# The Role of Lower Plants in the Research Programs in Arboreta and Botanical Gardens

When I first prepared a draft of this paper late in 1971, after Professor Howard had invited a contribution, I was of the opinion that lower plants, interpreted here as non-vascular plants, had no other significance in the arboretum or botanical garden than as highly suitable material for research. However, after a second visit to the Higashiyama Botanical Garden in Nagoya, Japan, in early April, 1972, I have had to modify this view, as in a spectacular exhibit of interesting ground covers were included, as well as several orchids, two mosses (a species each of *Leucobryum* and *Rhodobryum*), which apparently flourish in the moist climate of oceanic Japan. Of course, moss gardens are traditional in Japan; the most impressive is the Kokedera in Kyoto.

Botanical gardens conducted primarily for botanical purposes were a product of the European Renaissance, and were closely related to a university or some other institution. The earliest gardens of this type were found in Italy during the sixteenth century, and the movement spread northward into France, Germany, Holland and England during the seventeenth century. Because of the broad intellectual spectrum of the universities, it was not considered unusual or anomalous to include the study of cryptogamic plants in the botanical gardens associated with them. Also, once botanical gardens began the sponsorship of collectors in other and richer botanical areas of the world, or the sending out of full-fledged expeditions, many plants other than vascular plants had to be identified and curated, either in the garden or the herbarium. Moreover, it is only natural that the administrative officers of a botanical garden or arboretum should be concerned with actual or potential diseases of the plants they are cultivating, so that the association of mycologists and plant pathologists with such botanical institutions became customary soon after the disease-producing capacity of bacteria and fungi was discovered.

By definition, an arboretum is more specialized than a botanical garden, which, by its own definition, in turn, is free to consider all kinds of plants, in addition to woody ones, as objects for display to the public, for instruction, or for research purposes — or for all. To my knowledge, cryptogamic botany has rarely been considered as an appropriate adjunct to an arboretum, except perhaps in its wholly practical aspects, with reference to plant diseases, as already noted. In most of the great botanical gardens of the world, however, cryptogamic plants have received almost better attention than in other botanical institutions.

I have divided this paper into two parts, first, a cursory historical review, and second, a review of the situation today, plus a tabular summary derived from two relatively modern sources, *International Directory of Botanical Gardens II* (1969) and *Index Herbariorum.* Part I. The herbaria of the world (Fifth edition, 1964).

*Historical Review*

For a brief historical review, on a "for example" basis, I shall begin with the New York Botanical Garden, simply because it is the institution I know best.

Cryptogamic botany has been represented at the New York Botanical Garden from its very beginnings, in close association with Columbia University. Elizabeth Gertrude Knight Britton, wife of the founder and first director, was a bryologist of great talent who built up the bryological collections in the herbarium of the New York Botanical Garden and carried on productive research in mosses. Robert Statham Williams joined the staff of the Botanical Garden in 1899 and became a highly distinguished bryologist. Marshall Avery Howe, who joined the staff of the Garden around the turn of the century, had written his thesis at the University of California on the Hepaticae of that state, then turned his hand to the marine algae, especially of tropical areas, once he moved to New York. Lucien M. Underwood, a distinguished specialist on ferns, spent many years at the New York Botanical Garden. From the very beginning a mycologist has been in residence; Dr. Clark Rogerson and Dr. Kent Dumont today represent their several illustrious predecessors. The field of plant pathology has also been represented continuously during the present century at the New York Botanical Garden, and the brilliant work of Dr. B. O. Dodge on *Neurospora* led subsequently to several Nobel prizes. As a result of the involvement of cryptogamic botanists in the scientific work of the

*Elizabeth Gertrude Britton. Photograph taken at her desk at The New York Botanical Garden, June 22, 1902.*

*Lucien Marcus Underwood on Blue Mountains in Jamaica.*
*Photo: A. Rehder, 1903.*

Botanical Garden from the very beginning, the collections have grown steadily; also, in the early days many important private collections were purchased which are now invaluable because of their large proportion of type specimens.

This surprising abundance of cryptogamic botanists at the New York Botanical Garden had several causes. As already mentioned, Mrs. Britton was a prominent bryologist, and undoubtedly had considerable influence on her husband's interest. Moreover, Dr. Britton had a very broad scope of interest — after all he himself had started out as a geologist — and his concept of the Garden was very broad. Finally, with so many botanists of all kinds working in the tropics in new areas, it was necessary to have different specialists to handle the large amounts of the several groups of plants that were collected and brought back to New York. I have used the New York Botanical Garden as my first example, not because of vested interest, but simply because of all American institutions it has had the widest scope of cryptogamic botanists in the country over a long period, and still maintains broad representation in these fields.

The Missouri Botanical Garden has emphasized its work on higher plants, so that cryptogamic botany has never become very well developed as a broad field. However, there has always been some one specialist in cryptogamic botany in residence, and at the moment the cryptogamic botanist is a bryologist. The Brooklyn Botanic Garden has placed its emphasis almost totally on higher plants, cultivated ones as well as native plants, almost to the exclusion of cryptogams. Dr. Paul Burkholder, one of the few exceptions, was considered an algologist largely because he used this group of plants in his physiological experiments, although he did not concern himself with developing a collection either of herbarium specimens or of living cultures on a broad representational basis.

At Kew, Sir William Hooker and Sir Joseph Hooker, father and son, were both accomplished cryptogamic botanists, with a special interest in bryophytes, in addition to their even greater brilliance in higher plants, so that, as directors of Kew, they encouraged the development of bryological collections. However, since the Hookers, bryological research at Kew has been desultory and the collections have lain fallow. The same situation seems to be true of the fungus collections. In fact, for decades there has been talk, sometimes serious and sometimes not so serious, of turning over the collections of lower cryptogams to the British Museum (Natural History), and this may now have been done with the fungi, in exchange for herbarium specimens

of higher plants of greater interest at Kew. I should hasten to say, however, that the collections of ferns and their relatives at Kew are outstanding, both ferns growing in the great fern collection and in the herbarium, thanks to a series of specialists in this group. I am sure that the ferns will continue in ascendency at Kew.

At the Komarov Botanical Garden and Botanical Institute at Leningrad cryptogamic botany has perhaps reached a higher level of development than in any other botanical garden around the world, unless we except the early days of the New York Botanical Garden. There are productive workers in the field of freshwater and marine algae, in many groups of fungi, and in bryophytes. In many ways, this is the most influential botanical center in Russia.

The Royal Botanical Garden at Berlin-Dahlem has long been a great center of bryological research, as well as in other groups of cryptogams, especially lichens and fungi. The bombing of Berlin during World War II destroyed many of the cryptogamic collections, however, and most type specimens of Carl Müller especially do not seem to be any longer in existence, although many of the higher plants had been put into safekeeping for the duration of the war.

Most other major botanical gardens in Europe have a long history of involvement with lower cryptogams, of which the University Botanical Garden and Institute in Copenhagen, and the Royal Botanical Garden in Brussels deserve special mention.

To repeat, the emphasis on the taxonomy and geographical distribution of lower plants has been as great, if not greater, in major botanical gardens as in other kinds of botanical institutions.

### *The Modern Situation*

Major botanical gardens are still following their ancient tradition of using lower plants as research material, even though today much of the work tends to be more experimental and less descriptive. The classical experimental work by Dr. B. O. Dodge on *Neurospora* has already been mentioned. Also at the New York Botanical Garden, an important research program is directed to the biochemistry of natural products of fleshy fungi, and to the sex hormones of water molds. Other botanical gardens throughout the world are carrying on similar research programs. The deep concern of many people for the improvement of environmental conditions is reflected in the botanical gardens that are developing special races of plants that may serve as

indicators of air pollution, for example. Mosses and lichens have been discovered to be excellent indicators of air pollution, in both negative and positive ways. In a negative way, most lichens and mosses that normally grow on tree trunks several feet above the ground are very sensitive to air pollution, especially to sulfur dioxide, so that there is an almost perfect correlation between the increasing concentration of $SO_2$ and the decreasing number of plants of bark-inhabiting lichens and mosses. On the other hand, some few mosses and lichens seem to be able to metabolize $SO_2$, and are therefore able to survive or even thrive in a polluted atmosphere. Their presence alone gives positive evidence of air pollutants, just as the absence of species that do not tolerate pollutants gives evidence of a more negative nature. A good deal of information can be obtained from the herbarium on the increase in air pollution by early collections of indicator species in areas where they no longer can survive. The use of lower plants as indicators of other environmental factors, such as moisture, humidity, rainfall, pH, etc., makes them useful tools for ecological research in botanical gardens.

In early times, the nature of botanical gardens and arboreta was simple — they either did or did not include lower plants in their research programs. Today the situation is so complex that unravelling the administrative structure has become the key to answering the question. Although the administration of botanical gardens and arboreta is a perennial topic of conversation among the staff members thereof, I do not know of any scholarly or comparative study of administrative structure on a historical or evolutionary basis. However, I do detect one trend that you may recognize also from your own experience, namely, the development of the botanical institute through the gradual separation of the herbarium function from the botanical garden and arboretum function, and the separation of both of these from the teaching function. I might cite, as an example of this trend, the situation in Montreal, where the Institut Botanique of the University of Montreal and the Jardin Botanique de Montréal share the same building, carry on somewhat overlapping herbarium activities yet whose staffs at some times in the past were really not on close terms. At the University of Michigan, the Botanical Garden is closely affiliated with the Department of Botany, whereas the herbarium is a separate department of the Literary College. In other institutions, at the other end of the spectrum, there may be no administrative separation of teaching, living plants and herbarium.

In combing through *International Directory of Botanical Gardens* II (1969) and *Index Herbariorum* (Part I, Fifth edition, 1964), for the background information to establish the modern situation, I encountered many ambiguous entries. As a result, although I have tried to quantify the data extracted from these two publications in tabular form, there still remains a strong qualitative element, based on my own judgment in the interpretation of entries (Table 1). My error in interpreting the entry as a botanical research institute, separate from the botanical garden, may have resulted in the omission of important institutions. Also, my adherence to these two publications as my source of information means that the data summarized here are already out of date. I could have corrected and up-dated the entries for several institutions that I know personally, yet this treatment would have been unfair to those institutions unfamiliar to me. To give consistency to my data base, I have adhered firmly to the information gleaned from two publications, while recognizing fully the error built into the use of data that may be up to ten years old. (See Table 1.)

William Campbell Steere
President,
New York Botanical Garden

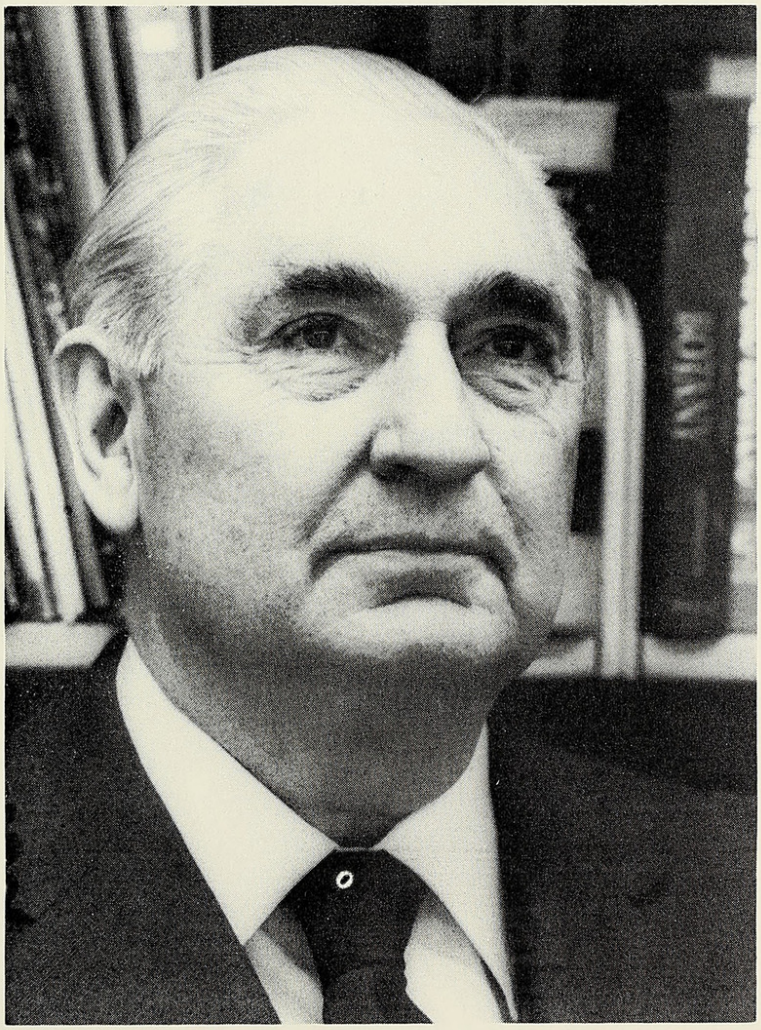

TABLE 1. List of Botanical Gardens and Arboreta showing numbers of staff members whose primary research interest is in non-vascular plants or in plant pathology. Derived largely from *International Directory of Botanical Gardens II* (1969), with supplementary information from *Index Herbariorum*. Part I. Fifth Edition (1964)]

| COUNTRY AND NAME OF INSTITUTION(S) | NUMBERS OF STAFF MEMBERS | | | | | |
|---|---|---|---|---|---|---|
| | ALGAE | FUNGI | LICHENS | BRYOPHYTES | PATHOLOGY * | ALL OTHER FIELDS |
| *Australia* | | | | | | |
| Royal Botanic Gardens, Sydney | 1 | | | | | 12 |
| *Belgium* | | | | | | |
| Jardin Botanique National, Brussels | 1 | 1 | | 1 | | 4 |
| *Brazil* | | | | | | |
| Jardin Botânico de São Paulo | 3 | 4 | 1 | 1 | | 27 |
| *Canada* | | | | | | |
| Botanic Garden & Arboreta, Ottawa | | 2 | | | | 11 |
| *Denmark* | | | | | | |
| Botanic Garden of University, Copenhagen | 1 | 1 | 1 | 1 | | 6 |
| *Egypt* | | | | | | |
| Botanic Garden Univ. Alexandria | 1 | 1 | | | | 3 |
| *France* | | | | | | |
| Station de Botanique et de Pathologie Végétale, Antibes | | 1 | | | 2 | 5 |
| Jardin Botanique de l'Ecole Nationale Supérieure Agronomique, Grignon | | 1 | | | 2 | 1 |
| Jardin Botanique Strasbourg | | | | | 1 | 3 |
| *Germany* | | | | | | |
| Institut für Spezielle Botanik und Arboretum, Humboldt Univ. Berlin | | | | 1 | | 6 |
| Botanischer Garten und Botanisches Museum, Berlin-Dahlm | 1 | | 1 | 1 | | 11 |
| Staatsinstitut für | | | | | | |

(TABLE 1 *continued*)

| COUNTRY AND NAME OF INSTITUTION(S) | NUMBERS OF STAFF MEMBERS | | | | | |
|---|---|---|---|---|---|---|
| | ALGAE | FUNGI | LICHENS | BRYOPHYTES | PATHOLOGY * | ALL OTHER FIELDS |
| *Germany (continued)* | | | | | | |
| Allgemeine Botanik und Botanischer Garten, Hamburg | 1 | 1 | 1 | 1 | | 7 |
| Botanischer Garten, Univ. Rostock | | | | 1 | | 3 |
| *India* | | | | | | |
| National Botanic Garden, Lucknow | | 1 | | | 2 | 19 |
| *Indonesia* | | | | | | |
| Kebun Raya, Bogor | 2 | | | | 1 | 4 |
| *Italy* | | | | | | |
| Orto Botanico, Univ. Camerino | | | | 1 | | 2 |
| Istituto ed Orto Botanico, Napolí | 1 | | | | | 2 |
| Orto Botanico, Univ. Padova | 1 | 1 | | | | 4 |
| Istituto ed Orto Botanico, Parma | | | | | 1 | 3 |
| Istituto Botanico Univ. Torino | | 3 | | | | 4 |
| *Japan* | | | | | | |
| Asakawa Experiment Forest Tokyo | | | | | 1 | 2 |
| Botanic Garden, Univ. of Kanazawa | | | | 1 | | 2 |
| *Mexico* | | | | | | |
| Jardín Botánico, México D.F. | | 1 | | | | 9 |
| *Netherlands* | | | | | | |
| Botanical Garden and Arboretum Wageningen | | 1 | | | | 12 |
| *Philippines* | | | | | | |
| U.P. College of Forestry Botanical Garden, College | | | | | 3 | 8 |

(TABLE 1 *continued*)

| COUNTRY AND NAME OF INSTITUTION(S) | NUMBERS OF STAFF MEMBERS | | | | | |
|---|---|---|---|---|---|---|
| | ALGAE | EUNGI | LICHENS | BRYOPHYTES | PATHOLOGY * | ALL OTHER FIELDS |
| *Poland* | | | | | | |
| Polish Academy of Science Arboretum, Kornik | | | | | 1 | 16 |
| *Portugal* | | | | | | |
| Instituto de Botânica "Dr. Gonçalo Sampaio," Porto | 2 | | | | | 6 |
| *Rhodesia* | | | | | | |
| National Botanic Garden, Salisbury | | | | | 1 | 1 |
| *Romania* | | | | | | |
| Grădina Botanică, Univ. Cluj | 1 | 3 | 1 | | | 10 |
| Grădina Botanică, Univ. Cuza, Iasi | 1 | 2 | | | | 5 |
| *Singapore* | | | | | | |
| Botanic Garden | 1 | 1 | | | | 5 |
| *Spain* | | | | | | |
| Jardín Botánico Madrid | 1 | | | | | 4 |
| *Switzerland* | | | | | | |
| Conservatoire et Jardin Botaniques, Genève | | | | 1 | | 7 |
| *USSR* | | | | | | |
| Botanical Garden, Kaunas, Lithuania | | | | | 1 | 6 |
| Central Republic Botanical Garden Kiev, Ukraine | | | | | 1 | 7 |
| Botanical Garden, Kiev Univ. | | | 1 | | 2 | 6 |
| Polar-Alpine Botanic Garden, Murmansk | | 1 | | 1 | | 4 |
| Botanical Garden of Moldavia, Kishinev | 1 | | | | | 14 |
| Central Botanical Garden, Minsk | | | | | 1 | 6 |

(TABLE 1 *continued*)

| COUNTRY AND NAME OF INSTITUTION(S) | NUMBERS OF STAFF MEMBERS | | | | | |
|---|---|---|---|---|---|---|
| | ALGAE | EUNGI | LICHENS | BRYOPHYTES | PATHOLOGY * | ALL OTHER FIELDS |
| *USSR (continued)* | | | | | | |
| Main Botanical Garden, Moscow | | | | | 2 | 17 |
| Central Siberian Botanical Garden Novosibirsk | 1 | | | | | 9 |
| Botanical Garden Petrozavodsk Univ. | | | | | 1 | 3 |
| Botanical Garden of Latvia, Riga | | | | | 1 | 8 |
| Arboretum, Sochy | | | | | 3 | 11 |
| Botanical Garden, Sukhumi, Georgia | | | | | 1 | 4 |
| Botanical Garden Tallin, Esthonia | | | | | 1 | 9 |
| Central Botanical Garden, Tbilisi, Georgia | | | | | 1 | 13 |
| State Botanical Garden, Yalta, Crimea | | | | | 2 | 17 |
| *United Kingdom* | | | | | | |
| Univ. Botanic Garden Birmingham | | 1 | | 1 | | 5 |
| Royal Botanic Garden Edinburgh | | 2 | | | | 17 |
| Botanic Garden Univ. Hull | | | | | 1 | 3 |
| Royal Botanic Garden Kew | | 4 | | | | 46 |
| South London Botanical Institute London | | 1 | | | | 1 |
| Agricultural Botany Field Station Botanic Garden, Reading | | | | | 2 | 10 |
| Royal Horticultural Society's Garden, Wisley | | | | | 2 | 3 |
| *United States* | | | | | | |
| Grays Harbor Arboretum, Aberdeen, | | | | | | |

(TABLE 1 *continued*)

| COUNTRY AND NAME OF INSTITUTION(S) | NUMBER OF STAFF MEMBERS | | | | | |
|---|---|---|---|---|---|---|
| | ALGAE | EUNGI | LICHENS | BRYOPHYTES | PATHOLOGY * | ALL OTHER FIELDS |
| *United States (continued)* | | | | | | |
| Washington Univ. Michigan Botanical Garden, Ann Arbor | | | | 1 | 1 | 2 10 |
| Los Angeles State & County Arboretum | | | | | 1 | 10 |
| Brooklyn Botanic Garden | | | | | 1 | 8 |
| Sub-Tropical Experimental Station, Homestead, Florida | | | | | 3 | 9 |
| Christy Woods Arboretum, Muncie, Ind. | | | | | 1 | 4 |
| New York Botanical Garden, Bronx | | 3 | | 2 | 2 | 17 |
| Missouri Botanical Garden, St. Louis | | | | | 1 | 16 |
| State Arboretum of Utah, Salt Lake City | | | | 1 | | 2 |
| *Yugoslavia* | | | | | | |
| Botanical Garden, Univ. Ljubljana | 1 | | | | | 2 |

* Under Pathology are also included entries for bacteriology, virology, and entomology.