



# THE HARVARD FOREST, 1968-69

Harvard University



Frontispiece: Old growth forest on the Harvard Pisgah Tract in New Hampshire. Recent studies suggest these pine and hemlocks originated after a hurricane and fire in the mid 1600's. Photo taken in 1915, see page 9 for related photo taken in 1938.

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.....1968-1969

STAFF

The staff of the Harvard Forest during the year of 1968-69 consisted of the following persons:

Martin H. Zimmermann, Acting Director (through September 1968)  
Ernest M. Gould, Jr., Forest Economist, Acting Director  
(from October 1968)  
Walter H. Lyford, Soil Scientist  
Hugh M. Raup, Bullard Professor of Forestry, Emeritus  
J. Mark A. Swan, Research Fellow (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 (from March 1969)  
Julia W. Savage, Secretarial Assistant (through March 1969)  
Barbara M. McCurda, Secretary (jointly with Cabot Foundation)  
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

The staff of the Cabot Foundation, working at the Harvard Forest, during the year 1968-69 consisted of the following:

Martin H. Zimmermann, Forest Physiologist (sabbatical leave from  
October 1968)  
Philip R. Morey, Forest Botanist  
P. B. Tomlinson, Forest Anatomist (Joint Appointment with  
Fairchild Tropical Garden, Miami, Florida  
on sabbatical leave from November 1968)  
A. Malcolm Gill, Research Fellow (to October 1968)

Dr. Zimmermann was awarded a Guggenheim Fellowship and spent most of the year on a sabbatical leave. He and his family left on October 1st for Zurich, Switzerland, to work at the Swiss Federal Institute of Technology for ten months. Dr. Tomlinson was on sabbatical leave at the Department of Botany of the University of Auckland, New Zealand. He is expected to return to Miami in November, 1969.

Dr. Gill left the Forest in October to take up new duties as Plant Ecologist at the Fairchild Tropical Garden in Miami, Florida. Mrs. Savage retired as secretarial assistant in March and Mrs. Danahar has filled her position since that time.

Dr. Raup spent another interesting year as Visting Professor at the Isaiah Bowman Department of Geography ("TIBDOG") at The Johns Hopkins University.

#### STUDENTS

Mr. A. Jon Cassista with the support of the Cabot Foundation finished his field work at the Harvard Forest. In August 1968 he moved to Cambridge to complete his thesis for a Ph.D. degree in biology. Mr. Melvin T. Tyree returned to the Forest in June of 1969 to spend another summer studying forces affecting the flow of solutes through trees. He will stay until September under the auspices of the Cabot Foundation, when he will continue his Ph.D. program at Cambridge, England. Mr. Richard H. Rosen of Abt Associates enrolled in the MFS program in September and spent the school year taking courses in biology, economics and engineering in Cambridge.

During the year two courses were given in Cambridge for Harvard seniors and graduate students. Mr. Lyford presented a seminar on "Processes of Soil Development" in the fall term and Dr. Morey gave a course on "Structure and Physiology of Trees" in the spring.

A group of the first-year Landscape Architecture students from the Harvard Graduate School of Design again spent several days at the Forest in September. During their visit they became familiar with central New England's landscape, history and ecology.

## BULLARD FELLOWS

Dr. Brian Hopkins arrived in October 1968 from the University of Ibadan. He spent his year in Petersham working on a book about the African savanna. After attending the XIth International Botanical Congress in Seattle during August, he will return to England.

Dr. Eugene Steinbrenner came to the Forest in August 1968 from the Forestry Research Center in Centralia, Washington where he is soil scientist for the Weyerhaeuser Company. He spent the next year preparing a publication about the theoretical framework and practical application of soil/site classification to forest land. This information on productivity is a major component of the information base that has led the Weyerhaeuser Company to its new policy of High Yield Forestry.

Dr. Donald S. Skene arrived in July 1968 from the Commonwealth Scientific and Industrial Research Organization in South Melbourne, Australia. His work for the past year was jointly supported by Bullard and Cabot Fellowships.

Dr. William B. Critchfield, geneticist at the Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, in Berkeley started his Bullard Fellowship on March 10, 1969. Dr. Critchfield is spending most of his time at the Biological Laboratory in Cambridge finishing work on leaf dimorphism which he had started some years ago for the Cabot Foundation.

Mr. Robert E. Buckman, Assistant Division Director of Timber Management Research in the Washington Office of the United States Forest Service, took up residence in Cambridge in September. He spent the academic year studying at the John Fitzgerald Kennedy School of Government.

## VISITORS

During the past year the Forest was, as in the past, host to a large number of visiting scientists, students and university groups. Among the former was Dr. H. Holstener-Jorgensen who is in charge of forest soils research at the Danish Forest Experiment Station.

In August of 1968 a three day symposium on tree roots was held at the Forest, stimulated by Mr. Lyford and supported financially by the Cabot Foundation. About thirty scientists from many parts of the United States and Canada presented papers and held informal discussions of their work. The Petersham facilities and the forest itself are peculiarly well adapted to making such conferences successful.

In June the meeting of the Northern Region of the Garden Clubs of America was held in Worcester and an afternoon was spent at the Forest.

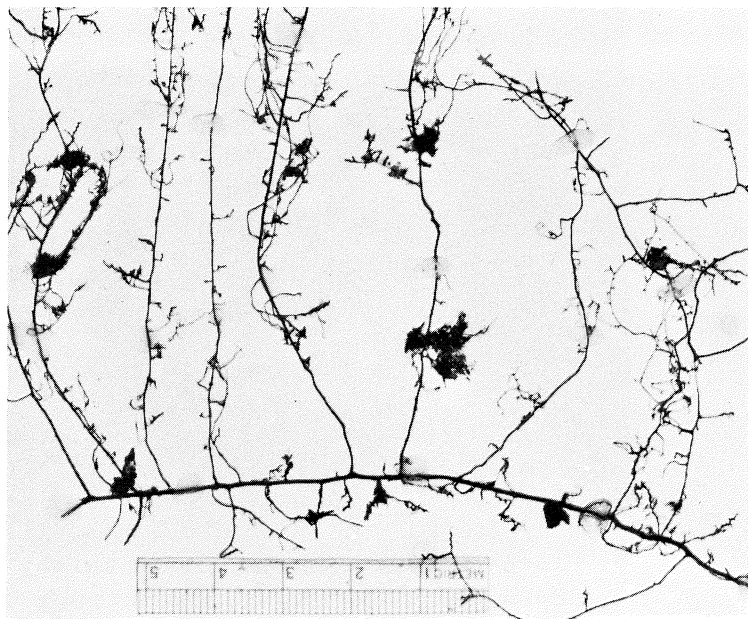
There was also a marked increase in the number of spring and summer visits from various high school classes throughout Massachusetts. These groups have generally been attracted by the Fisher Museum. This year in an attempt to enrich their experience and provide some additional outdoor activity for all museum visitors a self-guiding natural history trail was installed. This trail begins at the museum steps and follows a short walk over the old Sanderson Farm, thus illustrating on the land the theme of man and his natural environment which is set by the indoor display of dioramas. If this educational experiment succeeds, it can be further extended and enlarged to serve the increasing number of young people who visit the Forest.

## RESEARCH

For many years two kinds of research have been carried on at the Forest. The first is "short term" and personal, consisting of the projects carried out by each member of the staff in his particular field of interest. The second is "long term" and institutional, made up of the cases in silviculture and stand manipulation which can only come to fruition after many years of continued observation. This backlog of experiments is maintained by the joint efforts of the Forest Staff and provides some unique data about the growth and development of forests over the past 50 years.

### Short-Term Research

Mr. Lyford continued to place most of his emphasis on forest tree root research. He and Dr. Gill collaborated on a paper about the importance of injury to tree root systems. Mr. Lyford also summarized his work on red oak roots and spent a good deal of time preparing for the Tree Root Symposium. This year work was started on the distribution of roots in the forest floor and on the importance of this portion of the soil to the root system as a whole. Dr. Morey's investigation of mycorrhizal work fits into this part of the study.



On the left the white-painted roots of red oak have returned to the surface from the large lateral roots 10 to 20 inches below. When these upward-growing roots reach the forest floor they elaborate into the fine network shown on the right.

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In addition, Mr. Lyford mapped in great detail the soils along a 10-mile stretch of gas-line trench in eastern Massachusetts as a means of evaluating the importance for the growth of trees of very narrow soils and their intricate pattern. Because the roots of a mature tree are 50 to 80 feet long any one may grow in as many as three or four different soils. This mapping supplements similar work in 1964 along a 12-mile trench in central Massachusetts.

Fertilization trials were started this spring in stands on two areas of the Forest. These studies aim at exploring any "border effects", changes in root habit, increased top growth, soil changes, and differences in appearance that affect amenity.

During the year a paper based on previous work dealing with the soils of a mountain forest in Puerto Rico was finished and is listed at the end of this report.



Dr. Swan has spent part of his time on a paper about 300 years of forest succession on the Pisgah Tract. This study began as a thesis by Mr. J. David Henry and it will throw considerable light on the natural mechanisms and forces that have affected forest development in the area. The following pictures illustrate some of these factors and study methods.

In addition, Dr. Swan has continued his work on the development of swamp vegetation on the Harvard Pond. Swamps cover almost a third of the landscape in this part of New England and a better understanding of their vegetative development can contribute to our understanding of this often neglected part of our natural environment. The recent passage of the Inland Wetlands Bill has focused public attention on marshy areas in Massachusetts.

Dr. Swan has also developed three papers from his work with mathematical models to represent the distribution of trees over various environments in the landscape. One of these papers has been published, one is in press and the other in the draft stage.

Mr. Karnig has continued his studies of aesthetic thinnings at the Black Rock Forest. We hope that information on techniques of improving visibility and the cost of such amenity operations accumulated over the years will form the nucleus of a paper covering this type of work at both forests. Mr. Karnig was co-author of two Black Rock Forest Papers listed in this year's publications.

My own research into the problems of land use planning has continued. Although the final report on planning for the production of timber and landscape amenity was completed it has not yet been possible to prepare a publication about this work. However, collaboration with Dr. O'Regan at the Pacific Southwest Forest and Range Experiment station on the use of computers in long-term planning has continued.

The Forest has a long standing policy of cooperating with the Town of Petersham whenever possible. This is also in line with the present

The age of the living white birch growing on a clone of chestnut sprouts tells when they were cut. The sprout age shows when the parent tree was cut; judging from its size the original chestnut germinated in the early 1700's.







Pisgah Tract after the 1938 hurricane. Destruction of the old growth shown in the frontispiece led to the start of a fresh forest once more, this time not preceded by fire and quite different in composition.

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trend toward University involvement with community affairs. Two opportunities arose this year with the creation of a Petersham Conservation Commission and the need for tax reassessment. I have been the first Chairman of the Commission not only because of personal concern, but also because of the excellent opportunity it affords to study the problems of town planning firsthand. We have already devised a water pollution by-law which the Town Meeting adopted last March.

In addition, the Town needs an ownership map in order to meet the State's requirement of "one hundred percent" assessment. Mr. Lyford and I have undertaken to supervise making this survey over the next few years and the Town Meeting voted \$ 2,000 to underwrite the initial cost. This summer we have hired a graduate photogrametrist from the Department of Forest and Wildlife Management at the University of Massachusetts. Mr. William R. Niedzwiedz has started field work and the mapping is progressing on schedule. This project will also furnish us with a great deal of new data that will promote our interest in the past, present and future land use in the town.

Dr. Morey has started a series of experiments to discover the effect that the herbicide 2,3,5-tri-iodobenzoic acid (TIBA) has on the development of wood in American elm. The first tests on

seedlings show that the vessels are considerably reduced in diameter, so a second series of trials was started on large forest trees. Because the Dutch Elm disease spreads through the large vessels in the annual ring it is hoped that reducing the size of these conduits may give some measure of protection.

In addition Dr. Morey has become interested in some aspects of the work that Mr. Lyford has been doing with the fine root system of red oaks. The distribution of mycorrhizal roots in the various soil layers on different sites is of special interest and a study is being made that will throw some light on the anatomy and success of fine roots.

Finally Dr. Morey has shown that the cell wall substance is preserved in fossil woods with origins as ancient as Devonian. He is presently studying the status of major cell wall substances in coal bearing sediments, especially peat and lignite and has clearly established the presence of lignin and cellulose in Oligocene lignized wood.

Dr. Skene has centered his work around two fields, vascular anatomy and wood development. He has used the cinematographic technique developed by Drs. Zimmermann and Tomlinson to study the length and three-dimensional interconnections of vessels in the xylem of American beech, and of sieve tubes in the phloem of white ash. He has spent this year perfecting the microscopic techniques necessary for the success of the method in order to get a deeper understanding of the movement of materials in the tree.

In the area of wood development Dr. Skene has focused on the time taken for different growth processes in gymnosperms, especially the kinetics of cambial activity and tracheid development. A collection of eastern hemlock is being made to allow more detailed analysis of this species.

Mr. Tyree is continuing the investigations he started last year into the conductivity of sapwood to ions and water. He is particularly interested in measuring the frictional drag between cations (positively charged ions) and the rest of the sap in the sapwood. He is developing an electrical technique for measuring the magnitude of the ion/sap frictional interaction. This is done by passing pulses of current alternately with and against the stream of sap in trees; the ions then encounter more or less frictional drag depending on whether they move with or against the stream. By knowing the magnitude of this difference in frictional drag he can calculate the rate at which sap rises.

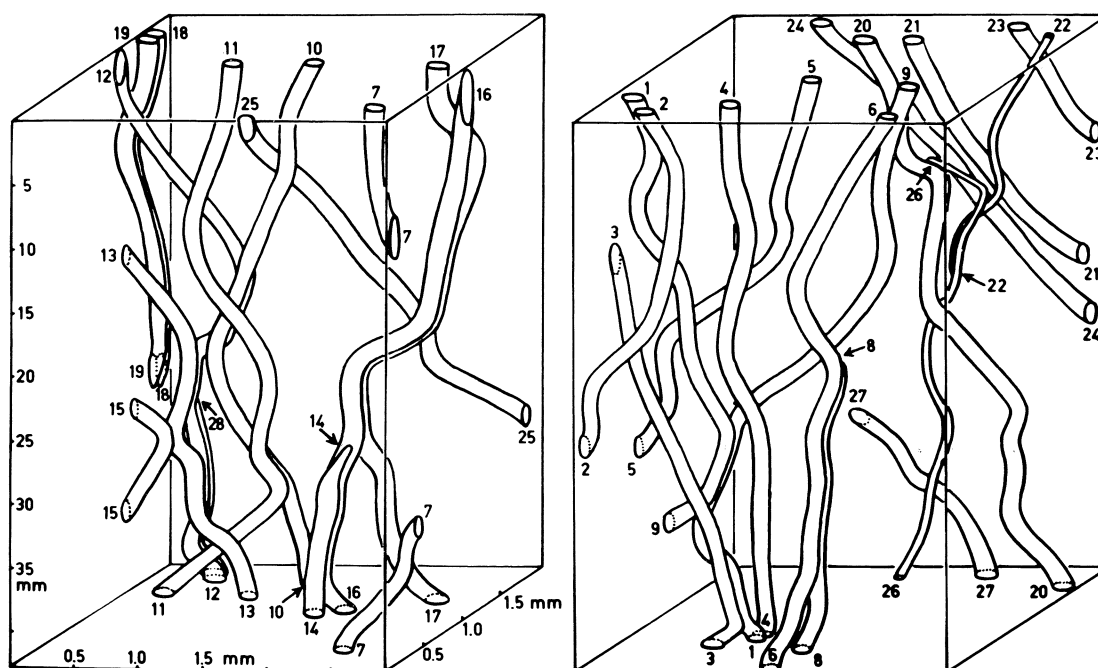
Dr. Tomlinson spent most of his time abroad. He was at the Royal Botanic Gardens Kew during the summer of 1968, working on problems

of systematic anatomy of monocotyledonous plants, a project being carried out jointly with the Jodrell Laboratory at Kew. The results of these efforts are published as a series of books entitled "Anatomy of the Monocotyledons" of which Dr. Tomlinson has just published volume 3, listed at the end of this report. In November Dr. Tomlinson flew to the University of Auckland in New Zealand. He used the Department of Botany as a base of operations for collecting material of monocotyledonous trees in New Zealand, Australia and the South Pacific Islands.

Dr. Zimmermann spent most of his time at the Department of Wood Microtechnology of the Swiss Federal Institute of Technology in Zurich, producing a 16 mm documentary film on the structure of wood. The film was made with the motion-picture technique which had been developed by him and Dr. Tomlinson; it demonstrates some imperfectly known three-dimensional features of wood anatomy. The film will be released by the "Institut für den wissenschaftlichen Film" Göttingen, Germany for worldwide distribution. In addition, Dr. Zimmermann worked on joint projects on translocation with the Laboratories of Electron Microscopy and Plant Physiology. He gave a number of lectures in Switzerland, Germany and Denmark.

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Diagrammatic reconstruction from analytical film showing the water conducting capillaries in cigar-box wood (*Cedrela fissilis*). This diagram covers a single block of wood but to avoid confusion the vessels have been arbitrarily separated into two blocks.





Experimental thinning in Tom Swamp I. These hardwoods originated following a pine cutting in 1918 and have been thinned three times. All the understory trees were removed in 1956, and in May 1969 the upper picture was taken with Charles Upham 50 feet and George Kenney 100 feet away. The lower picture shows the stand in June after cutting 60 percent of the trees, removing the slash and over 13 cords of firewood per acre. The left portion has been fertilized and Walter Lyford is standing 100 feet away on the dividing line marked by white stakes.



### Long Term Research

Our silvicultural experiments passed a milestone when the first "hand raised" hardwood sawlogs were cut this spring in Tom Swamp II from a 4.5 acre area that was originally clear cut in 1908. This was the first place operated after Harvard received the Forest and the resulting stand contains trees that are probably the oldest managed hardwoods in the region. The original experiment aimed at regenerating white pine but the feed back of information gained in studying development over time soon changed the objective to hardwood sawlogs. This area contributed to documenting what later was recognized as the "old field white pine - hardwood succession" which has occurred on about three-quarters of the land in central New England. This year, after 61 years of management, the third thinning yielded 11 cords of firewood and nearly 900 board feet of small but excellent quality sawlogs per acre. The residual stand is now in good shape for rapid growth. Once the operation is complete the stand will also have an enhanced attractiveness for wildlife and hikers.

Another significant operation was a heavy thinning in the experimental area of Tom Swamp I near Sunset Lane shown on the left. This 1.5 acre area was the site of a special experiment with low thinning in 1956 which showed that although the understory trees made up 30 percent of the basal area per acre these trees were not inhibiting the growth of the residual overstory trees. An unexpected serendipity came when we found the area was unusually attractive to visitors. This year another heavy thinning removed all but 90 dominant trees per acre and a portion of the area was fertilized with 1000 pounds of urea per acre. It is hoped that we will get a better understanding of how fertilizers speed the production of large stems and also what impact this may have on the amenity value of the forest. This is one of the areas fertilized by Mr. Lyford to explore the affects on growth and amenity.

A regeneration experiment was also set up on 4 acres of a hardwood stand in Slab City VIII. The two-intensity thinning experiment in Tom Swamp IV was also finished. All of these experiments netted 138 cords of fuel plus 8 M. b. f. of sawlogs to help defray the costs of research.

During the winter many of the trees in the Black Brook Plantations at Hamilton, Massachusetts were severely damaged by unusually heavy wet snow. A number of trails were blocked and some fire hazard was created. This situation was rectified by the woods crew under Mr. Upham's supervision.

At the Black Rock Forest a new aesthetic thinning was made along the east side of Tamarack Pond. This is the fourth summer when one or more such thinnings was made at strategically located spots within the forest. All of these operations have been carefully documented and photographed to analyse the costs, returns and changes in appearance. In addition some of the drought killed oak was salvaged to get salable wood and improve the appearance of the landscape. All told about 20 cords of wood were sold, considerably less than market demands, due to a tight labor market. Most of the work of trail maintenance and thinning was done by three student helpers in the summer. The heavier cutting was done by stumpage sales.

An increasingly important function at the Black Rock Forest has been the use of the area by hikers and hunters. A new facet of outdoor use was started this year in cooperation with the Museum of the Hudson Highlands. Mr. Karnig set up three separate guided tours which were very well attended. The object was to give local knowledge of the area to people who wished to use the forest for hiking, nature study and fishing, as well as a better understanding of the function of forests in our environment. The experimental work was also explained and opinions on amenity were gathered. A system of color-coded trails was installed and a new hiking map of the forest was printed for distribution to interested visitors.

Mr. Karnig was also active as Vice Chairman of the New York Section, Society of American Foresters.

#### Swift River Trust

The Forest gave financial help to the Swift River Trust in constructing the new dam at Connors Pond. In addition, our woods crew installed some of the flash boards and has taken charge of manipulating the sluice gate at times of high water. The finished installation has greatly enhanced the beauty of the southern entrance to Petersham over route 122.

Petersham, Massachusetts.  
August, 1969

Ernest M. Gould, Jr.  
Acting Director



## PUBLICATIONS

The following articles have appeared in print during the fiscal year of 1968-1969:

- Gill, A. M. and P. B. Tomlinson 1969. Studies on the Growth of Red Mangrove. *Biotropica* Vol. 1, No. 1.
- Gould, E. M. Jr. 1968. Planning for Forest Development on Small Holdings. *J. Forestry* Vol. 66, No. 10.
- Gould, E. M. Jr. 1969. Whatever Became of the Invisible Hand? *Forest History* Vol. 12, No. 4.
- Karnig, Jack J. and Walter H. Lyford 1968. Oak Mortality and Drought in the Hudson Highlands. *Black Rock Forest Papers* No. 29.
- Karnig, Jack J. and Benjamin B. Stout 1969. Diameter Growth of Northern Red Oak Following Understory Control. *Black Rock Forest Papers* No. 30.
- Lyford, Walter H. 1969. The Ecology of an Elfin Forest in Puerto Rico, 7. Soil, Root, and Earthworm Relationships. *J. Arnold Arb.* Vol. 50, No. 2.
- Morey, P. R. and J. Cronshaw 1968. Developmental changes in the secondary xylem of Acer rubrum induced by various auxins and 2,3,5-tri-iodobenzoic acid. *Protoplasma* 65: 287-313.
- Morey, P. R. and J. Cronshaw 1968. Developmental changes in the secondary xylem of Acer rubrum induced by gibberellic acid, various auxins and 2,3,5-tri-iodobenzoic acid. *Protoplasma* 65: 315-326.
- Morey, P. R. and J. Cronshaw 1968. The effect of plant growth substances on the development of tension wood in horizontally inclined stems of Acer rubrum seedlings. *Protoplasma* 65: 379-391.
- Morey, P. R. and J. Cronshaw 1968. Induction of tension wood by 2,4-dinitrophenol and auxins. *Protoplasma* 65: 393-405.
- Morey, P. R. and E. D. Morey 1968. Observations on epon-embedded Griffin Hill Peat, Two Creeks Picea, Cedrus penhallowii, and Callixylon. *Amer. J. Bot.* 55: 722 (abstract).
- Morey, P. R. and E. D. Morey 1969. Observations on Epon Embedded Griffin Hill Peat (Massachusetts), Two Creeks Picea (Wisconsin), Cedrus pennallowii (Sierra Nevada, California) and Callixylon (Delaware, Ohio). *Palaeontographica B* 125: 73-80.



- Morey, P. R. and E. D. Morey 1969. Senckenberg Lignite: A Lignitized Wood with Apparently Original Cellulose and Lignin. Science 164: 836-838.
- Ødum, Søren 1968. Frø Af Nordøstamerikanske Træer Og Buske Indsamlet Til Arboretet I Hørsholm. Dansk Dendrologisk Årsskrift 31 1968.
- Raup, H. M. The Relation of the Vascular Flora to Some Factors of Site in the Mesters-Vig-District, Northeast Greenland: Meddel. Om Grønl. Vol. 176, No. 5.
- Raup, H. M. Observations on the Relation of Vegetation to Mass-wasting Processes in the Mesters-Vig-District, Northeast Greenland: Meddel. Om Grønl. Vol. 176, No. 6.
- Raup, H. M. Studies of Vegetation in Northeast Greenland, in Essays in Plant Geography and Ecology, ed. K.N.H. Greenidge, Published by Nova Scotia Museum, Halifax.
- Swan, J. M. A., R. L. Dix and C. F. Wehrhahn 1969. An ordination technique based on the best possible stand-defined axes and its application to vegetational analysis. Ecology 50: 206-212.
- Tomlinson, P. B. 1969. Commelinales - Zingiberales. Vol. III of Anatomy of the Monocotyledons. C.R. Metcalfe ed., Oxford University Press (Clarendon Press), London.
- Tomlinson, P. B. and M. H. Zimmermann 1969. Vascular anatomy of monocotyledons with secondary growth - an introduction. J. Arnold Arb. 50: 159-179.
- Zimmermann, M. H. 1968. Physiological aspects of wood anatomy. Bull. Internat. Assoc. Wood Anatomists 1968/2: 11-14.
- Zimmermann, M. H. 1969. Translocation of nutrients in plants. Chapter 14 of "The Physiology of Plant Growth, Development and Responses". pp. 383-417. M.B. Wilkins, ed., McGraw-Hill Publishing Co. Ltd. (England)
- Zimmermann, M. H. 1969. Translocation velocity and specific mass transfer in the sieve tubes of Fraxinus americana L. Planta 84: 272-278.
- Zimmermann, M. H. 1968. Vascular construction and development in the aerial stem of Prionium (Juncaceae). Am. J. Botany 55: 1100-1109.
- Zimmermann, M. H. and P. B. Tomlinson 1969. The vascular system in the axis of Dracaena fragrans (Agavaceae). I. Distribution and development of primary strands. J. Arnold Arb. 50: 370-383.