PHYTOGEOGRAPHY AND VEGETATION ECOLOGY OF CUBA

BY

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To the memory of my unforgettable master

Julian Acuña Gale

expert of Cuban botany and agriculture,
the model of a great man and scientist

INTRODUCTION

My studies on the flora and vegetation of Cuba began in 1965 and were initially based entirely on published work. The literature on the Caribbean region was fairly poor, therefore, I extended the literature survey to the general features of tropical vegetation, with emphasis on the geobotanical methods applied or potentially applicable to the tropics.

In this respect, my study-tour to Paris in 1967 was most worthwhile for I had the opportunity to attend a course on tropical botany at the University of Paris and to consult with some of the most distinguished representatives of tropical vegetation research and mapping (Professors M. Mangenot, A. Aubréville, Dr. J. Vidal and Dr. Mme S. Jovet Ast). I am most grateful to them for their advice, patience and tolerance. I was deeply impressed by Professor H. Gaussen whose personal letters, publication series on bioclimatology and mapping provided me with a thorough systematic and methodological concept of the modern bioclimatological principles.

My first study trip to Cuba took place from July 1969 to September 1970, with the task to organize and instruct a geobotanical mapping group, and to draw a vegetation map of Cuba at the scale of 1:1,000,000. This work received a modest financial and a considerable moral support by the Hungarian Academy of Sciences, primarily by István Láng Secretary General for which I should like to express my gratitude. I should like to stress the scientific advice and professional support received from J. Balogh, Member of the Hungarian Academy of Sciences, Professor of Zoology at the Eötvös Loránd University, Budapest, the most recognized Hungarian expert of tropical soil biology; and from T. Pócs, head of department of the Institute of Ecology and Botany of the Hungarian Academy of Sciences, who has extensive experience in tropical bryology and bryogeography.

The fact that it was possible to complete the mapping project within the 14 months of my first Cuban stay and to obtain important results in geobotany, phytogeography and taxonomy was due to the Cuban Academy of Sciences and the inexhaustible help of Cuban colleagues, co-workers and professionals. Primarily, I should mention my master, J. Acuña Gale, the great personality of Cuban botany and agriculture who regretfully passed away in 1973 but who still lives in my grateful memory. By revising 14 000 herbarium sheets of our collection, with his unselfish and devoted teaching of his taxonomic knowledge and extensive field experience he was an outstanding example of both botanical expertise and human greatness. In a few months he introduced me to the flora of six and a half thousand vascular species of Cuba thus making me able to carry on a successful vegetation study.

I am grateful to O. Muñiz, former Director of the Botanical Institute of the Cuban Academy of Sciences, who could ensure favourable working conditions for me even in the difficult phase of the organization of the institute. He took the lion's share in organizing our expeditions and actively participating in the field trips thereby contributing to their success. Besides this, he was my devoted collaborator in the preparation of the maps of the phytogeographical regions and vegetation of Cuba. Thanks are due to the numerous members of the staff of the institute. I am grateful especially to Dr. Antonia Garcia Gavilán for her long and painstaking work in collecting meteorological data and in helping me with the literature survey, to Isabel Elias for performing calculations in the life-form and flora analyses and expert management of the collected plant material, to Sergio Vazquez for his exceptional and enthusiastic field work, to Nazario Gonzales for his multilateral help, and to A. Izquierdo, Director of the Water Management Research Institute, for providing me with unpublished data of measurements of the institute. Without their understanding and help, our investigations aimed at determining the potential vegetation and creating a bioclimatological survey of Cuba could not have been possible.

During my second Cuban visit of 29 months (1974—1976), together with E. del Risco and R. Capote, we worked out the long-term plan of the Geobotanical Department which had meanwhile been set up in the Botanical Institute of the Cuban Academy of Sciences.

Research was commenced in two topics:

1. Ecological studies of a tropical evergreen forest in the MAB — station in the Sierra del Rosario.

2. The preparation of the Vegetation map of Cuba at the scale of 1:250 000. In the framework of an earlier project, together with E. del Risco, we completed the vegetation map of the Zapata Peninsula at the scale of 1:100 000. In the course of our work an opportunity arose to continue our research on the ecology and geobotany of Cuba with the help of gifted young Cuban geobotanists. E. del Risco deserves appreciation since, after a year of collaboration, he is compiling the geobotanic monograph of Zapata Peninsula. I received valuable help from my young collaborators. R. Capote, in the course of mapping the vegetation of Pinar del Rio province at a scale of 1:250 000, became proficient in the application of modern geobotanic mapping methods. J. Urbino gained experience in the geobotanical interpretation of aerial photographs, and helped me in mapping the plant communities. We worked out an analytic key for the geobotanical interpretation of aerial photographs. Ramona Oviedo participated in the taxonomic identification of the collected material and, during our collecting trips, became a reliable expert of the dicotyledonous flora of Cuba.

Althougth I use only partial results from our joint research in this book, the colleagues deserve acknowledgement for their diligence and enthusiastic collaboration. Thanks are due to O. Muñiz, for his support and deep understanding without which our project could not have been finished with success.

Data processing and evaluation required a further three years of intensive work.

I am indebted to dr. Zoltán Szőcs, my colleague, for his valuable help in the computer processing of the huge mass of phytosociological data. For scrutinizing the literature on plate tectonics and providing guidelines, thanks are due to Dr. Károly Brezsnyánszky. I am grateful to Mrs. H. Muhoray for preparing the drawings, and to Mrs. F. Zotter and Mrs. S. Baksza for their help in compiling the manuscript.

I should like to express my thanks to Prof. Imre Máthé and Pál Jakucs, Members of the Academy, to Prof. Tamás Pócs to László Kádár, Professor of Geography of the University of Debrecen, and to Dr. Edmund Tanner, Lecturer of the Botany School of Cambridge University, for the critical reading of this text thereby eliminating mistakes and misinterpretations.

In some taxonomic and botanical historic questions, Prof. Richard A. Howard, former Director of the Arnold Arboretum of Harvard University, and Prof. William T. Stearn, former Director of the Botanical Department of the British Museum oriented me very kindly. I am very thankful for their help.

The English text was translated by Mrs. I. Kecskés and Dr. J. Podani and the critical reading of the translation was made by Dr. J. Podani, Prof. L. Mihályi and Dr. E. Tanner. For their helpful and important remarks I wish to express my gratitude.

Last but not least, I am extremely grateful to my wife, Zsuzsanna B. Thury, and to her kind parents for their understanding, endurance and capacity for sacrifice without which this book could hardly have been written. I have to thank my wife especially for her valuable work in revising the Herbarium of the Academy of Sciences of Cuba (HAC) for carrying out leaf-size measurements of Cuban trees and shrubs, and for her help in the compilation of the literature.

Scientific preliminaries and objectives

The scientific preliminaries in Cuba, just as in most tropical countries, are closely correlated with the history of the country, political situation and economic conditions. Cuba was a Spanish colony until the end of the last century a half colonized republic under the sway of American monopoly, until 1959. So the scientific life was similar to that of the colonized countries. The plant kingdom of Cuba was studied and discovered mostly by foreigners, mainly American, Scandinavian, German and French researchers. The respectable figures of Cuban botany, such as Blain, Sauvalle, Roig and Acuña, were physicians, pharmacists, agricultural engineers who struggled as amateurs to attain the highest ranks in the knowledge and study of the Cuban flora. However, they had neither time nor financial support necessary to compete with the professional foreign researchers supported by considerable funds. Nevertheless, they did not want the botanical values of their country to be discovered without their participation and they (especially Roig and Acuña) — took a major share in flora research and in the establishment of the national collection.

After the revolution, the situation of science changed basically. The Cuban Academy of Sciences was formed with numerous research sites and institutions. In these institutes there are many foreign experts, especially from the East-European countries who work under the guidance and control of home institutions with the organization of Cuban research workers, according to a more or less well-developed long-term research plan.

Exploration and study of the Flora

Two hundred years of Cuban botanical research are almost entirely associated with flora research. Its history was compiled up to the turn of the century by Urban (1898), till 1945 by León (1946) and until 1957 by Alvarez Condé (1958).

The history of flora research in Cuba can be divided into three stages. The first is from the discovery of Cuba till 1850; this period is characterized by sporadic collecting extended over small areas. More important explorers of this period were Kunth, Linden, La Ossa, Valenzuela, La Sagra, etc., whose collections were later named and revised in the early volumes of De Candolle's Prodromus and later by A. Richard in volumes X and XI of the great Cuban Encyclopaedia of La Sagra (1845, 1850). The feature best reflecting the second period is a comprehensive work encompassing large areas; it lasts from 1850 to the turn of the century. A most prominent figure is C. Wright who travelled all over Cuba with the exception of the highest mountains and tripled the number of the phanerogamous plant species known from this territory in 10 years.

His collections were identified by Grisebach, an outstanding expert in both taxonomy and plant geography 1857, 1860, 1862, 1864, 1866. To Grisebach's work Wright contributed additions (in Sauvalle 1868—71, 1873). Apart from him, dozens of specialists (Sullivan, Eaton, Berkeley, Muller, Underwood, Mueller von Argau, De Candolle, Schlechter, Urban) dealt with Wright's material which, even today, reveals points of interest to botanists.

The third phase of flora research stretches from the turn of the century till 1960. A feature of this period is the striving for a flora synthesis that summarizes the intensive collecting work of many researchers. The goals of this period are the establishment of large collections (New York, Stockholm, Berlin, Santiago de las Vegas, Havanna), the elimination of the "white spots", the reconstruction of Wright's itinerary and the identification of his type localities. Among the many excellent collectors (Combs, Curtiss, Baker, Britton, P. Wilson, León, Roig, Jack, Marie-Victorin, Acuña, Howard, Killip, Alain), J. A. Shafer's and, above all, E. L. Ekman's activity emerges in importance and achievement. Ekman was the first to explore the highest peaks of Sierra Maestra and Sierra del Cristal which were considered to be unconquerable. He alone collected more taxa than all the botanists together before him. The elaboration of the collections made in this wonderful period is being carried out by three exceptionally talented taxonomists (Urban, Britton and Marie-Victorin) as well as numerous excellent specialists (for example Hitchcock, Chase, R. E. Fries, Moldenke, O. C. Schmidt, Loesener, Kükenthal, Cogniaux, Schlechter, Maxon, Morton, Standley, Mc Vaugh, etc.). In consequence of their work, the vascular flora of Cuba surpassed 6300 known species. After numerous attempts at synthesizing (Gómez de la Maza and Roig 1914, Roig 1928, Britton, Wilson and León 1914, 1932 ined.), the first comprehensive work appeared in five volumes by León (1946). León and Alain (1951—1957), Alain (1962), and in a supplement (Alain 1969). Although this work is an important milestone in the Cuban flora research, it cannot be regarded as a final one.

In the 10 years since its publication, eight new phanerogamous genera and almost 500 new species and subspecies enriched the Cuban flora as a consequence of research partly by Alain Liogier further by Bisse, Lippold, Areces, Mészáros, and partly by Borhidi, Borhidi, Acuña and Muñiz, Borhidi and M. Fernandez, Borhidi and Muñiz, M. Fernandez and Borhidi, Muñiz and Borhidi, Klotz, Lepper, Manitz, Köhler, Meyer, Dietrich, Leyva, Alvarez, Diaz, J. Fernandez etc.

At present, the fourth phase of flora research is taking place whose goal is the preparation of a detailed critical flora work. A characteristic of this phase is that whereas only selected localities were explored previously, now the aim is the thorough study of whole geographic regions and the increase of knowledge on the natural variability of taxa. Such work demands collecting from many areas and an extensive critical approach. This kind of work has been started from 1975 within the framework of the "New Flora of Cuba Project" organized by the National Botanical Garden of Cuba in collaboration with the Botanical Department of the University of Jena (GDR) with the participation of about 50 specialists of Cuba, GDR, USSR, Hungary, Poland, The Netherlands, Belgium etc. A large number of preliminary studies and genus-monographs have been published as products of this project in the reviews "Revista del Jardin Botánico National", "Ciencias Biológicas", "Acta Botanica Cubana", "Acta Botanica Hungarica", "Feddes Repertorium", "Wiss. Zeitschrift der Universität Jena" etc.

Plant geographical studies

The so-called "ecological" research (or more precisely, geobotanical, chorographical and plant geographical) was extremely restricted till 1960. Ekman (in Urban 1923, 1924) first provided a short description of some characteristic Cuban plant formations. In the course of flora explorations about one hundred floristic and geographic publications appeared mainly due to León and Alain, Acuña and Roig. The first trip with a geobotanic approach was due to Seifriz, who distinguished ten plant formations and thereby provided a survey of the most important vegetation types of the island (1943). The most intriguing is the magnificent three-volume diary of the expedition of Marie-Victorin and León (1942, 1944, 1956), which is virtually a storehouse of original observations. Many original chorological data, plant distribution maps and numerous valuable comments are contained in it with respect to the structure and distribution of certain vegetation types, and to their more interesting plant species. Carabia's (1945a) study on the vegetation of Sierra de Nipe, Lötschert's (1958) work on the conic karst vegetation of Sierra de los Organos, and P. Ponce-León's (1952, 1953, 1954) zonation studies on the vegetation of the sandy and rocky littoral belts and the lowland semi-deciduous forests are worth mentioning. These are simply qualitative surveys of vegetation without structural and quantitative analyses. The first quantitative analysis was carried out by Howard and Briggs (1953) on the microphyllous shrubforests, in the limestone "dog-tooth" area of the south coast of Las Villas. E. Smith's work, "The Forests of Cuba", provides a survey on the tree species of Cuban forests valuable from a forestry point of view and gives a practical classification of forests. Its qualitative lists and sample plot analyses contain many valuable data but are incomplete from a phytosociological viewpoint. As the lists were compiled primarily for the assessment of valuable timber species, they give the impression that the composition of tree species of Cuban forests is everywhere almost identical, this is not the case, of course.

Geobotanical research

The geobotanical, phytosociological and ecological research, understood in the strictest sense, began following the revolution in the sixties mainly with the collaboration of Czechoslovakian, German and Hungarian botanists. V. Samek's work should be particularly emphasized. He investigated the pine-woodlands and forests of Isla de Pinos, Cajalbana and Sierra de Nipe, and the water vegetation of sandy lagoons of the Guanahacabibes Peninsula (Samek and Moncada 1970) with the phytosociological methods of the Zürich–Montpellier school (1967, 1973 a,b). Furthermore, he mapped the vegetation of Isla de Pinos (1967, 1969). Hadač and Hádačová (1969, 1971), studied some plant communities in the sandy regions of Pinar del Rio, and carried out autoecological investigations on several Cuban plant species. Schubert and Danert (1969, 1971) studied two nature conservation areas (El Veral and Cupeyal) with respect to their plant communities and microclimate. Gantcheff (1968) attempted to write a phytosociological monograph on the vegetation of the latter area.

With respect to the ecological effect of serpentine rocks on the tropical vegetation, Berazain (1979, 1981), Borhidi (1975, 1980), Borhidi and Pócs (1985) reported new results. On the origin and distribution of Cuban savannas Borhidi and R. Herrera (1977) have presented a detailed account. The first systematic review of the Cuban plant communities appeared in 1979 (published by Borhidi, Muñiz and Del-Risco). Since that time an intensive exploration of the plant communities has been made by Borhidi, R. Capote, Balátová-Tuláčková and their collaborators (see: Acta Bot. Hung., Folia Geobot. et Phytotax., and Acta Botanica Cubana).

Phytogeographic division

The first short summary of the phytogeographic relationships of Cuba appeared in the first volume of the Flora of Cuba (1946:45—63) by León who distinguished 3 phytogeographic regions and 9 districts. The more recent, so-called "geobotanic map" of Voronov is only a little more detailed (Atlas Nacional de Cuba 1970:59). Samek's (1973 c) work is a valuable phytogeographical study, which is primarily based on the distribution patterns of endemic species. A different view was pointed out by Bisse (1975) about the phytogeographic regions of Cuba. He proposed to distinguish 4 floristic sectors. This opinion was not followed by Klotz (1978). The work of R. A. Howard (1974) on the vegetation of the Antilles is worth mentioning. It presents interesting tables on the patterns of plant distribution in the Antilles. Numerous smaller articles appeared on the characteristics of plant area types, especially on the richness of endemic species (León 1926, Carabia 1945, Alain 1953). The most outstanding works are the excellent review of Alain (1958) and Muñiz's map on the ecological requirements and geographic distribution of the endemics (Atlas Nacional de Cuba 1970:60). All these works and the field experiences served as bases for the authors to work out a new phytogeographic survey of Cuba related to the recent results of the Global Tectonics (Borhidi 1985, Borhidi and Muñiz 1986).

Vegetation maps

Five vegetation maps of Cuba have been made. The first appeared in the inside face of the cover of the first volume of Flora of Cuba (León 1946), at the scale of 1:5 million. This illustrated the natural vegetation, distinguishing among 8 vegetation units altogether.

The second map appeared in the Atlas Nacional (1970:58—59) after our work had begun. It was prepared in the scale of 1:1.5 million by A. Alonso and Voronov with the collaboration of Cuban geographers. This map is based on 3 months of field work and depicts the actual vegetation of Cuba. However, large areas are indicated as being agricultural lands, the map does not distinguish among the different polydominant forest types (there are at least 6 types). Its units cannot be identified with the generally accepted types shown by tropical vegetation maps. A potential vegetation map at the scale of 1:3 750 000 is available (Borhidi 1974). It contains 21 vegetation units and is the simplified version of map (1:1000 000) published by Borhidi and Muñiz in 1980 and 1984 distinguishing 34 vegetation units, and several derived thematical maps. Another important map was published on the actual vegetation of Cuba by A. Areces in the Atlas de Cuba (1978:38—39) in a scale of 1:1.750 000.

Bioclimatic studies

Bioclimatic research started only in the recent past. Only one publication has appeared. Samek and Travieso's work on Cuban climatic regions (1968) is based exclusively on data from lowland meteorological stations and so it is biased. Since the authors were not aware of either Gaussen's or Walter's or Meher-Homji's climatic divisions, their climatic types are of local importance.

As a summary of a comprehensive bioclimatological study, the first correct bioclimatological map and a complex bioclimatological and vegetation transect was published in Borhidi's book (1974) and later in Borhidi and Muñiz (1980, 1984).

After the critical examination of the preliminaries outlined above, I set as my goal the following procedure and order of realization.

Map of the potential vegetation

My main task was the modern reconstruction of the natural potential vegetation in a map at a scale of 1:1 million. The following partial tasks had to be solved to achieve this goal.

Typification of vegetation

Establishing the vegetation units to be mapped and their structural analysis at the formation level are involved in typification. In connection with this, the meaning of the different local vegetation names are to be revealed.

Vegetation analysis

The analysis of structure and composition of the different units of vegetation and their ecological investigation are objectives of plant sociological and ecological basic research.

Bioclimatological research

Bioclimatological basic research of the actual vegetation is indispensable for the theoretical reconstruction and mapping of the natural potential vegetation. Considering that three quarters of the area of Cuba are covered by secondary and semi-anthropic formations, the preparation of a bioclimatological map of Cuba has become necessary. It was also important to provide an as comprehensive bioclimatic synthesis of the whole country and its most varied regions as possible.

Life-forms and phytogeographic elements

As the structural investigation of the vegetation types to be mapped is based on the life from types, it was our aim to know the life-form types and the distribution types (geoelements) of the vascular flora of Cuba (almost 6600 species). On this basis it was possible to prepare the first ecological spectrum and plant geographic analysis of the Cuban flora (Borhidi 1982).

Phytogeographical regionalization

In connection with the vegetation mapping, the extension of the programme of the expedition made it possible to explore the inner and outer phytogeographical relationships of the flora, so our aim was to prepare a new phytogeographic regionalization of Cuba. Its first version was elaborated by Borhidi and Muñiz in 1970 in manuscript later published by Borhidi (1973, 1976) in Hungarian. A Spanish version of this phytogeographic subdivision has been published in the second volume of Acevedo's Geography of Cuba (1986) and an English version by Borhidi (1985) and Borhidi and Muñiz (1986).

Geobotanic monograph

For the realization of the above goals it was finally possible to link all these in a geobotanic synthesis, the topic of this section. What the author had in mind was such a uniform comprehensive phytogeographic-geobotanic work which has been prepared in most countries of Europe but which is available only in a few tropical countries.

I have to stress that with respect to botanical investigations, in spite of what was mentioned above Cuba may only be considered to be behind compared to the European countries. As to the tropical countries, it is a relatively well-studied country. For laying the fundamentals of a synthesis, however, multilateral studies had to be carried out. In Europe, such a synthesis arises almost by itself from the meticulous measuring and data collecting activities of numerous research institutes and several dozen researchers over a few decades. In contrast with this, in Cuba a similar information and methodological basis of geobotanic research to be laid down at an accelerated rate, concentrating exclusively on the goals on which the subsequent more detailed research could be built.

This work, as a basic geobotanic synthesis, wished to serve two goals: a) by revealing the actual and potential situation of the natural resources of the vegetation, it attempted to give a scientific basis for a more rational land use and regional management and for developing an environmental protection system; b) laying the geobotanic basis on which Cuban botany could undertake scientific tasks related to terrestrial ecosystems in the framework of MAB or other biological research programmes.

Material and methods

Expeditions

For the realization of the mapping task, a 140-day field research expedition programme was developed. In the course of this, we travelled in Cuba from Cabo San Antonio to Punta Maisi and Isla de Pinos (Isla de la Juventud) around 10 000 km with trailer and landrover. Our field studies and observations were checked on several flights and complemented by aerial photographs. In many cases, we started out from the data of the geological and pedological maps. We established in the course of our field excursions that there were 36 types of zonal, extrazonal and azonal vegetation types to be mapped.

Vegetation belt profiles

First of all, the localization of the vegetation belts of the different mountain regions was clarified. We prepared profiles about altitudinal distribution of the climatic and vegetation belts, schemes of succession series and catenas of the contact and complex formations and communities.

Phytosociological sampling of plant communities

In the course of phytosociological sampling, we studied primarily the natural plant communities and, within these, the Lignosa type noda, the polydominant tropical forests, shrub forests (matorrales) and thickets nobody had previously dealt with. Altogether, over 500 phytosociological samples, more than 20 transects and a further 20 vegetational profiles have been prepared.

Methodological problems of sampling

Sampling created several methodological problems. We attempted with my collaborators to find the most appropriate method for solving the task. Therefore, the same vegetation object was very often studied with different methods.

Sampling of monodominant and oligodominant vegetation

We established that for the sampling of communities composed of few strata and the monodominant and oligodominant communities (meadows, water vegetation pine woodland, oak forests) the method of the Zürich–Montpellier school was perfectly suitable. This method was adapted in most cases; the abundance-dominance and sociability values of the Braun-Blanquet scale were estimated. The 11 valued Domin scale was also made (see Kershaw 1968, Hadač and Hadačová 1971) since the values obtained in this way are more suitable for data analysis according to Bannister (1966). Our experience suggested that the advantages of the Domin scale in data analysis technique diminish because of the sampling errors. It is difficult to estimate certain values of the Domin scale in the field.

Sampling of polydominant tropical forests

The sampling of polydominant tropical forests was carried out using two kinds of methods, which were often combined. On the one hand we prepared a vegetation transect of an area of 5 × 30 to 5 × 150 m (cf. Lindeman 1953, Webb 1959), according to Richards' method in Richards, Tansley and Watt (1940), depending on the vertical structure of each community. On the other hand, square plots were taken using the method of the Zürich–Montpellier school. The minimal areas were different in the community levels. In the canopy it varied between 500—5000 m^2, in the shrub layer it was 300—1000 m^2, and in the herb layer the minimum area was 50—200 m^2. In the epiphytic layers, the number of individuals was recorded or estimated for an average tree and the occurrence within a square was also recorded (according to Tixier 1966). In the other levels, dominance and sociability were determined on the scale mentioned above.

Method of transforming a Richards' transect into a Braun-Blanquet's square plot

The study of a tropical polydominant forest with the Zürich–Montpellier school method is a tedious hard work. Nevertheless, we found it necessary to use such a method for sampling as we could get more detailed data, thus a more objective comparison of the floristic composition of tropical polydominant forests became possible. That we could express a profile of the Richards' type for the canopy in the AD scale meant a considerable saving of time and costs. The essence of the method is that for each species we calculated the average canopy diameter by measuring that of each individual. From it the percentage cover of every species could be directly calculated.

Sampling plots in scrub forests

The most difficult sampling was that of the closed scrub forests if we consider that the high density was accompanied by high diversity. In these communities, 2 × 20 m transects were cut and 5 such transects were taken as one sample.

Classification of vegetation units by computer techniques

In the classification of the sociological units studied, the obviously different water plant communities, swamp meadows coastal grasslands and mangroves were separated from the other communities.

Forty forest and scrub communities — containing 2042 species in 267 samples were classified using several computer methods. The floristic diversity of noda was studied by Z. Szőcs, using principal component analysis (PCA, Lawley and Maxwell 1963 and Harman 1967) with 5 factors taken into account.

The classification of noda was examined according to their structural characteristics, flora element composition and life-form structure in the studied communities. The agglomerative clustering procedure of Orlóci (Orlóci 1967, Goldstein and Grigal 1972) was used. The calculations were carried out by a CDC 3300 computer.

The reconstruction of the original vegetation

We paid particular attention to revealing and establishing the original vegetation types of the cultivated areas and to the study of the origin of actual anthropic and semi-anthropic formations. On the basis of 5 years of observations of the new 3000-station precipitation network of the Water Management Institute, we drew up a new precipitation map of Cuba and a map of the climatic water balance (precipitation—evaporation). To characterize the climates ecologically, we analyzed published data from 400 stations and processed unpublished rough data of a further 600 stations. On the basis of 217 climatic diagrams selected from these analyses, according to Gaussen's bioclimatological classification, we established the climatic types of Cuba and their distribution, and prepared the bioclimatological map of Cuba. Eleven complex bioclimatological and vegetation transects were made at the characteristic points of the island for studying the correlation between climate and vegetation. These investigations permitted us to reconstruct by extrapolation the potential natural vegetation of the anthropically modified waste territories, and to draw up the vegetation map of the country.

From the bioclimatological research we prepared an ecological map of Cuba according to Holdridge's life-zone system. We found some inaccuracies in the parameters of the Holdridge's life-zone pyramide and proposed a new quick method for PE estimation. The method was checked by linear regression analysis.

Life-form and phytogeographic analysis

We determined the life-form and chorological distribution pattern types of 6350 phanerogamic and 500 vascular cryptogamic plant species of Cuba. On this basis the first life-form and chorological analysis of the Cuban flora was prepared. A leaf-size analysis of the trees and shrubs (about 3000 species) was also performed.

Phytogeographical division

In order to clear up the phytogeographical position of Cuba the phytogeographical subdivision of the Caribbean floristic region has been revised and a new phytogeographic map and regionalization of Cuba as well as the phytogeographical geobotanical characterization of phytogeographic regional units (phytogeographic region, province, sector, district) have been prepared. To illustrate the characteristic distribution patterns and evolution of Cuban flora, original chorological maps were prepared. Further conclusions were drawn as to the origin, probable evolution centres and migration routes of some characteristic ecological groups.

Taxonomic work

In addition to mapping, 20 000 plant specimens were collected and identified with the help of Acuña. From this material 5 new genera, more than 350 species, subspecies and varieties have been described. In some cases, we carried out special taxonomic studies on phytogeographically significant species (e.g., *Amyris stromatophylla, Maytenus buxifolia, Calycogonium rosmarinifolium, Anemia coriacea)* and genera (e.g. *Schmidtottia Machaonia, Scolosanthus, Moacroton, Leucocroton,* etc).

Documentation of results

This book will be concerned only with floristic-geobotanic results and will not deal with taxonomic research, although these results, e.g., distribution maps, formed the starting point for the conclusions so they are implicitly present. Reference will be made to these wherever appropriate.

Figures

We attempted to illustrate the topic of this book with appropriate figures and photographs, with an aim to emphasize more essential aspects from the mass of data supplied by the text and tables. Apart from the most important formations and vegetation types, the photographs will show several dominant and characteristic species and indicator plants.

The logic of the discussion

The logic of the discussion, in accordance with the demands of the synthesis does not follow the deductive train of thought from the phenomenon towards the cause. By discussing the vegetation as a result of environmental and evolution processes, it wishes to approach the topic inductively and to comprehend the development, structure, various properties and distribution of the vegetation. Accordingly, starting out from the climate-soil-vegetation trilateral-system, the book will treat first the climatic conditions and mainly the special bioclimatical aspects of climate-vegetation interrelations (Part I), some general and more important questions of the soil-vegetation relationships (Part II).

Then, it will deal with the origin, migration, chorological and ecological aspects of the flora (Part III) and then the phytogeographic regions of Cuba will be presented (Part IV). The mapped vegetation units, their structure, composition and general ecological properties will be given, also treating the problems of classifying tropical vegetation (Part V). Finally, an attempt will be made to give a systematic survey of Cuban plant communities (Part VI).

From the synthetic aspect of the book it was unavoidable to write some general chapters about the geography, climatic, geological, and soil conditions of Cuba, in which we did not carry out original research but which contain necessary basic information whose knowledge promotes the understanding of the parts on bioclimatology, ecology, phytogeography and geobotany.