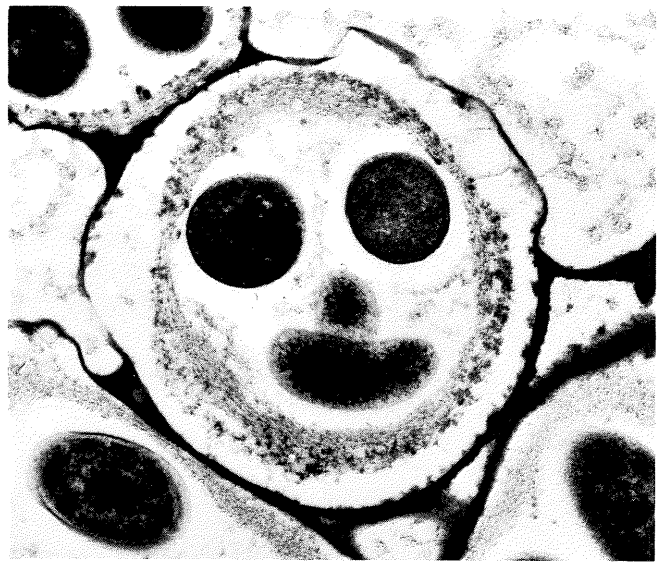
Robert W. Johnson from the Department of Botany at the University of Toronto spent almost three weeks here this summer. He is doing research on the velocity of phloem sap movement in ash trees, a subject that Martin studied some years ago. Bob wished to use some of the same equipment that Martin did and the same species. Luckily Monica was able to show him the things we have available in the lab and the out-of-doors.

Right - Bob Johnson setting up to measure phloem sap velocity in a white ash using the ratio wave technique developed by Martin Zimmermann. Luckily Bob has a good head for heights!

John Torrey found that the University of Aberdeen was an excellent host institution during his tenure as a Fulbright Senior Scholar. Research contacts with the Department of Forestry, Bacteriology at the School of Agriculture, the Botany Department and Department of Microbiology at Marischal College were friendly, helpful and cooperative. John's research centered on efforts to understand the infection process whereby the soil micro-organism Frankia enters roots of certain woody dicotyledonous plants inducing the formation of nitrogen-fixing root nodules. He used the methods of plant organ culture, sharing an already established research laboratory in the Department of Forestry, devoted largely to micropropagation of forest trees using plant tissue culture and protoplast culture. In the relatively short time available excellent progress was made in how to grow excised roots of Allocasuarina, the test host plant, and in learning about satisfactory ways to associate the host tissue and the micro-organism in vitro. The work is incomplete but will be continued here in Petersham.

A collaborative study by Mark Fontaine and Susan Lancelle was completed on the development of specialized structures called vesicles in cultured Frankia isolated from root nodules of Alnus. Morphological and physiological stages in the development of these vesicles, which are the proposed sites of nitrogen fixation, were described. Transmission electron microscopy was used to document ultrastructure changes which occur during development.

Sue Lancelle completed structural studies of the infection process and early development of Rhizobium-induced root nodules of Parasponia rigida, a tropical member of the elm family. A collaborative project was then undertaken with Peter Hepler and Dale Callaham of the University of Massachusetts to study the ultrastructure of Frankia in culture using rapid-freezing methods. These methods provide much more structural information than can be obtained by conventional fixation techniques alone.



Right - Species of the tropical genus Parasponia (Ulmaceae) bear nitrogen-fixing root nodules in association with certain slow-growing Rhizobium strains. This genus is the only verified example of symbiosis between Rhizobium and a non-legume. One peculiarity of the association is that release of rhizobia from infection threads, a process that normally happens in bacteroid formations in legumes, does not occur. Instead the rhizobia remain enclosed in thread-like structures which ramify throughtout host cells. The above electron micrograph shows a cross-section of such a thread containing healthy-looking rhizobia. The host cell cytoplasm has degenerated and appears very electron-dense. X 20,000.

Marcia Murry in collaboration with Zhang Zhongze studied environmental factors influencing the formation of vesicles, the presumed site of nitrogen-fixation in most actinorhizal root nodules. Unlike Alnus-type root nodules, the endophyte in Casuarina nodules does not produce vesicles. Studies of an effective isolate from Casuarina grown in culture, correlated vesicle development with nitrogenase activity (an anaerobic process) under aerobic conditions. However, under very low oxygen tensions, vesicle development was inhibited and the nitrogenase activity which developed in these avesicular cultures was very oxygen sentitive. These results suggest the oxygen protection of nitrogen fixation in Casuarina nodules is provided by the nodule rather than by the vesicle.

FOREST OPERATIONS

Silvicultural work this year was confined to the small amount of cutting needed to enlarge and improve the view westward from Shaler Hall. The wood yield, together with that left over from last year, will be used to help heat the main buildings this winter.

The rest of the time was spent on the usual round of building, grounds and machinery maintenance. One major improvement was to connect the CEF with the old Sanderson Farm well. This has a good supply of excellent quality water which is better for the plants in the greenhouse than water from the drilled well. The added well also provides an emergency water supply in case the main source fails.

HARVARD BLACK ROCK FOREST

Jack Karnig has started an experimental system of growing tree seedlings in a raised bed. This method has been quite successful with black walnut and oak. The walnut seed is from trees growing on the headquarters lot and the seedlings will be outplanted on some of the best sites on the forest.

The Institute of Ecosystems Studies at the Cary Arboretum has launched an investigation of gypsy moth behavior in Compartments III and IV. Ms. Karen Budwill is in charge of the field crews while Dr. Clive Jones is the chief investigator.

Jack has maintained the remeasurement of long-term silvicultural plots. One set of new diameter readings was given to Dr. James White, of the Department of Botany, University College, Dublin to update other measurements used in research Jim is doing on the dynamics of tree populations.

The fall of 1983 produced a bumper crop of acorns, which germinated in unusual numbers this spring. This summer there are thousands of healthy oak seedlings under our nearly mature oak stands. Normally most of these seedlings would not survive long due to environmental factors like drought and deer browsing. Jack established twenty milacre plots along the Continental and Bog Meadow Roads and has recorded the oak seedling count on each plot every two weeks. Nearby he has placed wire cages around other seedlings as deer protection. His records this summer should suggest whether drought or deer are the principal cause of seedling mortality.

Two unusually heavy rain storms caused a good deal of road damage during the spring. On April 6 over six inches of rain fell in a 24-hour period when there was 10 inches of snow on the ground. The runoff was immense. During road repairs seven inches of rain fell on saturated soil between May 27th and the 31st. Luckily we got some help from the Black Rock Fish and Game Club to repair the most badly washed segments of the Carpenter Road.

William Bulson, our fuelwood contractor, has had to stop logging in Compartment III because of the gypsy moth study. To compensate, Jack located an alternative site in Compartment XI and marked a 75 cord thinning of mixed hardwoods.

Left: A black walnut seed was planted here in 1969. In June 1973 Michelle Karnig stands beside the 4-year old tree.

Right: Three years later, in June 1976, both Michelle and the tree are springing up.

Left: Eight years later, June, 1984. The tree now 15 years old casts heavy shade for John Brady and Bear.

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Petersham, Massachusetts
August 1984

Ernest M. Gould, Jr.
Acting Director

THIS TEST IS:WMNF, Hardwood, Vol. Control, Rise From Present Cut to Sustained Yield.

ORIGINAL STANDS

	ACRES AVAIL	1	2	3	4	DECADES 5	6	7	8	9	10	ACRES UNCUT
ORIGINAL STD. NO. 1 :												
Yld	.00	2.20	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	.00
Ac.	134416	45568	51391	37457	0	0	0	0	0	0	0	0
Vol	0	100250	123338	89897	0	0	0	0	0	0	0	0
ORIGINAL STD. NO. 2 :												
Yld	.00	2.00	2.20	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	.00
Ac.	122448	0	0	23555	70632	28261	0	0	0	0	0	0
Vol	0	0	0	56532	169517	67826	0	0	0	0	0	0
ORIGINAL STD. NO. 3 :												
Yld	.00	1.80	2.00	2.20	2.40	2.40	2.40	2.40	2.40	2.40	2.40	.00
Ac.	155058	0	0	0	0	51992	89873	13193	0	0	0	0
Vol	0	0	0	0	0	124781	215695	31663	0	0	0	0
ORIGINAL STD. NO. 4 :												
Yld	.00	1.40	1.80	2.00	2.20	2.40	2.40	2.40	2.40	2.40	2.40	.00
Ac.	59375	0	0	0	0	0	0	59375	0	0	0	0
Vol	0	0	0	0	0	0	0	142500	0	0	0	0
ORIGINAL STD. NO. 5 :												
Yld	.00	.00	1.40	1.80	2.00	2.20	2.40	2.40	2.40	2.40	2.40	.00
Ac.	17187	0	0	0	0	0	0	17187	0	0	0	0
Vol	0	0	0	0	0	0	0	41249	0	0	0	0
ORIGINAL STD. NO. 6 :												
Yld	.00	.00	.00	1.40	1.80	2.00	2.20	2.40	2.40	2.40	2.40	.00
Ac.	23202	0	0	0	0	0	0	9738	13464	0	0	0
Vol	0	0	0	0	0	0	0	23371	32314	0	0	0

REGENERATED STANDS

REGEN. STD. NO. 1 FROM DECADE 1 HARVESTS:												
Yld	.00	.00	.00	.00	1.60	2.20	2.60	2.80	3.00	3.10	3.10	.00
Ac.	45568	0	0	0	0	0	0	0	45568	0	0	0
Vol	0	0	0	0	0	0	0	0	136704	0	0	0
REGEN. STD. NO. 2 FROM DECADE 2 HARVESTS:												
Yld	.00	.00	.00	.00	.00	1.60	2.20	2.60	2.80	3.00	3.10	.00
Ac.	51391	0	0	0	0	0	0	0	24916	26475	0	0
Vol	0	0	0	0	0	0	0	0	69765	79425	0	0
REGEN. STD. NO. 3 FROM DECADE 3 HARVESTS:												
Yld	.00	.00	.00	.00	.00	.00	1.60	2.20	2.60	2.80	3.00	.00
Ac.	61012	0	0	0	0	0	0	0	0	56914	4098	0
Vol	0	0	0	0	0	0	0	0	0	159359	12294	0
REGEN. STD. NO. 4 FROM DECADE 4 HARVESTS:												
Yld	.00	.00	.00	.00	.00	.00	.00	1.60	2.20	2.60	2.80	.00
Ac.	70632	0	0	0	0	0	0	0	0	0	70632	0
Vol	0	0	0	0	0	0	0	0	0	0	197770	0
REGEN. STD. NO. 5 FROM DECADE 5 HARVESTS:												
Yld	.00	.00	.00	.00	.00	.00	.00	.00	1.60	2.20	2.60	.00
Ac.	80253	0	0	0	0	0	0	0	0	0	11046	69207
Vol	0	0	0	0	0	0	0	0	0	0	28720	0
REGEN. STD. NO. 6 FROM DECADE 6 HARVESTS:												
Yld	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.60	2.20	.00
Ac.	89873	0	0	0	0	0	0	0	0	0	0	89873
Vol	0	0	0	0	0	0	0	0	0	0	0	0
REGEN. STD. NO. 7 FROM DECADE 7 HARVESTS:												
Yld	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.60	.00
Ac.	99493	0	0	0	0	0	0	0	0	0	0	99493
Vol	0	0	0	0	0	0	0	0	0	0	0	0

PRODUCTION PROFILE AND GOAL

Ac.	0	45568	51391	61012	70632	80253	89873	99493	83948	83389	85776	0
Vol	0	100250	123338	146429	169517	192607	215695	238783	238783	238784	238784	1902970
Gol	0	100250	123339	146428	169517	192606	215695	238784	238784	238784	238784	0
PNW- 5	%	61545	28538	12769	5571	2386	1007	421	3587	1296	2041	119161
INVENTORY AT BEGINNING AND END OF DECADE AND DECADAL GROWTH:												
BEG	0	902840	923674	907070	889154	849156	811307	779541	755339	754256	775632	0
END	0	802590	800336	760641	719637	656549	595612	540758	516556	515472	536848	0
GRO	0	0	121084	106734	128513	129519	154758	183929	214581	237700	260160	0

An IRAM cutting schedule for the 511,686 acres of hardwood in the White Mountain National Forest. The 10 planning periods are mis-labeled as decades, in this case each is 20-years long. Original stand 1 is oldest at 101-120 years, stand 2 is next at 81-100 years old, etc. For each stand row 1 shows the thousands of cubic feet per acre that could be cut in a given planning period. Row 2 shows available acres on the left, acres actually cut in a given period and acres left uncut on the right. Row 3 gives total volume of any acres cut in a period.

The goal set for each period was in volume as shown in the Production Profile and was designed to start at present production and gradually reach the level that could be sustained on a 110 year rotation. Cutting the oldest stands first gives the approximate result desired. (There was a bug in the PNW row, since squashed!)