The ARNOLD ARBORETUM of HARVARD UNIVERSITY

Annual Report 1984-1985

To the President of the University:

For several decades the value of the living collections of the Arnold Arboretum for botanical research has been in question. The issue has come to the fore again this year. It challenges a central mission of this institution, and is therefore the subject of this introduction.

Modular construction and relative ease of vegetative propagation are among the properties of plants that make them valuable for research into basic biological processes. At Harvard, Professor Lawrence Bogorad has advanced our knowledge of the development, and particularly the developmental genetics, of chloroplasts: organelles within green cells within which photosynthesis is carried out. He has used for this work unicellular green algae, which are an approximation to the individual cell, the basic module of all plants. Professor Daniel Branton has described the means by which such organelles are formed; while Professor Arthur Ayers uses naked protoplasts (the living content of cells after removal of enclosing walls) for research into the fungal pathology of plants. The interests of these scientists are focused on biological processes common to all plants. But we know, for instance, that the chestnut blight caused by the fungus *Endothia parasitica* only infects chestnuts and, further, some chestnuts more than others. To address these more particular processes which underlie all biological diversity and, through them, to address the mechanisms which have created diversity is the province of comparative biology.

In the introduction to my Annual Report for the Arnold Arboretum of 1981, I explained how systematic biology, the description of patterns of variation among organisms, provides the template upon which all other biological endeavor proceeds; and, is moreover, a discipline in its own right. Comparative biological research can identify further patterns of variation which can enrich systematic classification. Professor Barry Tomlinson's comparative research into the anatomy and developmental morphology of the palms and other monocotyledons, and into tropical trees, notably the mangroves, serves as an example in which the innovative application of classical methods in comparative botany, notably through the study of patterns of growth in the whole plant, can reveal the developmental patterns which underlie the morphological diversity upon which systematic research is based.

But, as I indicated in my 1983 Report, there remains almost a vacuum between this organismic level of comparative research and basic research at the level of cell and molecule. It is this terrain which Professor John Einset, whose work I described last year, is currently exploring at Jamaica Plain.

In my letter of appointment, Dean Henry Rosovsky specified that my task as Director would be to bring the academic work of the Arnold Arboretum into the mainstream of Harvard biology. The Arboretum's traditional strength is in systematics, research that has most need of our herbaria. Conversely, the herbaria serve as resources principally for systematics. But the Arboretum expends half of its income on its living collections. Specifically, then, what opportunities do a well-documented collection of hardy, long-lived plants, slow to reach maturity, afford for research into theoretical biology, as well as the practical applications that can follow therefrom?

In brief, our living collections provide ready access to representative, and sometimes comprehensive, living samples of taxa derived from all over the world, yet here grown side by side in similar conditions. Owing to their general ease of propagation, replicates can be readily prepared for certain kinds of experimentation. They provide, then, a readily accessible source for research and instruction into dynamic aspects of comparative biology at all levels between the individual organism and its component molecules, as well as at the level of the species and higher taxonomic levels. Such species collections obviously do not afford material for research into infra-specific comparative biology, population biology, or systematics, for which larger within-species samples are required; nor do they afford material for many aspects of ecological research, in which the plants must be studied in nature. In these fields living systematic collections do nevertheless provide opportunities for pilot studies prior to formulation of major research projects, and for refining methods before they are used in remote field sites where mistakes can be costly.

The living collections of the Arnold Arboretum, like the herbaria, provide opportunities far greater than can be availed of by the small botany faculty at Harvard. Faculty in a number of neighboring universities have an interest in using the living collections. The diversity of these interests well exemplifies their value in contemporary research.

Plants, and particularly long-lived plants, being sedentary, have evolved a vast range of chemical defenses against herbivores, seed predators, and pathogens. Often highly specific both in their effects and in their distribution between and within plants, plant chemical defense can provide information on evolutionary relationships and even, in some cases, evolutionary direction. Professor Gillian Cooper-driver, Boston University, is a specialist in comparative research into plant chemical defenses with whom I am currently collaborating. She would make extensive use of the collections were suitable on-site laboratory facilities available.

The co-evolution of plant chemical defenses and processes of biodegradation and sequestration of these chemicals by pathogens and insect herbivores are currently of major interest among evolutionists, crop protection researchers, and community ecologists. For instance, the biological diversity of ecosystems maybe substantially a consequence of the evolution of specific herbivore-host interdependencies which, by limiting the densities of the host-plant populations, free up space in which a diversity of other plant species can survive. Professor Dean Bowers of the Museum of Comparative Zoology is interested in the catalpa sphinx moth, whose larva ingests and sequesters specific alkaloids synthesized by its host, the catalpa tree, for its own defense against birds. For her research, Bowers has need of unpolluted fresh leaves and pods of catalpa and other trees that would be unobtainable were it not for the Arboretum's Living Collections.

Higher plants are unique in the diversity of their reproductive biology. Versatility in the distribution of their male and female gametes within and between flowers, and between plants of the same and different species, provides excellent opportunity for research basic both to population genetics and to the evolution of sex. Knowledge of breeding systems is an essential prerequisite to plant breeding. Long-lived plants have particular scope for diversity in flower specialization. This diversity, as expected, reaches its zenith in the tropics (particularly among trees, where it is a major research interest of Professors Kamaljit S. Bawa, University of Massachusetts, and Peter Ashton.) Though both developed this interest before becoming associated with the Arboretum’s collections, they have cooperated with Dr. Amar S. Hans, Senior Tree Geneticist in the Zambian Forest Service, and Professors Nimaland Savitri Gunatilleke, University of Peradeniya, Sri Lanka, when these scientists worked at the Arnold Arboretum, as Mercer Fellows, to familiarize themselves with appropriate techniques for tropical trees. For this purpose they employed the living collections at Jamaica Plain and at Weston. Laboratory facilities for these visiting scientists were made available by Bawa at the Boston campus of the University of Massachusetts, but on-site facilities would have allowed the use of additional techniques.

The allocation of plant resources to male and female functions at time of flowering influences their subsequent allocation in terms of fruit and seed distribution, numbers, and size. Professor Richard Primack, Boston University, is among the first to study the interdependence of strategies for resource allocation during the flowering and fruiting stages of reproduction. He has concentrated his work on plants growing in our living collection owing to the diversity of reproductive strategies that they manifest. Indeed, he would not have developed this field of interest had he not been working in Boston.

Professor David O'Malley, University of New Hampshire, is a tree population geneticist with a particular interest in gymnosperms. Using the Arboretum's collections, he is interested in the genetic effect on the variability of the descendants of the often small number of individual

plants of exotic species such as *Ginkgo biloba*. This is obviously important to conservation research.

Comparative developmental biology has been particularly hampered by inaccessibility of appropriate materials that must be collected at intervals from the plant during the development process. As one example, Professor Michael Donoghue used the living collection at the Arnold Arboretum for his thesis work at Harvard on the genus *Viburnum*, for which genus our collections are one of the most comprehensive in the world. First, he showed that the major divisions within the genus differed in their architecture and mode of growth. Then he became interested in the sculpturing of the seed shell, which provides important characters for species delimitation. By sequential collecting, he has been able more recently to investigate the developmental anatomy of this sculpturing in a search for evidence of evolutionary relationships within the genus. *Viburnum* is a large genus, distributed throughout the north temperate zone. Such extensive and time-consuming collection would have been impossible in the wild. For the same reason, for his research into the embryogenesis of primitive East Asian and Australian flowering plants Professor N. Prakash, University of New England, New South Wales, recently visited the Arboretum as a Mercer Fellow to gather material rather than explore the forests of China and Japan and even his own native Queensland.

Professor John Torrey, Director of Harvard Forest, has depended on the Arnold Arboretum over many years for living plants for his physiological research into symbiotic microorganisms that fix nitrogen within the roots of certain tree genera. Some of his current research, carried out at both whole-organism and molecular levels, involves inquiry into the eventual transmittal of the genetic material that mediates nitrogen fixation into plants which do not form the symbiotic association in nature. Here again, the Arboretum's living collections provide unparalleled living material ready to hand.

But the potential of the living collection as a resource for research that bridges the new advances in molecular and cellular biology and classical comparative biology and systematics is most cogently demonstrated by the research of Professor John Einset of the Arboretum. He has now shown that the response characteristics of plants in tissue culture, originally demonstrated in tobacco by Skoog, is not general to all higher plants, but that taxa respond in different ways that correlate with, and can hence be predicted from, contemporary systematic classifications. Einset's work is attracting growing interest from the nursery industry: discoveries in tissue culture are too often the guarded secret of commercial interests, and the free communication of Einset's results have set a standard. Two resources are essential for Einset's work: the living systematic collections of the Arnold Arboretum and the laboratory, which albeit modest, has already been equipped for him in the greenhouse head house building.

The laboratory facilities installed for Einset, though adequate, preclude all but rudimentary facilities for others, and leave no room for further facilities for faculty at the Arboretum. One current field of great practical as well as theoretical interest is the co-evolution among pairs of ecologically interdependent species, including the co-evolution of plants with animals. Examples include not only flowers and pollinators, which have been studied in part by Richard Primack, and insect herbivores, studied by Deane Bowers, but the host of often highly specific fungal associates of trees, which include pathogens such as chestnut blight and symbionts such as the mycorrhiza that infect tree roots and mediate nutrient uptake. The Arboretum's living collections can provide excellent opportunities for experimental investigation into the chemical and physiological bases of plant-fungus specificity. Such work helps define the general principles of disease resistance. Also, by increasing our understanding of the means by which species-rich forest communities are maintained in equilibrium, this research is vital in the design of the low-cost, high output multiple-species cropping systems that are now being encouraged, particularly in tropical regions. An appointment in this field could provide the opportunity for the Arnold Arboretum to become a leader concerning tree species and crops. Another field of current interest, discussed in my Annual Report for 1983,is developmental biology.

But funds are available neither for a new position (though a junior position could become available on the retirement of Professor Richard A. Howard in 1988) nor the laboratory that would be needed on-site. Laboratory space is not even currently available in Cambridge either, less satisfactory though that would be.

Currently, the following Harvard courses use the Arboretum: Biology 11 (Plant Physiology); 18 (Diversity in the Plant Kingdom);102 (Biology of the Gymnosperms); 103 (The Taxonomy of Seed-bearing Plants); 166 (Plant Growth and Development); 209 (The Phylogeny of the Flowering Plants); 274 (Case Studies in Experimental Plant Morphogenesis); and also classes of the Graduate School of Design. In addition, classes from over 15 other universities visit annually (See my Annual Report for 1981, page 220). Of these, only Professors Einset's and Torrey's courses involve laboratory work on-site. Laboratory and lecture facilities for small classes are fundamental to increasing the use of the living collections for instruction, especially for courses on the subject of the faculty research I have described. These facilities would, in addition, provide opportunities for developing Harvard extension and summer school courses for which the living collections have great but currently unrealizable potential. Only three extension courses and one summer school course in plant biology are currently offered. Such facilities would also, of course, provide much-needed expansion space for the Arnold Arboretum's public programs.

In summary, additional laboratory space is needed in Jamaica Plain both for Harvard faculty and for faculty from neighboring universities, and for associated postdoctoral fellows.

The laboratory and teaching space here proposed at Jamaica Plain is intended as a general service facility for scientists in the greater Boston area and for visitors, as well as for Harvard faculty and students who wish to work with the living collection. It is analogous, therefore, to a reading room in a library rather than to a faculty laboratory. Assuming that these staff have office space, and off-site laboratory facilities provided at Cambridge or in their own universities, we expect that 800 square feet each would provide adequate (though minimal) on-site laboratory space for two faculty together with associates. The surface area available on the second floor of the greenhouse headhouse is 2,700 square feet. Allowing for the staircase and service facilities, a teaching space of 800 square feet could also therefore be made available.

The case for raising capital for building these laboratory facilities, by modification and extension of the greenhouse headhouse at Jamaica Plain, has meanwhile been presented to the faculty of the Department of Organismic and Evolutionary Biology in April 1984: it was approved by unanimous vote.

Harvard's overall priorities are nevertheless currently centered in Cambridge, as instruction is inevitably concentrated there.

It is clear, then, that the living collections of the Arnold Arboretum have reached a crossroads. As living collections they cannot stand and wait, but must either go forward as a strong facility dedicated to increasing our knowledge concerning woody plants --or they must decline. It is equally clear that the opportunities provided by the living collections of the Arnold Arboretum transcend the needs of one university, though, and that means must be found to increase the accessibility of our collections to the wider community of scientists if the future of the collections is to be assured. With the support of the numerous colleagues in the Boston area who currently use and value the collections, I am confident that our proposals can be realized.

RESEARCH AND INSTRUCTION

Dr. Carroll E. Wood's major research effort on *A Generic Flora of the Southeastern United States* continues. To date this research has resulted in the publication of 107 papers dealing with the families and genera of seed-bearing plants in the 9 southeastern United States. Some 50 ancillary papers have also been published.

Following Dr. Norton G. Miller's departure in 1983 from the flora project to become director of the Biological Survey of New York State, the National Science Foundation Grant held by Drs. Wood and Miller was split and a collaborative project established. Dr. Thomas A. Rosatti then joined Dr. Miller in Albany, and Dr. Ishan Al-Shehbaz replaced Dr. Miller in Cambridge. Research continued in Cambridge with Dr. Wood, Dr. Al-Shehbaz, and Dr. George K. Rogers. Following receipt of a further grant, Dr. Gordon C. Tucker, who received his Ph.D. from Duke

University in June 1985, joined Drs. Miller and Rosatti in Albany in August, 1985. The goal is to complete the flora by 1991, when Dr. Wood retires. During the year, accounts of the tribes of Cruciferae (*Brassicaceae*) and of the genera of the tribe Thelypodieae by Al-Shehbaz; of the Plantaginaceae by Rosatti; of the genera of Phytolaccaceae by Rogers; and of the subfamilies and tribes of Gramineae (*Poaceae*) by Christopher S. Campbell, University of Maine, were published in the *Journal of the Arnold Arboretum* (in which the entire series of papers has appeared). Five further manuscripts have been accepted for publication.

Al-Shehbaz continued his work on the genera of the tribe Alysseae (*Cruciferae*), and Rogers began work on the genera of the large tropical family *Rubiaceae* in the Southeast. Wood continues to work toward completion of an account of the large subfamily *Faboideae* of the family *Leguminosae*. Dr. David E. Boufford, curatorial taxonomist and supervisor of the Harvard University herbaria, is completing a treatment of the *Urticaceae* of North America that he began as an outgrowth of a treatment of the family for the Vascular Flora of the Southeastern United States, edited by J. R. Massey. Illustrations for nearly all of the North American representatives of the family have been prepared in China. Dr. Stephen A. Spongberg, curatorial taxonomist, also initiated and brought close to completion a treatment for the *Saxifragaceae* of the southeastern United States. Elizabeth F. Wells of Georgetown University is collaborating with Spongberg by preparing the treatment for the genus Heuchera.

Boufford's work on an atlas of New England plants with Ray Angelo has continued. Angelo has surveyed the holdings of the New England Botanical Club Herbarium through Carex, and the taxonomy and nomenclature of the pteriodophytes and *Compositae* have been worked out, based on recent taxonomic treatments. Chromosome counts have been incorporated in a brief descriptive portion. A gazetteer of New England place names, capable of being modified for mapping on a grid system and for computer mapping, has been prepared to aid in mapping plants with scant label data. This finding guide to counties is 57 pages long and contains about 6,800 entries.

Boufford also spent three weeks, in May 1985, in the field in the southern Appalachian Mountains making general collections, though concentrating on material of Diphylleia cymosa (*Berberidaceae*) for cytological studies. The North American member of this genus of three species (the other two species are in Japan and China) is unknown cytologically.

With the help of postdoctoral fellow Elizabeth A. Kellogg and project assistant George Staples, Dr. Richard A. Howard made considerable progress in preparing final copy of early Dicotyledonous families for volume 4 of the *Flora of the Lesser Antilles*, of which he is editor. Illustrations are also nearing completion, and he plans publication in 1986. He also continued work on a *Dendrologie des Petites Antilles* with cooperation from French botanists.

Howard also continued monographic treatments of the Icacinaceae and Polygonaceae for the *Flora of Venezuela, Flora of Nicaragua, Flora Meso-Americana* and, now, the new *Flora of the Guyana Highlands*, edited by Julius Steyermark. The Nicaragua treatment is nearing completion.

Funded by the National Science Foundation, Howard made a two month trip to Europe in July and August, visiting Gottingen, Berlin, and London for study. He examined all of Grisebach's collections cited in that author's Flora of the British West Indian Islands; photographed important specimens for the herbarium; and used the archives at Kew, the British Museum, and the Linnaean Society of London for continuing historical research. He also made study visits to the New York Botanical Garden and National Herbarium.

A three-week trip with E. A. Kellogg, P. F. Stevens and E. S. Howard to St. Lucia, and (without Stevens) to Anguilla in the West Indies, was partially supported on National Science Foundation and partly on Atkins funds. Collections included 6 or 7 endemic, and probably endangered, species.

Elizabeth Taylor, a graduate student advised by Professor Stevens, has broadened her studies of Neotropical species of Sterculia (*Sterculiaceae*) by investigating variation in indumentum, pollen, fruit, and seed in other *Sterculiaceae*. This is enabling her to relate her findings within part of Sterculia to that of the rest of the tribe and, it is hoped, will help her in understanding the phylogeny of her plants.

Anna Weitzman, also advised by Stevens, spent the latter part of 1984 in the field in Venezuela. She obtained material of five species of Freziera (*Theaceae*), the genus she is studying. She gained valuable general experience of Neotropical plants in the course of collecting at several locations, and by participating in a multidisciplinary expedition to Cerro de Neblina. On returning she continued exploratory work within Freziera.

Paul M. Rich, who is supervised by Professors P. B. Tomlinson and P. S. Ashton with the assistance of Professors William H. Bossert and Thomas McMahon of the Division of Applied Sciences, completed fieldwork in Costa Rica, during which he has been investigating the mechanical characteristics of palm trees. He is in the process of completing his thesis.

Dr. D. C. Michener, Research and Curatorial Taxonomist on the curatorial grant of the National Science Foundation for the Living Collections, continued his personal research into the wood anatomy of *Polemoniaceae* and *Scrophulariaceae*. This included a publication on the former (with S. Carlquist and V.M. Eckhart), a paper on the latter at the 1985 meetings of the American Institute of Biological Sciences, and an extensive field trip with Dr. Prigge, University of California, Los Angeles, to collect wood of Leucophyllum (*Myoporaceae*) from a range of populations.

Dr. Bernice G. Schubert, formerly Senior Lecturer on the staff of the Arboretum, this past year has continued to work on collections and literature relating to projects described in previous reports. In the first half of 1985 she spent 5 weeks in Mexico, working at the National Herbarium, Universidad Nacional Autonoma de Mexico, studying and naming new collections of Desmodium from all parts of the country, and working with Oswaldo Tellez on Dioscoreaceae for the Flora Mesoamericana. During the fifth week she worked in Merida, Yucatan, in the herbarium of INIREB, which is devoted to the plants of the Yucatan Peninsula. During this week also, she devoted some time to the study of Dioscorea for the Flora de Veracruz that she is preparing with M. en C. Victoria Sosa. Sosa is currently Director of the Yucatan project.

The East Asia programs of the Arnold Arboretum were further strengthened during the year. From June through September 1984, David Boufford was in China as American Co-leader of the second joint Sino-American Botanical Expedition. The American group consisted of Drs. Bruce Bartholomew (California Academy of Sciences),Dan H. Nicolson (Smithsonian Institution), and Paul L. Redfearn (Southwest Missouri State University and Missouri Botanical Garden). The Chinese botanists were Professors Hsi-wen Li (co-leader of the Chinese team), Shao-wen Yu and Yong-ge Su (Kunming Institute of Botany), Tsun-Shen Ying (Co-leader of the Chinese team),Si He and Cheng-gong Ma (Institute of Botany, Beijing). Funded by the National Science Foundation and the Chinese Academy of Sciences, this expedition to northwestern and central Yunnan Province in southwestern China was primarily centered around the Diancang-Shan (Cang-Shan) Mountain Range in the Dali Autonomous Region. This range is particularly rich in species despite the widespread destruction of habitat that has taken place during the thousands of years of human habitation of the area. Over 2,330 species in 755 genera and 170 families of seed plants (including about 70 species of Gentiana and 40 species of Rhododendron) have been reported from this area of only about 500 square kilometers (10 kilometers from east to west and about 50 kilometers from north to south). The mountain rises to 4,122 meters, from a relative elevation of 2,000 meters on the east and about 1,300meters on the west. Situated at about 25 30' north latitude, the mountain has a climate strongly influenced by the southeast Asian monsoon. The mix of climate and elevation makes it possible to grow such fruits as apples, peaches, plums, and bananas intermixed. Frost is rare at low elevations, but higher elevations receive snow.

Permission to take living plants and seeds from Yunnan could not be arranged, and only herbarium specimens were collected. In total, more than 20,000 sheets representing about 1,600 numbers of vascular plants were collected. The most complete set of specimens will remain in China, but the second most will be deposited in the herbarium of the Arnold Arboretum, as the lead institution in the country for research into the Botany of east Asia. Additional specimens will go to the other institutions. Bartholomew and Boufford were also

allowed to collect specimens in the vicinity of the Kunming Institute of Botany and in the Western Hills near Beijing.

As part of the exchange agreement, Professors He, Li, Su, and Ying will spend up to one year in the United States in 1985-1986. Professors Li and Ying will be at the Arnold Arboretum; they arrived on 1 June 1985. Li will be determining certain generic relationships in the Lamiaceae, and Ying will be working with Boufford on a revision of the east Asian species of Mahonia (*Berberidaceae*).

Discussions were held in Beijing on long-term projects that could be carried out between Chinese and American botanists. A botanical survey of Guizhou Province, one of the least known provinces in China and in the whole temperate northern hemisphere, that would result in a model flora of the province was favored. It was decided that the Arnold Arboretum would lead such a project in the United States. The project will include training of Chinese botanists in field techniques in Guizhou, and in the preparation of floras, revisions, and monographs when they visit the United States as part of the project. A grant proposal was ready for submission at the end of the fiscal year.

Following Boufford's return, Dr. Ashton visited China for three weeks in October 1984 at the invitation of the Chinese Academy of Sciences, to discuss the strengthening of scientific collaboration between the Arnold Arboretum and Chinese botanical institutions. Ashton had discussions at a number of institutions, in Guangzhou, Kunming, Chengdu, and Peking, that centered on collaborative research and the exchange of scientists, plant material, and literature.

Boufford also spent three weeks in the field in Japan and in visits to Japanese botanical institutions in Tokyo, Matsumota, Nikko, Chiba, and Kyoto on his return from China, during which he made additional collections. This year Boufford edited a book entitled *The Diversity of Plants in Japan* for publication. It contains about 30 papers, dealing with all groups of plants and factors influencing speciation and morphological differentiation. With Ms. Wang Siyu, an interpreter from the Botanical Institute of Academia Sinica currently visiting the Arnold Arboretum as a Mercer Fellow, he also edited the English translations of about140 treatments of rare and endangered plants for a publication on the endangered plants of China.

George Staples, a graduate student supervised by Professor Howard, is proceeding with research towards a revision of the mainly Asian genus Porana and an evaluation of the Poraneae (*Convolvulaceae*), for his thesis. He was awarded a doctoral dissertation improvement grant by the National Science Foundation to permit travel in India and Nepal, Thailand, Burma, and China in the fall semester of 1985, where he will study species in the field, making collections and gathering special materials for cytological and anatomical studies to be completed in Cambridge. Only one species of this genus is currently in cultivation, but others

encountered may be promising ornamentals, and viable parts will be collected for future cultivation. Staples will also visit Asian herbaria to study materials that cannot be sent on loan. During the summer and fall of 1984, Staples visited herbaria in London, Paris, and Geneva with the aid of grants from the Anderson Fund and the Atkins Fund.

The research of Dr. Stephen Spongberg continues to center on the simple-leaved Asian species of Sorbus, and considerably more time was devoted to this research than during the previous year. In August and September 1984, he visited the herbaria of the Royal Botanic Garden, Edinburgh; the British Museum (Natural History); the Royal Botanic Gardens, Kew; and the Laboratoire de Phanerogamie, Museum National d'Histoire Naturelle, Paris. Examination and determination of type material has helped to resolve nomenclatural problems, and additional material has also helped to determine geographical ranges.

For Dr. Shiu-ying Hu, retired staff member, this is the fortieth year of association with the Arnold Arboretum. She presented an invited paper, "The Role of Botany in Chinese Medicinal Material Research," at a symposium in 1985 at the Medicinal Materials Research Centre of the University of Hong Kong, before proceeding to the People's Republic, where she lectured in twenty cities. Dr. Hu undertook fieldwork in the Kokonor region of the Quinghai-Tibetan plateau, in Inner Mongolia, and in coastal Jiangsu. She was honored by awards from the Nanking Institute of Botany and the South China Agricultural University.

Dr. Peter S. Ashton continued his research on the demography and breeding systems of tree species in forests of lowland tropical Asia. Two major new projects were awarded funds and initiated. One, in collaboration with the Forest Research Institute of Malaysia and Dr. Stephen P. Hubbell of the University of Iowa, is based in Pasoh Research Forest, Peninsular Malaysia, and is supported by the Forest Research Institute and the National Science Foundation. In the next three years, a 50 hectare block of virgin forest will be mapped down to tree sizes of 1 centimeter in diameter with a view, first, to analyze patterns of distribution in relation to soils and to species associations. Thereafter, performance will be monitored, with the ultimate aim of better understanding how so many plant species of similar habit (in this case, approximately 700 tree species are expected to be included) co-exist, how they can be conserved, and, ultimately, how those of economic value can be incorporated into crop systems. Work began at Pasoh in June 1985 under the direction of N. Manokaran and Jeff Klahn. Ashton and Hubbell were on hand to assist at that time.

In Sri Lanka, Dr. Ashton, in collaboration with Dr. Kamaljit S. Bawa, University of Massachusetts, and Drs. I. A. U. Nimal Guntilleke and C. V. Savitri Gunatilleke, University of Peradeniya, initiated a program that is supported by the United States Agency for International Development. It is based on the celebrated Sinha Raja forest, now the last extensive lowland rainforest on the island, and where the Gunatillekes have established field station. The aim is to

investigate six forest species that are of importance to the rural economy, but which are being exterminated as the forest recedes and demand increases. Knowledge of aspects of the biology of these plants which forms an essential prerequisite to their introduction into cultivation, notably concerning their reproduction biology and population genetics, is being sought. The fieldwork will be undertaken by four trainee Sri Lankan graduate students. Bawa visited Sri Lanka during the initial phases; Ashton plans a visit to work in the field later in 1985.

Stephen Rogstad, a graduate student advised by Ashton, completed field research in Malaya, Borneo, and New Guinea. His thesis research, which concerns the systematics and ecology of a group of related sympatric rain forest tree species in the genus Polyalthia (*Annonaceae*), is scheduled to be completed in the coming year.

Alex Moad, who is jointly supervised by Ashton and Professor Fakhri Bazzaz, was this year awarded a Fulbright Scholarship to spend one year in Malaysia. Based since January 1985 at the Sepilok Research Station and Forest in north Sabah, Moad is studying the physiological ecology and demography of the seedlings of some sympatric species in the important timber tree genus Shorea (Philippine mahogany).

Dr. Peter F. Stevens's work on the genus Mesua (*Guttiferae*) occupied most of the summer of 1984, and did so again in 1985. In 1984 he visited herbaria in London and Paris, and then in several places in western Malesia-Kuala Lumpur, Singapore, Kuching, Bogor, and Sandakan. Studies included its relatives, particularly the genus *Mammea*, and particularly the species of *Mammea* from Madagascar. When in Malesia, he spent as much time as possible looking for *Mesua* in the field. Although he found few species in flower or fruit, he collected a considerable number and preserved material from them in alcohol for anatomical studies. He observed the growth of each species; in several cases it was possible for him to study stages from that of the seedling to the adult tree. This disclosed that *Mesua sensu stricto* grew in a way completely different from that of the rest of the genus (this has been called *Kayea* in the past). Observations on several species of *Mammea*, a relative of *Kayea* and *Mesua*, disclosed yet another way of growing. In addition, a form of vegetative reproduction that is uncommon among trees of the lowland tropical rainforest, namely, root suckering, was observed in the species of *Mammea* and in one species of the large genus Garcinia, also of the Guttiferae. One striking feature of the genus *Kayea* is the relative rarity of most species: few individuals of any one species are found at any one locality (this is especially true of Mammea). This contributes to the difficulty of evaluating the variation pattern in these genera. At the end of February a technician, James Albright, began an anatomical study of material brought back from the field trip, and of herbarium material. Preliminary results amply confirm the distinctness of Kayea from Mesua, and they suggest an equally interesting dichotomy within the genus Mammea. Stevens is extending his studies to other genera of the Guttiferae, and also to fruit and seed structure.

Stevens is also continuing his historical research. A summary of his earlier historical work, written for a no specialist audience, resulted an attempt to explain the importance of studies of the development of systematic ideas for systematists working today, at a public seminar he presented at Jamaica Plain. This summary is to be published in the *Botanical Bulletin*, Beijing.

At Kew, Stevens began an analysis of the taxonomic work of George Bentham, the centenary of whose death fell in 1984. George Bentham, the nephew of Jeremy Bentham, was one of the greatest 19th century systematists. Preliminary reading of some of Bentham's copious writings, and a study of Bentham's letters to Asa Gray (one of his closest friends) in the archives of the Gray Herbarium, have led to a reevaluation of ideas of the development of "the natural method" in botany. The natural method is supposed to have received its shaping at the hands of Antoine Laurent de Jussieu. Family-level nomenclature starts with him, and his explicit use of the method of synthesis in the formation of groups is seen as a foundation of modern evolutionary systematics, in which taxonomic groups are considered to be both real and discrete. However, when reading Bentham's opus it seemed that Bentham was very ambivalent about the reality of taxa, and that he was not alone in his ambivalence. This led Stevens to an extensive study of the writings of proponents of the natural method from 1750 to 1850. It then became clear that de Jussieu adopted synthesis because he believed in the continuity of nature; synthesis was the only way to proceed when there were no divisions, or groups, to be expected in the natural world. DeJussieu also explicitly discounted the value of comparative anatomy in the natural method, a rejection with the most serious consequences. Comparative anatomy did not finally develop as a systematic tool until the late 1800s, and failure to use this tool earlier made the distinction between groups more difficult and led to the persistence of beliefs that there was continuity in the natural world. Stevens's analysis also has important implications for those who are interested in studying the development of natural history, a discipline that has traditionally been associated with rather superficial, unsystematic, and nonanalytic observation of the natural world. He has completed a draft manuscript dealing with some of these ideas.

Further substantial research achievements have been made by Professor John Einset. His work on cytokinin biochemistry and physiology has progressed rapidly after discovery that Actinidia species growing in the Arnold Arboretum make ideal experimental material. He is rapidly approaching answers to two fundamental questions: What are the metabolic pathways in cytokinin genesis? And Where are the sites in which cytokinin production occurs in plants?

Einset's other interest is in the comparative physiology of woody-plant shoots in tissue culture. Some 150 species, in a wide range of Angiosperm families, have been examined. The research has, as a bioproduct, led to a refinement of methodology for the micropropagation of Syringa and other taxa in the Oleaceae.

During this year Professor Ashton collaborated with Professors Tomlinson, M. Dean Bowers, John W. Einset, and Andrew H. Knoll in teaching Biology 144, "Biology of the Flower"; and with Professors Otto T. Solbrig and Kenneth P. Sebens in Biology250, "Tropical Ecology," teaching a two-week field course in Venezuela in January 1985. With Dr. Thomas P. Givnish, Ashton also ran a graduate course in tropical forest biology at the Yale School of Forestry.

Dr. John Einset taught Biology 166, "Plant Growth and Development," and collaborated in Biology 144. Professor Richard A. Howard offered Biology 209, "The Phylogeny of Flowering Plants," and was a guest lecturer in Professor R. E. Schultes's Biology 104, "Plants and Human Affairs." Professor Peter F. Stevens collaborated with Professor Melanie L. J. Stiassny in Biology 148, "Systematic Biology." Professor Carroll E. Wood taught Biology 18, "Diversity in the Plant Kingdom," with Professors Tomlinson, Donald H. Pfister, and Nicholas A. Welschmeyer; and Biology 103, "Taxonomy of Seed-bearing Plants."

Stevens and Wood together advise Shawn Sigstedt, a graduate student who joined the department this year.

Several research staff, including Drs. Boufford, Einset,Howard, and George K. Rogers and Spongberg have actively contributed to the adult education program of the Arnold Arboretum.

LIVING COLLECTIONS

This year has witnessed unparalleled activity at Jamaica Plain, in spite of severe staff shortages. The Eleanor Cabot Bradley Rose Collection was dedicated and planting begun; the first full year of the plant-verification project was completed successfully; the southeast side of Bussey Hill was developed for collections expansion and improved access; the entrance gates were fully restored; walking paths within the Arboretum were improved and a new access lane begun that will link the new Forest Hills subway station with the Arnold Arboretum through a corridor of greenspace; and an earthen berm completed that will hide the railroad at the base of Peter's Hill and reduce noise.

The Bradley Collection was formally dedicated on 12 June 1985. A bench of North Dakota granite, designed by Claud Bunyard, was unveiled. Situated on a hillside and backed by oaks, it overlooks the collection. The dedication followed more than one year of planning and site preparation. During the previous year Dr. Stephen Spongberg, Curatorial Taxonomist for the Living Collections, had prepared the list of required taxa. In July 1984, Managing Horticulturist Gary L. Koller implemented his plan for beds on the ground. At the end of the fiscal year most of the beds had been thus prepared.

During the fall of 1984, Koller defined a pathway leading from Meadow Drive through the oak woods, directly into the new rosaceous collection area. This has been planted with wild collected accessions of Acer pensylvanicum, sited to restrict pedestrian traffic, and visual site

lines and plantings of Saxifragaceae. In the future, massed plantings of wild-collected Hydrangea will be expanded in this area.

An unusual number of important grounds-restoration and improvement projects have been accomplished or initiated this year. The most striking has been the restoration of the original ornamental iron gates, their protection with lines of ornamental bollards, and the placement of bollards in side entrances to restrict access by motorcyclists. Painted Charleston green, the gates dramatically improve the appearance of the grounds. The work was made possible by grants from the Brown Fund of the City of Boston, and the Henderson Fund.

Under the direction of Gary Koller, major regrading, begun and reported on in the previous year, was done on the side of Bussey Hill facing South Street. A new grass path, to be known as Woodland Hill Path, now links the South Street Gate, up across the slope connecting with Beech Path, to Bussey Hill Road. New expansion space has been provided, and beds are being prepared for the leguminous shrubs and others dislodged from the old shrub collection. These and other path improvements are aimed at completing, in the coming year, a perimeter path around the main block of the Arboretum, to be named in honor of Charles Sprague Sargent, first director. This will for the first time provide a circular tour for walkers and crosscountry skiers, and greater vehicular access and security.

With support and assistance from the Boston Natural Areas Fund and from the Modern Continental Construction Company, a new lane bed has been laid and raised above flood level from the South Street Gate, along the foot of the hill abutting the Bussey Brook wetlands in the South Street tract, as far as the culvert carrying the brook beneath the railway. A further 200 meters, ending on Washington Street opposite the station entrance, is to be completed by the station contractors.

The earthen berm screening Peter's Hill from future rail traffic along the northeast perimeter was completed and hydroseeded during June 1985. This berm, a gift from the DeMatteo Construction Company, has already reduced the frequency of incursions of stolen vehicles. It also provides screening from the surrounding neighborhoods. The following improvements have been carried out in the collections under Koller's supervision during the year:

On the slope directly behind the Hunnewell Visitor Center is a grove of assorted conifers and other plantings including Rhamnus, Liriodendron, and Magnolia. With the help of Arboretum Associate Dr. Richard Warren, undocumented plants and plants not of accessions quality were identified and removed. The various taxa of prostrate Euonymus plantings at the intersection near the Centre Street Gate had merged and become confused. An attempt to determine the identity of individual accessions failed. In order to restore the appearance of this very visible location, this thicket was removed.

In May, a meeting was convened to discuss the present status of the mature tree collections at the Arnold Arboretum. Many of the venerable oaks, maples, hickories, and other types of trees are represented by plants nearing or exceeding 100 years of age. While many specimens remain in superb condition, others show signs of decline. This decline has resulted in increased maintenance as well as the loss of low branches on many specimens. As a result, users of the collections cannot easily gain access to leafy twigs. The meeting resulted in an agreement that the tree collections must be managed more actively by replacing senescent and poorly documented individuals. A program for the acquisition of new germplasm is needed, and a more active effort to identify poor quality material will be initiated.

A new piece of equipment, the Hustler mowing machine, has greatly increased the efficiency of our mowing operations. This mowing machine, and the new planting-bed design, have reduced mowing time in the Bradley Collection of rosaceous plants from a day and a half each week to approximately one-half day now, while mowing time for the lawn in front of the Hunnewell Visitor Center has been reduced from four hours to one.

Visitor use of the grounds has increased markedly, even during the hot summer days and in winter, when the Arboretum is used increasingly as a resource for cross-country skiing. Close monitoring by the Living Collections staff failed to find significant damage resulting from skiing.

The work of the Plant Records Section continues to expand on account of the six-year project supported by the National Science Foundation to verify the identity of the existing Living Collections. This year a further grant was received, from the Insititute of Museum Services, to verify and remap, and thereby to conserve, the dense plantings near the top of Bussey Hill, many of which had become confused and overgrown. For this, an additional full-time assistant, Ethan Johnson, was hired together with George Carthy for shorter periods.

Project staff David Michener and Sandi Elsik have done an outstanding job. This year 68 volunteers, recruited and supervised by Elsik, contributed 2,076 hours; 51 of these volunteers contributed more than 10 hours each. Altogether, 2,250accessions were collected, for a total of 7,900 sheets; 2,460master herbarium labels were typed for a total of ca. 10,000individual labels. Excepting conifers, all the labels for the previous collecting season were typed and inserted and the plants sorted at least to family. Incidentally, information for 463defective plant labels, 307 map corrections, and 312 corrections to the plant records were supplied.

The following groups are now essentially collected: *Betula, Buddleia, Carpinus, Castanea, Fagus, Hamamelidaceae, Ilex,Ligustrum, Moraceae, Ostrya, Populus, Salix,* and *Ulmus*, plus several monotypic groups. *Well-collected are: Acer, Aesculus,Amelanchier, Araliaceae, Berberidaceae, Calycanthaceae, the conifers, Corylus, Cotoneaster, Eleagnus,*

Fabaceae, Juglandaceae, Lonicera, Physocarpus, Styracaceae, Theaceae, Tilia, Viburnum, and an array of small genera.

The Institute of Museum Services conservation project on Bussey Hill has enabled the grounds staff to identify and remove undocumented plants and increase maintenance there.

This year Jennifer Hicks, Curatorial Assistant for Plant Records, reviewed the status of field-checking, map revision, records review, and label replacement in the living collections. Since it is expected that a full cycle for field-checking of records of the living collections at Jamaica Plain should require ten years, the review covered work completed in that period of time. It was determined that of the 68 master maps which cover the 265-acre Jamaica Plain site, only eleven have not been field checked within ten years, and only 14 have not been field-checked within five years; and that of the 41 additional maps that detail shrub plantings impossible to render at the 1" = 20' scale of the master maps, only two have not been field-checked within ten years, and only four have not been field-checked within five years. During the current year, ten maps have been field-checked and annotated, five have been field-checked and redrawn, and an additional eight have been redrawn on the basis of field-checks made in the previous year.

New trunk labels, produced by photographic reproduction on sensitized aluminum, will make their appearance on the grounds during the coming year. Since the Metal photo process allows greater flexibility than the old method, new labels will carry family names in addition to the information that previously appeared on our labels, and many will carry brief comments of horticultural, botanical or historical significance.

In 1984 the Arnold Arboretum joined with 17 other botanical gardens and arboreta across the country in the formation of a national Center for Plant Conservation, whose goal of to establish a permanent, well-documented, and accessible collection of all 3,000 rare and endangered native plant taxa of the United States. Fewer than 15 percent of these plants have ever been in cultivation before. In addition to serving as the conservator of endangered woody plants for the Northeast, the Arnold Arboretum also houses the national office of the Center, which is under the scientific direction of Dr. Frank Thibodeau, at the Hunnewell Visitors Center. With help from the Center, the Arboretum will jointly develop permanent research and conservation collections for many species new to cultivation, including such rare eastern taxa as Betula uber and Amelanchier nantucketensis. The former, for example, is now reduced to 20 individuals in the world, all still subject to collection pressures and even vandalism in the wild.

Funds for the collection program at the Arboretum, including maintenance as well as instruction, are provided by the Center. But the Arboretum has need for wet-lab capabilities at Jamaica Plain if it is to meet its own primary obligation in this program, which is to research.

During the year, 166 shipments of plant material, comprising1,109 items, were distributed to cooperating institutions, nurseries, and individuals in 11 countries. Included in these figures are 154 plants and 194 packets of seed, distributed to the Chinese Academy of Sciences Botanical Garden at Beijing as part of a collaboration to assist in building a collection of North American plants there. This is to be known as the Sino-American Friendship Garden.

A total of 155 shipments, consisting of 846 accessions, were received from 21 countries during this period. Included in these figures are 7 plants and 62 seed accessions from China, received as part of the collaboration mentioned above and also from the second Sino-American Expedition; 120 taxa collected by Assistant Propagator Robert C. Nicholson in Britain and Algeria; and 22 taxa collected wild in Mexico and the western United States by David Michener.

During the year, 487 accessions were propagated to prepare replacements for specimens in the Living Collections that appeared to be failing, were represented by insufficient numbers, or were scheduled for removal due to renovation of collections. Another208 accessions were propagated for distribution programs.

During a three-month absence, Robert Nicholson extended his research on the endangered Saharan conifer *Cupressus dupreziana*. He visited the only surviving population, measuring the trees and collecting wood samples, cones, and seed, which he successfully germinated for the first time in this country. In England and Scotland, Nicholson obtained material of a number of taxa not represented in our collections, including some from rosaceous plants originally introduced by E.H. Wilson.

In addition, Nicholson has completed his study of dormancy requirements in Ostrya, which he has diagnosed; included were studies of the rare and endangered North American species *O. knowltoni*. He has sought methods of tissue culture for hardy species of Thymelaeaceae, and achieved success with the rare and ornamental shrub Daphne genkwa; devised a new method for rooting Magnolia cuttings; and is experimenting with methods to induce germination in Fothergilla seeds.

John Alexander, Head Propagator, continues his hybridization experiments aimed at breeding lilacs resistant to leaf-roll necrosis and, in collaboration with Professors William J. Manning and William A. Feder of the University of Massachusetts, his research into the cause of that disorder. With Assistant Propagator Peter Del Tredici, Alexander visited the New Jersey Pine Barrens to view the rare *Corema conradi*, on which he is initiating propagation research, in the field. Propagating material of this and other species were collected.

Del Tredici's interest in the Canada hemlock has resulted in the publication this year of a booklet on the history of *Tsuga canadensis* 'Minuta', an extremely dwarf form of the plant.

The Case Estates. This year a long-range management plan for the Case Estates was drafted, including buildings, nurseries, display gardens, farm, and research areas. The plan aims to project the development of the Case Estates over the next ten years.

The Case Estates purchased a Digital Rainbow PC 100+ computer system and LEX 11 word-processing software. The primary purpose is to computerize nursery inventories and records. The system will also be used for maintaining plant records for the Case Estates collections. The Arnold Arboretum Associates in addition purchased Condor 3, a database managerial software package, to input and manipulate inventory data. Approximately 25 percent of the nursery inventories have been entered, and data entry will be completed by next winter. One hundred and fifty trees and shrubs, which represented approximately 75 different accessions, were transplanted from the Case Estates nurseries to their permanent locations within the Arnold Arboretum's collections.

A new nursery block was prepared adjacent to recent nursery blocks located in the Twenty-Two Acre Field near Wellesley Street. This block will accommodate nearly 650 plants that are scheduled to be moved from the Case Estates Saran house in the spring of 1986. Progress was made in deletion of the permanent nurseries. Many of the important plants in the largest block, the 600's, have been repropagated. Approximately 75 plants in the 600's that were previously repropagated or were not significant to the collections were deaccessioned and removed this year.

Loss of grounds staff time due to injury, and the unavailability of horticultural interns in early spring, combined with nursery priorities in impeding maintenance and development of the amenity areas.

Nancy Gomez-Ibanez, who worked as a gardener during the 1984 growing season, had formerly been Education Coordinator at the Morris Arboretum of the University of Pennsylvania. This year, Gomez-Ibanez joined the staff at the Case Estates on a part-time basis as Public Services Coordinator, in order to develop programs of instruction based on the Case Estates for the Weston Schools, and to coordinate rental of facilities, workshops, and other events. During the autumn of 1984 Gomez-Ibanez gave introductory tours to the third graders of the Woodland School, and explored ways of incorporating the Case Estates into their plant-study curriculum. This past June, she organized a tour for all of the science teachers (kindergarten through grades twelve) who participated in the Weston Public Schools Summer Workshop. She worked with third-grade teachers in developing a program which will utilize the Case Estates on a weekly basis during the autumn of 1985 and the spring of 1986 as part of the third-grade science curriculum.

TABLE 1

Statistics for the Arnold Arboretum Living Collections,

Fiscal Year 1985

Accessions	
New accessions received into the nursery	1,477
Taxa represented in new nursery accessions	1,175
Processing	
Plants accessioned into the permanent collections	670
Plants deaccessioned: missing or removed	942
Deaccessioned plants from which wood specimens were collected	-
Accessions representing taxa new to the permanent collections	94
Taxa occurring in nature represented in new accessions	205
Cultivars represented in new accessions	59
Total number of taxa represented in new accessions	284
Accessions readied for verification through collections of herbarium vouchers	2,854
Label replacements in permanent collections:	
Record labels	2,404
Display labels	397
Total	2,801
Inventory, June 30, 1983	
Total number of woody-plant individuals and massed single-taxa groups in the permanent living collections	14,724
Number of species represented	2,596

Number of infraspecific taxa found in nature	1,075
Number of entities named as cultivars, including spontaneous forms	2,365
Total number of woody taxa in the Arnold Arboretum	6,036

Service

Items propagated for staff research	121
Items distributed to other educational and research institutions	486
Items distributed to private and commercial recipients	623
Total number of shipments distributed	166

An increased number of Arboretum sponsored events took place at the Case Estates during the year. Besides the Annual Arboretum Plant Sale and Auction on September 23, 1984, an Open House was held on June 9, 1985. Over 1,000 enjoyed tours, lectures, plant and food stalls, and horse-chaise rides. International Design Symposium held a four-day Christmas festival of seasonal floral displays and sales in early December 1984.

In order to offset losses incurred through the continued poor performance of the Arboretum's Mercer Fund, it has been decided to sell the 40 acre field. While negotiations are in progress, the field has continued to be farmed. This year most of the prepared land was leased to market gardener Thomas Hanson, though Lands Sake, Inc., a not-for-profit organization based in Weston, retained one acre.

The Case Estates is fortunate in having a group of excellent volunteers. One who deserves special recognition is Margaret Thompson. During the past one and one half years Margaret has become an invaluable part of the Case Estates operations, performing as office manager. Her work has greatly upgraded the organization and efficiency of office duties and has allowed the manager of the Case Estates to spend more time on other activities. She has consistently demonstrated her professional skills although all of her work has been on a volunteer basis.

Public Service. This year, the Arboretum granted Assistant Plant Propagator Peter Del Tredici partial leave-of-absence to act as Program Director for the Boston Urban Gardener's Landscape Training Program. The eight-month project was designed to train low-income Boston residents in basic landscape design, installation, and maintenance. Funded by the City of Boston’s Neighborhood Development and Employment Agency, the program not only trained 12 people to work in landscaping, but also successfully placed 11 of them in jobs in the landscape industry. In addition, a 10,000-square-foot lot at the corners of Dudley Street and Blue Hill Avenue, in Roxbury, was landscaped as part of the on-the-job training for the program.

HERBARIA

At the beginning of the year, the managerial staff were further reorganized for more effective integration of curatorial operations. Dr. Donald Pfister, who is Director of the Farlow Herbarium, remains overall supervisor of the Harvard University Herbaria. Dr. Peter Stevens remains Supervisor of the Arnold-Gray herbaria, but with particular responsibility for policy and collections development. Stevens is Chairman of the Herbarium Committee. Curatorial Taxonomist Dr. David Boufford has now become the Manager of the University Herbaria, and is responsible for day-to-day implementation of policy. Michael Canoso assists him as Assistant Manager with specific responsibility for the Arnold and Gray herbaria.

The summary data for herbarium activity was compiled this year with a Digital Rainbow computer using data-base (CONDOR) and word-processing (SAMNA) software. This was made possible when nine Digital Rainbow computers were acquired in April 1984 for word-processing and record-keeping in the various departments of the Arboretum. The creation of a database for the exchange records is necessary in order to complete the automation of the Herbaria records, and will be accomplished during the coming year. In addition to annual-report generation and record-keeping, the computer is being used to produce shipping forms and labels, form letters, and general correspondence.

Curatorial Assistant Vernon Bates wrote programs which have made it relatively easy to run off large numbers of herbarium or annotation labels in any quantity desired. Another label program was written specifically for the Living Collections Verification Project and is designed to store certain kinds of information for future reference.

During this fiscal year, the majority of exchange material stored at Jamaica Plain was readied for distribution and sent out. Only one set of Chinese specimens remains and that is nearly ready for distribution. In Cambridge, all miscellaneous boxed material which had long been stored in the basement was distributed; however, some material still remains in various cases there.

The herbaria have continued to benefit from curatorial assistance provided by faculty, particularly Drs. Richard Howard and Peter Stevens. During December 1984, work continued on Barneby's treatment of the Cassiinae. In all, 1,060 sheets were annotated and 39 types added to the type collection. Dr. Richard Howard identified and annotated specimens of tropical America in the course of preparation of families for the Flora of the Lesser Antilles. He located and annotated some 200 type specimens and added these to the type collection. During the year all suspected types specimens in the Asteraceae, with the exception of the genus Senecio, were pulled and inserted in the type collection, and the status of about 1,500 Asteraceae types was verified and annotated. It is estimated that there are approximately 10,500 to 11,000types in the Asteraceae, and of these, about 7,000 have been annotated. In addition, Dr. Stephen Spongberg has been annotating collections of Asian Rosaceae, including types, in connection with his research on the genus Sorbus.

The first publication resulting from the type project, A Catalogue of Type Specimens in the Harvard University Herbaria(A/GH): Lamiaceae, by Philip D. Cantino, Vernon M. Bates, and David E. Boufford, appeared this year. The catalogue includes much of the data gathered on the 1,107 Lamiaceae types in the Harvard Herbaria.

Portions of two local herbaria were given to the Harvard University Herbaria during the year. Approximately 2,000 South American collections, chiefly Bang and Rusby's Bolivian

specimens, were given to the herbaria by Wellesley College in exchange for miscellaneous material to be added to their teaching collection.

Over 24,000 specimens were given by Clark University (CUW), which divested itself its herbarium, excluding its Worcester County collection. In addition, we are grateful to Dr. Stephen Spongberg, who this year donated his personal herbarium, assembled between 1959 and 1970, when he joined the staff of the Arboretum.

Walter Kittredge rearranged species in alphabetical order in most of the genera in the Herbaria. Previously, specimens were arranged in a "phylogenetic" system according to the most recent monograph of a particular group. Where treatments were old, the more recently described species were not accounted for. This resulted in taxa treated in the monograph being arranged in one manner, and additional species being placed in alphabetical order at the end of the sequence, which proved unwieldy.

Ida Hay continues to be responsible for the management of the herbarium of cultivated plants at Jamaica Plain. At year's end Anne Sholes, preparator there, retired after 14 years on the staff.

The placement of genera in alphabetical order within families in the herbarium in Jamaica Plain, which was begun in the previous fiscal year, was completed. At the same time about half the collection on the fourth floor was shifted to utilize two cases that had been used to hold unprocessed specimens. This allows more room for additions in this section of the herbarium.

Under Hay's supervision, volunteers now participate in the mounting of herbarium specimens. Hay has been spending one day each week in Cambridge, where she has been of considerable help in reinserting returned loans and other tasks. She has thus served as a vital link and means of communication between the Cambridge and Jamaica Plain facilities.

Despite an increase over the previous year in the number of specimens being mounted, the main problems in the vascular plant portion of the Herbaria continue to center here. The amount of material being received each year is great enough to occupy at least one additional full-time preparator. Since the Cambridge herbarium was expanded into the compactors and reorganized with the help of one extra staff and two-work study students, the backlog has continued to build to the point where there is now several months' worth of mounted material waiting to be sorted and inserted into the collections. It is estimated that one halftime person could keep the insertion current.

Since January 1985, Arboretum Associate Kevin Tremblay and Dr. David Michener have worked in the new Bailey-Wetmore wood collection and laboratory on a voluntary basis. In addition, Michener unpacked and organized the laboratory in its new location. Major curatorial

projects still needing attention include review of the Hankins fossil material, establishment of what is to be done with the substantial fluid-fixed collection, and continued processing of the backlog of wood from the Arnold Arboretum's Living Collection. To assist this last project Mr. Henry Goodell, Superintendent of the Living Collections, has lent the wood collection a band saw.

TABLE 2

Statistics for the Arnold Arboretum Herbaria, Fiscal Year 1985

Accessions

Specimens received during the year:	
By exchange	6,324
As gifts	3,690
In exchange for identification	1,576
Subsidy	1,110
Staff collections	7,218
Total accessions (staff collections)	19,918
Provenance of accessions:	
America north of Mexico	6,931
Rest of continental America	3,924
West Indies	644
Subtotal	11,499
Temperate Asia	2,384
India	2,879
Subtotal	18,376
Polynesia	114
Australia	89
Africa	221
Europe	619

Processing

Number of sheets:	
Through mounting	10,939

Through direct incorporation	2,149
Total number of sheets incorporated	12,808
Number of sheets removed	280
Number of sheets repaired	393

Inventory, June 30, 1984

Number of sheets in herbaria:	
Cambridge	1,153,992
Jamaica Plain	174,191
Combined total	1,328,183

Service

Number of sheets sent out:	
On loan to specialists	29,246*
On exchange	15,900
As gifts	267
Number of specimens received on loan:	
For staff	3,067
For students	5,084
For visitors	1,292
Total received on loan	9,443
Number of loaned specimens returned	6,278*
Number of orchid specimens placed on indefinite deposit in the Oakes Ames Orchid Herbarium	35

* Combined figure, Arnold Arboretum and Gray Herbarium.

The laboratory is routinely used by Michener for his own research. During the year Professor Barry Tomlinson, Harvard Forest, was successful in securing funds from the National Science Foundation to provide modern microscopic facilities at the laboratory.

LIBRARIES

The libraries are managed by Barbara Callahan, Librarian, who is chairman of the Library Committee. The Librarian worked with Director of the University Herbaria Donald Pfister, Farlow Herbarium librarian Geraldine Kaye, and the Botanical Museum librarian Wesley Wong to more closely integrate the work of all libraries of the Harvard University Herbaria.

The project to prepare a second edition of *Taxonomic Literature*, under the editorship of Dr. Richard Cowan, continued to make use of our libraries. Project staff paid two visits, during which they examined 2,820 volumes.

As part of the libraries' program for phased preservation a total of 84 volumes were enclosed in custom-made, acid-free boxes. These volumes are in poor condition and were given priority for attention because they have been selected by Dr. Cowan for inclusion in the second edition of his Taxonomic Literature.

Si-yu Wang, a translator from the Academia Sinica, Beijing, People’s Republic of China, working with Dr. David Boufford reviewed the Arboretum's holdings of botanical literature from China. Arrangements were made with the Librarian and Wang to obtain missing literature through outright purchase and through exchange of photocopies.

Beth Pessek and Lofton Wilson from the Harvard University Archives worked with Barbara Callahan, Sheila Geary, and Betsy Shaw on a Harvard-wide project to survey, and catalog into machine-readable form, manuscripts, and archival collections. Our records will eventually be entered into the Research Libraries Information Network (RLIN) database.

In addition to routine tasks, the Arboretum's collection of maps and plans, which includes early Arboretum site plans, building and renovation plans, and plans of work in progress, was reorganized, inventoried, and placed in acid-free folders.

The photograph archive was the recipient of a grant from the Arnold Arboretum Associates for conservation and preservation of the photographic print collection. This grant, along with the assistance of Elaine Foster, a volunteer, enabled us to upgrade the present storage conditions of the collection.

Volunteer Carin Dohlman completed her third year of work with the Archives. Because of Mrs. Dohlman's work on the Wilson Archive we were able to apply to the Institute of Museum Services for a Conservation Project grant to reformat two aspects of the archive. We propose to transcribe Wilson's collection notes, diaries, and journals specific to his Japan, Korea, and

Formosa expeditions, and to convert the Wilson photograph record of Asiatic exploration, currently on 3,000 glass plate negatives, to 35-mm safety film.

TABLE 3

Statistics for the Arnold Arboretum Libraries,

Fiscal Year 1985

Accessions		
Monographs:	Purchased	124
	Acquired through gifts or exchanges	76
New continuation volumes (e.g., journals):		
	Purchased	15
Total volumes and pamphlets added		566
Microfilms added		3
Microfilms added		37
Processing		
Titles:	Catalogued	215
	Recatalogued	52
Total, titles catalogued and recatalogued		267
Volumes bound: Monographs		307
	Serials	366
Total volumes bound		673
New volumes added after cataloguing and binding:		
	Subtotal for Cambridge	388
	Subtotal for Jamaica Plain	193
Inventory, June 30, 1984		
Total number of volumes and pamphlets in the Arnold Arboretum libraries at Cambridge and Jamaica Plain		90,399
Total, microfilm reels		252
Total, microfiches		10,904
Number of continuation titles:		
	On order	599
	Received through gift or exchange	372
Total, continuation titles received		

971507

Service	
Total volumes used by visitors	1,739
Photocopies supplied in lieu of interlibrary loans	1,924
Interlibrary loans received	382
Number of reference requests serviced	1,074

PUBLICATIONS

Elizabeth B. Schmidt assumed chairmanship of the Publications Committee on 1 July 1986, after Bernice G. Schubert's retirement at the end of the previous fiscal year. Four numbers of the *Journal* (Volume 65, numbers 3 and 4; Volume 66, numbers 1 and 2) appeared during fiscal year 1984-1985, with publication remaining on schedule. Our excellent relationship with Allen Press has continued. Volume 65, number 3 (July, 1984) was dedicated to Dr. Bernice G. Schubert on her retirement from the Arboretum staff. Volume 66, number 1 (January, 1985) included an Index to Authors and Titles, Volume51-65 (1970-1984), which was prepared by E.B. Schmidt, and which continued and brought up to date the index prepared for Volumes 150 that was published in 1973. The 616 pages in these four numbers contained 17 papers by 16 authors. For Arnoldia, the Arboretum's quarterly magazine, the year was again a period of adjustment. In September 1984, Eileen J. Dunne, the magazine's Editor since June 1982, resigned. To replace her, we appointed Edmund A. Schofield, former Associate Editor of Horticulture magazine, on a consulting basis pending the outcome of a membership survey that was soon to be launched by the Membership Department. By a ratio of seventeen to one, members reported that they consider Arnoldia an important benefit of membership. Schofield consequently became a member of the staff on June 1, 1985. Meanwhile, strategies were explored for reducing the costs of publishing Arnoldia and for increasing its non membership circulation, the ultimate goal being to make Arnoldia financially self-supporting. Among the successes achieved in strengthening *Arnoldia*'s editorial content has been Dr. John Einset's consent to write a regular column on the practical application of plant physiology and biochemistry to horticulture. Dr. Einset has already submitted several installments for the column. At year's end, news was received that the National Endowment for the Humanities has awarded the Arnold Arboretum a grant to complete the three-volume Guidebook series, started earlier with their support and under the coordination of Research Archivist Sheila Geary. The first book, *A Museum Without Walls*, will be coauthored by Geary and Ida Hay and will present the history of the Arnold Arboretum in the wider context of its times. The second, *New England Natives*, by Geary also, will detail the role of native plants in regional social history. The last, *People, Plants and Places*,

will recount the explorations that led to the introduction of some of our best-known plants. It is to be written by Dr. Stephen Spongberg.

PUBLIC PROGRAMS

This year has been a challenge, but has been marked by several successes. In spite of major staff changes the program has continued to grow. The Youth Program and the number of events increased substantially, as did membership and income.

Wendy Marks, who was appointed in 1979 as Manager for Public Facilities, later to become Assistant to the Director, stepped down at the end of the year. To her we owe the success of the Public Programs as we currently know them. Personally taking charge of the Programs at a time when staff consisted of a part time Membership Coordinator and herself, Marks in one year built up the structure which has served us so well. She continued to maintain an active interest in program development long after a permanent Public Programs Coordinator was appointed.

Three different personnel changes occurred in the Volunteer/Visitor Services position, and Ms. Katherine Terzi resigned after four very productive years as Education Coordinator. In April, 1985, Ms. Nan Sinton was hired as the new Education Coordinator, and Jeanne Christianson was hired as Volunteer/Tour Coordinator on a part-time basis. Nan and Jeanne have already further strengthened Public Relations and Education's programs and services. Throughout a difficult year, Public Relations Coordinator Kathleen Nixon and Membership Coordinator Robin Pelzman nevertheless succeeded in maintaining both continuity and momentum.

Public Relations. In addition to courses, lectures, special tours, group tours, Field Study Experiences for children, Members 'events, and exhibit receptions, Programs staff developed, organized, and ran eight special community events this year. These activities increase publicity for the institution as a whole and particularly for its services, programs and fundraising for increased membership, and for the local community participation and support upon which we increasingly rely.

The second annual plant sale, Members' giveaway, and rare plant auction was held at the Case Estates in Weston on Sunday, September 23, 1984. It attracted several thousand participants and grossed $15,000 in sales.

The annual Arbor Day Festival, held on April 27, attracted hundreds of participants to the grounds in Jamaica Plain. Mayor Raymond Flynn appeared in the afternoon, to receive a contribution from the Arboretum Committee and other groups for the Park Ranger Program. The Mayor at that time committed his Administration to the Program for its duration. Lilac

Sunday, one of the Arboretum's most popular public events, was held on the grounds on May 19, 1985.

The dedication of the Bradley Rose Family Garden on June 12took place under the Arboretum's tent in the garden and in the Hunnewell Visitor Center.

The Arboretum continues to benefit from the fundraising activities, special projects, and general community-organizing efforts of the Arboretum Committee. Barry Cheslin of Roslindale was elected to his second term as president in October 1984.Committee members were invaluable following the April announcement that there was not enough money in the Parks budget to fund the Ranger Program in 1985. This year the announcement came even closer to the proposed starting date for Ranger training. After an emergency meeting with the Boston Park Ranger Advisory Board, Robert McCoy, Parks Commissioner, and Councilor Hennigan, it appeared that the most effective way to restore the Ranger funds would be through publicity and community action. As happened last year, Councilor Hennigan worked tirelessly to restore the program, both at City Council hearings and with the Administration. *The Boston Globe, Herald,* and *Jamaica Plain Citizen* carried a number of articles that helped turn public opinion in the Rangers' favor.

The Arboretum Committee organized a litter clean-up day and a photo contest, "A Park for All People," in June. Approximately 15 volunteers and Committee members cleaned up an estimated ton and a half of trash, which was removed by employees of the City's Public Works Department.

In Fiscal Year 1985 the Committee had a membership of 58 local residents, with an additional 30 volunteers who participated in one or more major activities or events during the year. This winter, vice-president Keith Marcotte completed the filing process necessary to achieve nonprofit status.

Three issues of the Arboretum's newsletter *plantSciences* were published between July 1, 1984, and June 30, 1985. From "Collecting Plants in Brazil's Rainforest" to "Rediscovering China's Botanical Wealth," *plantSciences* drew attention to a variety of botanical, horticultural, and public-program issues and events. The *Harvard Gazette*'s "Arboretum" supplement, published in September and March each year, continues to elicit interest in Arboretum programs and activities. The Harvard community uses the supplement's registration form to sign up for workshops and courses.

Education Program. Adult Programs. The Education Program consolidated and reinforced the development of course structure that had been in place in 1983-84. These programs had been created by Katherine A. Terzi.

The response to programs at the Arboretum continues to be enthusiastic. Increasing out-of-state registrants confirm the regional need and scope for our programs. Courses repeated the established emphasis on one- to three-session short series and hands-on workshops. Subjects covered fell into three major groups: practical horticulture and gardening; plant science and ecology; and the human experience of plants, including arts, crafts, folklore, and floral design.

Course registration numbers dropped during the spring of 1985. This reflects a city-wide downturn in numbers attending adult education programs. The level of visibility of the Arboretum's programs has already been enhanced through the efforts of Public Relations Coordinator Kate Nixon. Cosponsorship has been sought with other museums and environmental organizations to increase awareness of the Arboretum's program and to broaden the base of course takers. Two all-day symposia were organized for Fall 1984, "Hardy Bamboos and Ornamental Grasses for New England Landscapes," coordinated by Gary L. Koller, and "High Tech/New Tech, Tree Care and Selection," in cooperation with the Massachusetts Arborists Association. These programs were each attended by about 90 participants.

A series of ten free luncheon lectures are offered on alternate Wednesdays between October and March. The Plant Information Service is offered on Monday and Tuesday afternoon. It is now staffed by two experienced volunteers, Barbara Eneneau and C. J. Patterson.

The Museum Institute for Teaching Science is a vehicle for a collaborative approach to develop and improve science literacy among elementary and middle school teachers, using the human and material resources of the science-oriented museums of the Boston area. The Arnold Arboretum has joined with six other museum institutions in developing this proposal. In March 1985, a director was appointed to promote the program. Nan Sinton continues to represent the Arboretum on the organizing committee.

The 1984 summer horticultural internship program was advertised as offering practical experience in grounds maintenance, and horticultural training with specialized opportunities in mapping, labelling, and greenhouse operation. Thirteen applicants eventually accepted.

Children's Programs. The success and continuation of the Children’s Program is due in large measure to the determination and vision of Arboretum Education Coordinator Katherine Terzi. During this second year it has fully established itself as a complement to classroom science lessons.

This fall the Children's Program received support from the Boston Junior League and from the Arboretum Associates Plant Auction.

Thanks to this funding it was possible to hire two skilled and enthusiastic coordinators in a part-time capacity: Mary Coombs, who served at first as an intern; and Diane Syverson, who joined the staff and has further strengthened an already well received and growing program.

The Brookline Public Schools' fourth-grade teachers attended a briefing workshop at the Arboretum on October 4. As a result of this meeting, 15 teachers representing eight schools scheduled fall field studies and continued to bring their classes to the Arboretum on an individual basis throughout the school year.

In August, the Arboretum was one of five cultural institutions to take part in a two-week Summer Science Institute sponsored by the Bank of New England, Simmons College, and Wheelock College. Seventy-five Science Fellows, representative science teachers drawn from the Boston Public Schools, grades K-5, attended. The workshop addressed the newly introduced Boston Public School science curriculum objectives. Arboretum staff presented a two-day workshop that gave teachers the opportunity to learn about our programs for children. In January, staff took part in Boston School Teachers All Professional Day, presenting two workshops. Thirty teachers were introduced to the children's program through a preview of the "Around the World with Trees "slide presentation, and an exhibit of "Youth Loans and Field Study Materials."

The success of the Children's Program has been manifested in several ways. In October 1984, Mary Coombs was invited to present her slide program, "The Children are the Explorers, Discoverers, and Scientists," to the International Conference of the North American Association for Environmental Education, held in Banff, Alberta.

Membership. This was a successful year for the Membership Department in many ways. New memberships outnumbered lapsed memberships for the first time in several years, with the new total standing at 3066 at year end. A record 754 new members joined the Friends, while 443 members lapsed and 59 members requested deletion.

The entire Friends organization was mailed a survey and a holiday membership promotion. Foremost, the survey revealed how much the Friends value Arnoldia, the Arboretum magazine. The survey also made clear that over one-fifth of the Friends joined at the Arboretum after a visit.

Volunteers. In July, 1984, Cornelia McMurtrie resigned after more than two years of dedicated service. Through her hard work the volunteer, guided-tour, and facilities-rental programs have taken shape. Barbara Gard held the position from October 1984 to March 1985, when Jeanne Christianson was appointed. Perhaps because of these changes, there was a substantial reduction in tour and lecture bookings.

As of June 1985, the volunteer corps consisted of 140volunteers, who donated 8,463 hours of service during the year. This is an increase of 29 volunteers over that reported in the1984 Annual Report.

The Arnold Arboretum Associates are a group of volunteers who have formed to raise funds for special projects that could not otherwise be supported. Mrs. David Stone has been elected cochairman with Mrs. Peter Ashton. At the second plant auction which they have sponsored in association with the Fall Plant Friends Giveaway and Sale at the Case Estates they raised over$11,000, which was successfully used to assist in the development of three principal projects reported on elsewhere: the Children's Program, which later received further support from various sources; the restoration of the photographic archives at Jamaica Plain; and the computerization of the nursery records at the Case Estates. In addition, a tent was bought for Arboretum events and rental for private parties at the Case Estates.

Table 4

Summary of Volunteer Assignments, Fiscal Year 1985

Assignments	Number of Volunteers
Public Programs:	
Volunteers	2
Membership	7
Public Relations	1
Tours	22
Gift Shop-weekend reception	5
Children's Program	18
Living Collections:	
Propagation	10
Specimen collecting and verification	68
Mapping and labeling	3
Conservation	1
Case Estates gardening	4
Herbaria:	
Cambridge	2
Jamaica Plain	4
Libraries:	
Archives	1
Slide Collection	3

Peter S. Ashton, Director