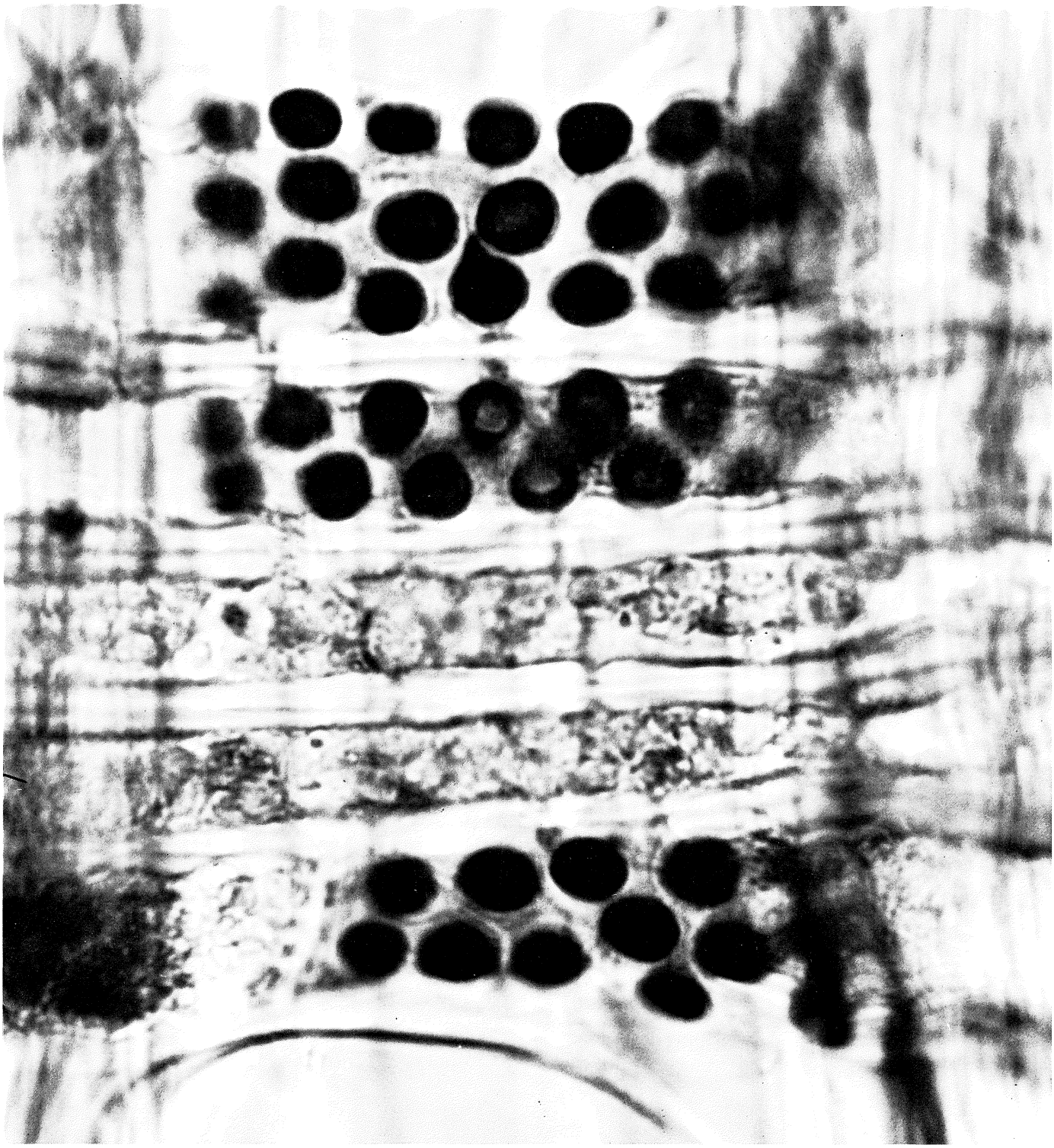
THE HARVARD FOREST, 1970-71

Harvard University



Frontispiece: This is a photograph of a radial section of the wood of sugar maple, taken through the microscope, magnified here 2400 times. The broad, white area running vertically down the center of the picture behind the black circles is a vessel where water moves up the tree. The horizontally-running bands are the living cells of a ray. This ray consists of "contact cells" (the cells with the black dots, pits connecting them with the vessel) and "isolation cells" (the second and third row from the bottom without black dots). The black dots are the result of a histochemical reaction showing increased activity of acid phosphatase, an indication that here are the points at which sugars are secreted into vessels, where sugars appear in the sap during the sap-flow season. Research on the mechanism of sap flow in sugar maple is described on pages 10 and 11 of this report.

H A R V A R D F O R E S T

H A R V A R D B L A C K R O C K F O R E S T

Annual Report 1970-1971

STAFF

The staff of the Harvard Forest during the year of 1970-71 consisted of the following persons:

Martin H. Zimmermann, Director, Charles Bullard Professor of Forestry
Ernest M. Gould, Jr., Forest Economist
Walter H. Lyford, Soil Scientist
Hugh M. Raup, Charles Bullard Professor of Forestry, Emeritus
J. Mark A. Swan, Forest Ecologist (Harvard and Black Rock Forest)
Jack J. Karnig, Forest Manager (Harvard and Black Rock Forest)

Supporting personnel included:

Barbara M. Kelley, Business Secretary and Librarian
Catherine M. Danahar, Secretarial Assistant
Vibeke Holm, Assistant to the Librarian
Charles F. Upham, Woods Superintendent
Gordon B. Mitchell, Woods Crew
George T. Kenney, Woods Crew
Edward H. Hyde, Woods Crew
Theodore S. Walkama, Custodian
Donald Mitchell, Assistant to the Manager of the Black Rock Forest

The staff of the Cabot Foundation, working at the Harvard Forest, during the year 1970-71 consisted of the following:

John G. Torrey, Director, Professor of Botany
Martin H. Zimmermann, Charles Bullard Professor of Forestry
P. B. Tomlinson, Forest Anatomist (Joint Appointment with Fairchild Tropical Garden, Miami, Florida)
Werner A. Iten, Research Fellow
Jörg J. Sauter, Research Fellow
Barbara M. McCurda, Secretary
Monika R. Mattmuller, Laboratory Technician (from June 1971)

The most important staff change this year is Dr. Torrey's move from the Biological Laboratories to the Harvard Forest. Dr. Torrey has been Professor of Botany at Harvard University since 1960 and Director of the Cabot Foundation since July 1, 1966. His move will probably increase the Cabot Foundation staff working in Petersham and thus help to make the Harvard Forest a more lively scientific community.

Miss Monika Mattmüller, laboratory technician, who had worked with me in Zurich during my sabbatical leave of 1968-69, arrived on June 9, 1971, to work in my laboratory here at the Forest.

STUDENTS

The course Biology 298, "Soil, Land and Human Environment", given by Dr. Gould and Mr. Lyford, and assisted by Dr. Swan, during the fall term of 1969, was described in our last annual report. It had been so successful that it was given again during the fall term of 1970. It had to be limited again to 10 students for reasons previously described. Also in the fall term of 1970, I gave my own course, Biology 111 (Structure and Physiology of Trees), which is normally offered every other year in Cambridge. Stimulated by these courses, four students, Catherine Badgley (Radcliffe 1972), Jerry LeClaire (Harvard 1972), Nora Morgenstern (Radcliffe 1971), and Richard Primack (Harvard 1972), spent a few weekends at the Harvard Forest during the spring term to do undergraduate research.

Mrs. Linda Seale, a graduate student, is working towards the degree of a Master of Forest Science. Her thesis problem is the circulation of nitrogen in trees. She spent her first summer doing a few exploratory experiments and the winter months working on equipment. She will carry out her final experimental work during the summer of 1971.

Miss Deborah Germond, a student of the local regional high school, Mahar, has been helping Dr. Sauter in his laboratory a few days a week after the school hours. Miss Mary Bryant, who just finished the local high school (Maria Assumpta Academy), is helping Dr. Torrey with miscellaneous clerical work and the setting up of his laboratories.

Two additional students were hired to help in various phases of research during the summer of 1971. They are Mr. Jerry LeClaire (Harvard 1972), and Mr. Nathaniel Guild (Harvard 1973).

Nora Morgenstern working on her project on the growth and distribution of Osmunda.

BULLARD FELLOWS

Dr. Perry R. Hagenstein used the academic year to reflect on public land management problems and the work of the Public Land Law Review Commission, for which he was Senior Policy Analyst from 1966 to 1970. He also helped the New England Natural Resources Center with the New England Leadership Conference, held to increase understanding of the PLLRC report. He spent most of his time at the John F. Kennedy School of Government, although he was a frequent visitor at the Forest where he worked with Dr. Gould.

Mr. Norman L. Kissick of the Faculty of Forestry, University of New Brunswick in Fredericton used his Bullard year to complete a first draft of a National Forest Fire Training Manual for use in a proposed National Forest Fire Training Program for Canada. Mr. Kissick's main concern, however, was the study of land-use planning. He spent some time in Toronto and Ottawa, Canada, learning about the problems faced by land-use planners, and of recent developments in land classification techniques. He also studied the work of graduate students in Landscape Architecture. He collaborated closely with Dr. Gould and Mr. Lyford during his time at the Forest.

Dr. Brian H. Walker arrived at the Harvard Forest from Rhodesia on March 29, 1971. So far he has been working on techniques of analyzing ecological data which he brought from Rhodesia. He is now writing and adapting programs for computer analysis. Together with Dr. Swan he is developing a method for rapid sampling and collection of quantitative vegetation data. This is particularly important under tropical conditions. Dr. Walker has visited a number of ecologists in New England to discuss common problems and he plans to attend a summer course at the University of Oklahoma.

VISITORS

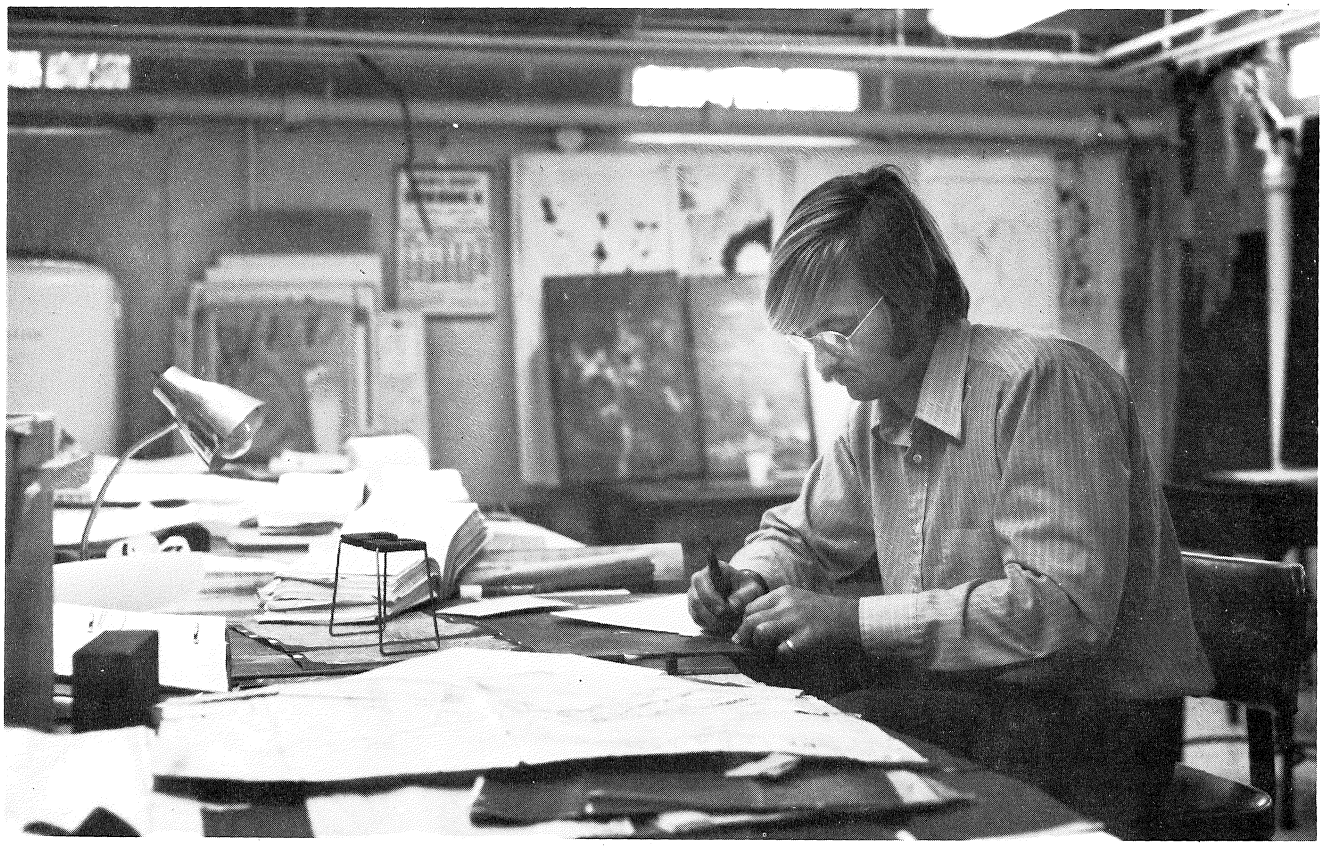
For the second time the Harvard Forest has been host to the New England Fern conference (May 14-16, 1971). The conference included an evening of student papers which proved to be very successful. A field trip was made on Sunday to Mount Toby.

Professor William Bentley spent the summer of 1970 with his family at the Harvard Forest, working on the details of the new organization of the School of Natural Resources at the University of Michigan and designing a new course in Resource Planning which was started the following fall. In addition, a research project was discussed with Dr. Gould on Forest Service planning which may lead to further collaboration.

During the year the Harvard Forest was again visited by numerous scientists and student groups.

RESEARCH

Dr. Gould's research continued to focus on the problems of designing forests that will satisfy many human needs. Activities in the field have taken several forms. His collaboration with Dr. William O'Regan has produced a computer program called PLANIT which will handle long-run forest production plans as a linear programming simulation. Advantage was taken of Mr. Kissick's presence at the Forest as a Bullard Fellow to design a model of a Canadian forest that will be used to illustrate a real-life planning situation with PLANIT. This work will move into a new phase this winter dealing with short-term planning.



William Niedzwiedz working on the land ownership map of Petersham.

Dr. Gould's work as Chairman of the Petersham Conservation Commission has also provided him with first-hand experience with planning land use in the hinterland of metropolitan Massachusetts. Problems of solid waste disposal and production of a Conservation Map of the Town have been the main concerns this year. The land ownership map of the Town is in its third and hopefully last year. This absorbed a good deal of Dr. Gould's and Mr. Lyford's time in the late winter. They feel that this work will be valuable in the future both as a means of teaching and for forecasting future use of the land in the area. Mr. Niedzwiedz resigned from this project in the spring and was replaced by another graduate student of photogrammetry from the University of Massachusetts, Daniel A. Oleksak.

Miscellaneous activities of Dr. Gould included cooperation in seminars with other universities. He was examiner for a doctoral and a masters degree at the University of Massachusetts. Mr. Taintner completed his independent study with Dr. Gould of the Boston harbor pollution.

As one of the long-range environmental studies at the Harvard Forest Mr. Lyford selected two small areas on the Prospect Hill Tract in 1970 for detailed soil-water-vegetation examination. In 1970 water-table depth and stream flow were observed periodically and in 1971 continuous recording instruments were established at several sites. These soon indicated rather marked and unexpected diurnal fluctuations in water-table depths, evidently caused by the forest's transpiration during the daylight hours.

Mr. Lyford's previous root studies have concerned red maple and red oak. When several tree species are growing together as in a mixed hardwood stand, the intermingling of woody roots seems at first glance to be hopelessly complicated. A detailed study of a small area where root systems of seven different tree species are intermingled shows that the complexity is not great if the root systems are mapped tree by tree. Overlay maps of the root system of individual species provides a good deal of information about relative depths and spacing. This is a beginning of an understanding of competition among roots of different tree species.

Dr. Swan completed several research projects during the past year. As in previous years, he spent considerable time on the uses of computers and statistical procedures to evaluate ecological data of vegetational surveys. Weaknesses in existing procedures have been pointed out and improvements of existing analytical techniques developed. Some of this work is carried out in collaboration with Dr. Walker using results of vegetational surveys in Rhodesia.

Two studies on the reconstruction of forest history in the Harvard Pisgah tract of southwestern New Hampshire have been completed, both emphasize the importance of disturbances like fires and windstorms in shaping species composition of the forest over the past three hundred years. An earlier study about similar problems in the Canadian boreal forest has already been published (see Bibliography).

A study of the processes and rates of development of a floating bog in Harvard Pond has just appeared in print (see Bibliography). Much of the information was obtained by examining the growth behavior of a common shrub, leatherleaf or cassandra (Chamaedaphne calyculata (L.) Moench). The annual height growth of mounds of Sphagnum moss developing on the floating bog can be estimated by the annual upward growth of pitcher plant stems growing in the mound. The pitcher plant (Sarracenia purpurea L.) has to keep pace with the upward growth of the moss in order to stay alive.

A pitcher plant growing in a mound of Sphagnum moss. The mound has been cut in half to show how height growth of the pitcher plant keeps pace with the height growth of the mound. Stubs of old leaves provide a time scale. The shrub (Chamaedaphne) roots on the mound and holds it together thus providing "solid" ground on which other shrubs and trees can start to grow.

Dr. Swan's phenological observations of common tree species of the Harvard Forest have been interesting. For example, bud burst for each of three species occurs simultaneously in Slab City Tract (750 ft. elevation) and on top of Prospect Hill (1400 ft.). In 1969, red oak was an exception. Some simple calculations on the red maple data, made by Dr. Gould, suggest that bud burst is reached after a specific number of degree days has accumulated.

For years Dr. Swan acted as our "weather man". This year a new recording rain gauge replaced the earlier "weekly drum" type recording device. The new instrument punches on paper tape the accumulated precipitation in inches and tenths every 15 minutes. Our weather station is serviced by the U. S. Weather Bureau and records are mailed to them. But these records are also useful to us as a background for our own research.

Dr. Sauter worked on three projects, all concerning the physiology of sugar maple (Acer saccharum Marsh.). The first of these dealt with the mechanism of maple-sap flow in late winter. Flows and reabsorptions of xylem sap, pressures and CO_2 production due to respiratory activity of living xylem cells were studied under laboratory conditions. In addition, measurements were made on trees in the field during the sap-flow season. The result of this work is a new hypothesis about the mechanism of maple sap flow, based upon the activity of living cells and its effect on the physical system of wood tissues, both responding to fluctuating temperatures. During the warm daylight hours CO_2 is produced by living cells, accumulates in the gas spaces of the fibrous tissue and creates a pressure on the vessels causing xylem sap to flow out through a tap hole. During cold nights, CO_2 is absorbed in xylem sap due to increased solubility at lower temperatures. As a result, pressures drop below atmospheric, and sap retreats to the ends of the vessels which have been severed by the tap hole where it is held by the valve action of the pits. This nightly below-atmospheric pressure "refills" the xylem by drawing water from the roots. That a pressure only slightly below atmospheric is sufficient to draw water from the roots has been shown experimentally with severed root ends in situ.

Dr. Sauter's second project dealt with the secretion of sugar from living tissue into xylem vessels. Cytochemical methods were used to follow the activity of a number of respiratory enzymes in the different parenchyma cells throughout the year. Highly specialized "contact cells" in rays and paratracheal parenchyma were found to be the obvious sites of sugar secretion into vessels, because respiratory activity was increased only in those cells and only during those periods when sugar was found in vessel water (see the Frontispiece). Dr. Iten investigated the same problem biochemically by perfusing stem sections with water and metabolic

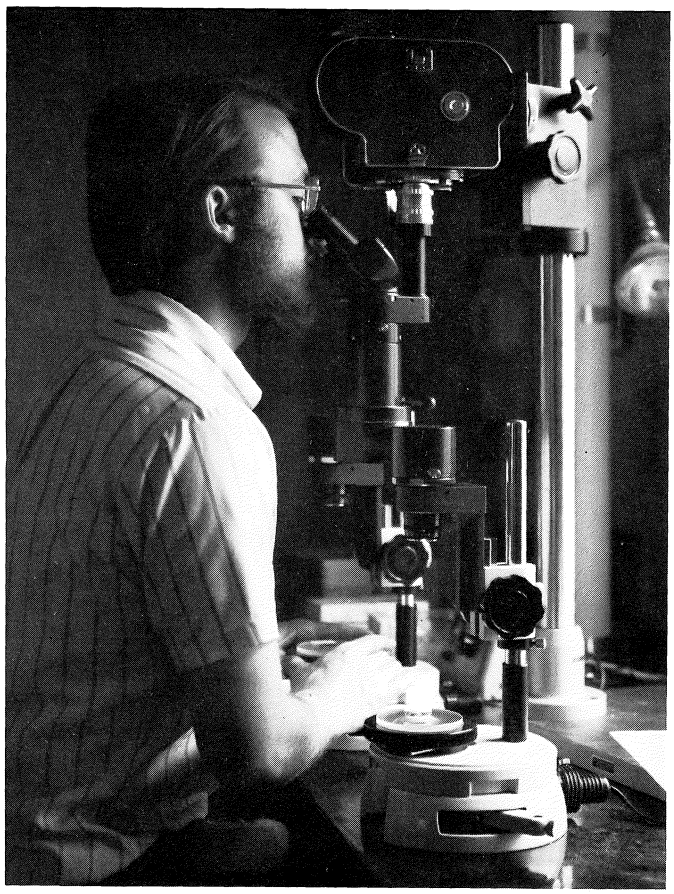
inhibitors. Iodo-acetate (10^{-4}M) induced a remarkable increase of "sugar production" whereas p-chloromercuribenzoate (10^{-3}M) which inactivates a number of respiratory enzymes, diminished the sucrose release to less than 50% of that of the controls.

Dr. Sauter's third project, also in collaboration with Dr. Iten, concerned the effect of temperature during late winter upon the starch content of sugar maple wood. Temperatures of 2 to 3°C induced resynthesis of starch in isolation cells of ray and axial wood parenchyma. At 5 and 9°C this resynthesis occurred faster, and at 21° resynthesis occurred initially, but was followed by mobilization of starch. Perfused stem sections which had been stored at different temperatures showed that increasingly higher sucrose amounts were released into the vessels from contact cells as the temperature increased from 0 to 25°C. Above 25° the sucrose content dropped rapidly, perhaps because of increased metabolic carbohydrate break-down. In standing trees much the same pattern was found, namely a minimum starch content in the middle of the winter, beginning of starch resynthesis with increasing temperatures at the beginning of the sap-flow season and a maximum just before bud break. These experiments indicate that starch dissolution under low temperatures in winter and starch dissolution at the higher temperatures of the mobilization period in the spring are different processes, separated by the resynthesis period during late winter.

Dr. Tomlinson's work on the systematic anatomy of monocotyledons continued and is collaborating closely with a number of specialists in allied fields. One of his successful projects has been an investigation of branching. Truly dichotomous branching of the shoot apex has been demonstrated in Flagellaria (Flagellariaceae) and the mangrove palm Nypa. It has been pointed out, on the other hand, that sympodial branching, such as is found in the Pandanaceae and Agavaceae, has occasionally been confused in the literature with true dichotomy (see the paper by Tomlinson, Simpson and Zimmermann in the Bibliography).

My own joint work with Dr. Tomlinson on monocotyledonous vascular development has focused in part on the problem of branching. Since we are now familiar with the principle of vascular development in the stems of many arborescent monocotyledons, we can recognize three different types of vascular connections between main and lateral axis, indicating three different periods of development.

During the past years we have been looking for vascular principles, i.e. those features of the vascular system which are similar in different species. Meanwhile, a great deal of information has accumulated indicating numerous variations of the basic theme, i.e. ways in which vascular systems differ in different species. One of the technical de-



Jerry LeClaire working on his undergraduate research project, mentioned on Page 4, with the new low-magnification shuttle microscope.

vices which facilitates this work is a new low-magnification shuttle microscope which was developed in collaboration with the Brookfield Machine Inc. of West Brookfield, Massachusetts.

Dr. Tomlinson again spent some time at the Forest to further our joint work, during August 4 to November 1, 1970 and April 20 to May 4, 1971; and I spent a few weeks with him at the Fairchild Tropical Garden in Miami.

RESEARCH FACILITIES

A former large bedroom (in the past referred to as the "bull pen"), above the east laboratories on the second floor, was subdivided during the spring of 1971, to provide quarters for Dr. Torrey. Five

Ray and Richard Bryant, our local carpenters, constructing the new laboratory facilities for Dr. Torrey.

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rooms have been made, an office, a small microscope room, two laboratories and a small tissue-culture room.

Our seminar room on the first floor west of the laboratories acquired laboratory benches along the south wall, including three sinks, new lighting and appropriate electrical outlets. This will provide student laboratory space for future summer courses at the Harvard Forest, the first of which will begin in July, 1971. The arrangement is such that the new facilities do not interfere with the use of the room as a conference or lecture room during the times when we do not need it as a laboratory (fall, winter and spring).

FOREST OPERATIONS

A thinning operation in the northwest sector of Tom Swamp Tract X is producing cordwood of small size and generally low quality. The trees left growing are mostly superior specimens of desirable species and spaced for rapid growth. One hundred twenty-four cords of firewood were produced during the past year, slightly more than the year before (116). Our own fuelwood consumption has dropped because of the installation of an oil furnace in the Community House, on the other hand more fuelwood was sold.

A nine-year-old pitch pine (Pinus rigida Mill.) growing in the Green Bank State Forest, New Jersey exhibits rapid height development. This tree is one of several hundred designed to test the relative adaptability of four different strains of the species obtained from various geographic sources. Jack J. Karnig is checking needle length and color.

The type of work accomplished by our four-man woods crew has undergone some change during the past four or five years. The time spent on logging and related work dropped from about 50% to about 30%. More of their time is now devoted to maintenance work.

SILVICULTURAL RESEARCH AT THE BLACK ROCK FOREST

The pitch pine progeny study initiated in 1962 is being continued. The outplanting at Green Bank State Forest, New Jersey is thriving. The trees were checked in March and survival and heights were recorded for analysis.

Growth data of a nitrogen-fertilized stand in Compartment IV near the Hulse Road have accumulated over a period of four growing seasons. It is hoped that the results of this can be prepared for publication at the end of 1971.

Petersham, Massachusetts
August, 1971

Martin H. Zimmermann
Director

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