THE VEGETATION OF THE NETHERLANDS ANTILLES

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INTRODUCTION

This vegetation survey is the outcome of an investigation of the islands of the Netherlands Antilles carried out under the auspices of the Foundation for Scientific Research in Surinam and the Netherlands Antilles. The data on which the present study is based were obtained during a trip which lasted from September 1952 until October 1953. During this trip the following islands were visited: Curaçao, Bonaire, Aruba, St. Martin, Saba, and St. Eustatius. A short visit was also paid to the island of St. Kitts (B.W.I.).

The present work gives an account of the actual vegetation of the Netherlands Antilles. Other studies, comprising the systematic results and conclusions of the survey, are being prepared, and will possibly be published in 1958.

In order to avoid confusion with regard to nomenclature and terminology, this report has been largely based on the system suggested by B e a r d (1944, 1949), as it appeared to be the most suitable for the area. The greatest deviation from Beard's system concerns the strand communities, the vegetation of salt flats and salinas, and the Hippomane woodland, which are considered as edaphic communities, whereas B e a r d regards them as being sub-climax communities of littoral woodland.

It must be emphasized that the descriptions of the regions investigated reflect only the plant growth at a certain moment, as the plant cover during the dry season greatly differs from that during the rainy season. In this connection the author has been unfortunate, since precipitation remained far below the average during his stay in the islands. In 1952, the approximate precipitation amounted to only 320 mm in Aruba, 470 mm in Bonaire and 490 mm in Curaçao, whereas the average precipitation in these islands amounts to 447 mm, 511 mm, and 559 mm respectively. With regard to the islands of the Windward Group the following figures may be given (1953): St. Maarten 870 mm, Saba 830 mm, and St. Eustatius 645 mm, as compared with the averages for these islands of 1027 mm, 1133 mm, and 1110 mm respectively.

Furthermore, it must be borne in mind that the vegetation has been strongly affected by human interference and by the grazing activity of goats and cattle, except as regards a few very restricted localities, such as, for instance, the top of The Mountain in Saba and the highest part of the rim of The Quill in St. Eustatius.

Where possible, the field data were obtained by enumerating strips or quadrats in forests and woodlands; in the thickets data were obtained by visual estimation. In doubtful cases samples were collected in order to check the identification.

Following B e a r d, a distinction has been made between forest and woodland. The former term, as used here, indicates a vegetation usually over 15 m in height, in which the trees show a more or less distinct

stratification into 2—4 layers; the latter indicates a vegetation 3—10 metres in height without distinct stratification of the trees, a large number of which have often become shrubby. Thickets do not usually exceed 1.50 m in height, and are composed mostly of shrubs or very low, shrubby trees.

The forests have been divided into two groups: seasonal forest and dry evergreen forest. Evergreen seasonal forest, and possibly also semi-evergreen seasonal forest, is a form of the tropical rain forest in the wide sense. The terms have been introduced by B e a r d (1944, 1949) to distinguish them from the equatorial rain forest growing in a climate without a well-marked dry season.

The following abbreviations have been used: v.a — very abundant, a — abundant, fr — frequent, r — rare, and o — occasional.

The present volume consists of two parts. The first part, comprising Chapters I to IV, deals with the Leeward Group, including the islands of Aruba, Bonaire and Curaçao. The second part, comprising Chapters V to VIII, deals with the Windward Group, including the islands of St. Martin, Saba and St. Eustatius. Chapters I and V deal with the environmental factors, such as the geographical position, climate, geology, etc. of the two groups. Chapters II and VI give notes on the flora, viz. botanical collections, plant geography, etc. In Chapters III and VII a description is given of the regions investigated. The figures between brackets in these chapters refer to the localities cited in the following Chapters IV and VIII, whilst the Roman figures, also between brackets, refer to the types of vegetation described in Chapters IV and VIII. In Chapters IV and VIII, types of vegetation occurring in the Leeward Group and the Windward Group, respectively, are discussed.

The topography of the vegetation maps is taken from various sources: that of Curaçao from J. I. S. Zonneveld (unpublished), that of Aruba from the Government Survey Department (1950), that of Bonaire from J. H. Westermann and J. I. S. Zonneveld (1956), whilst the topography of St. Maarten, Saba and St. Eustatius is taken from J. S. Veenenbos (1955). The vegetation maps were drawn by the draughtsman of the Botanical Museum and Herbarium of the State University of Utrecht.

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J. C. Paap and K. A. van Rijswijk, respectively Governor and Acting Governor of the islands of the Windward Group; Mr. L. Carthy, former Administrator of the island of Saba; and Dr. W. J. Goslinga, former Director of the Department of Education in Curaçao. And the author is indebted most of all to Brother M. Arnoldo, for his very valuable help: his knowledge of the local flora greatly facilitated the investigation, especially with regard to the islands of the Leeward Group.

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Attention is drawn to the following terms, which are often used in different meanings but which here cover the areas as stated:

West Indies	Antilles, Bahamas, Florida Keys, Bermuda, Cayman Islands, Swan Island, Old Providence, San Andrés
Antilles	from Cuba to Trinidad and Aruba
Greater Antilles	from Cuba to Puerto Rico
Lesser Antilles	from Virgin Islands to Trinidad and Aruba
Windward Group	from Virgin Islands to Grenada (Bovenwindse Eilanden, Islas de Barlovento, Iles sur le Vent, Inseln über dem Winde)
Leeward Islands	(British usage) from Virgin Islands to Dominica
Windward Islands	(British usage) from Martinique to Grenada
Leeward Group	from Los Testigos to Aruba and Los Monges (Benedenwindse Eilanden, Islas de Sotavento, Iles sous le Vent, Inseln unter dem Winde)


SKETCH-MAP
OF THE
CARIBBEAN
300 miles
500 km
U. S. A.
FLORIDA
GULF OF
MEXICO
BAHAMA ISLANDS
GRAND BAHAMA
GREAT ABACO
BIMINI
DRY TORTUGAS
ANDROS
NEW PROVIDENCE
ELEUTHERA
CAT IS.
SAN SALVADOR (WATLING)
EXUMA
LONG IS.
PLANA CAYS
CAICOS
TURKS IS.
GREAT INAGUA
ATLANTIC OCEAN
YUCATAN
COZUMEL IS
MEXICO
CUBA
ISLA DE PINOS
CAYMAN ISLANDS
GUATE-MALA
BRITISH HONDURAS
SWAN IS.
JAMAICA
NAVASSA
PEDRO CAYS
MORANT CAYS
HAITI
DOMINICAN REPUBLIC
MONA
I. BEATA
I. SAONA
HISPANIOLA
PUERTO RICO
LEEWARD ISLANDS
TORTOLA
VIRGIN IS.
ST. CROIX
ANGUILLA
ST. MARTIN
SABA
BARBUDA
ANTIGUA
ST. KITTS
NEVIS
MONTSERRAT
GUADELOUPE
DOMINICA
ISLOTE AVES
MARTINIQUE
ST. LUCIA
BARBADOS
ST. VINCENT
GRENADINES
GRENADA
WINDWARD ISLANDS
HONDURAS
EL SALVADOR
NICARAGUA
SERRANA CAYS
CARIBBEAN SEA
ARUBA
CURAÇAO
BONAIRE
ROQUES
ORCHILA
BLANQUILLA
TORTUGA
MARGARITA
TOBAGO
TRINIDAD
COSTA RICA
PANAMA
VENEZUELA
BRITISH GUIANA
SURINAM
FRENCH GUIANA
PACIFIC OCEAN
COLOMBIA
BRAZIL

THE LEEWARD GROUP

CHAPTER I

ENVIRONMENTAL FACTORS

GEOGRAPHICAL POSITION

The islands of Aruba, Bonaire and Curaçao form part of a row of small islands off the north coast of Venezuela.

	Situation	Greatest length	Greatest width	Approximate total land area	Highest point
Aruba	12°24'30" — 12°37'30" N 69°52'30" — 70°4' W	30 km	8 km	175 sq.km	188 m
Bonaire	12°2' — 12°19' N 68°12' — 68°25' W	35 km	11 km	265 sq.km	240 m
Curaçao	12°2' — 12°23'30" N 68°44'30" — 69°10' W	59 km	11 km	425 sq.km	372 m

Aruba lies 27 km north of the peninsula of Paraguaná and 76 km west of Curaçao; it is separated from the former by a stretch of sea with a maximum depth of 180 m, and from the latter by a channel 1,300 m deep. Bonaire lies 40 km east of Curaçao and 87 km from the South American continent; it is separated from the former by a stretch of sea with a maximum depth of 1,500 m, and from the latter by a stretch of sea with a maximum depth of 1,700 m. Curaçao lies 64 km from the peninsula of Paraguaná and is separated from it by a stretch of sea with a maximum depth of 1,400 m.

CLIMATE

A. Temperature

As they are situated in the tropics, the average annual temperature in the islands is 27.5° C. Only one temperature maximum occurs in the course of the year. September is considered to be the hottest month, January and February the coolest. The average monthly maximum temperature varies between 32.3° C (in September) and 28.7° C (in January), the average monthly minimum between 23.0° C (January) and 26.1° C (September). Conditions are therefore very equable.

Temperature of Hato Airport, Curaçao

from the original records of the Meteorological Service, 1947—1952 (in °C)

	Mean	Mean max.	Mean min.	Abs. max.	Abs. min.
January	25.9	28.7	23.0	29.9	21.2
February	26.1	28.9	23.5	30.1	21.2
March	26.4	29.3	23.6	30.1	21.6
April	27.0	29.8	24.5	31.4	22.2
May	27.8	30.8	25.5	32.6	23.9
June	28.0	30.8	25.3	32.1	23.3
July	28.0	30.9	25.3	32.0	23.6
August	28.1	31.6	25.3	33.0	23.2
September	29.0	32.3	26.1	34.2	23.6
October	28.5	31.6	25.6	33.3	22.3
November	27.8	31.1	25.0	32.6	22.1
December	26.9	29.5	24.0	30.9	21.1
Year	27.5	30.4	24.7		

B. HUMIDITY

The mean relative humidity is always rather high.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. Rel. Humid. %	73.6	73.6	72.8	73.5	74.8	75.1	75.1	75.0	72.8	74.8	74.5	76.8
Min. Rel. Humid. %	50.1	50.1	49.0	51.6	51.1	54.1	52.1	49.3	45.5	51.1	49.5	51.5

Cloudiness is greatest in the morning, least at noon, and increases again before sunset. The degree of cloudiness is rather low.

	< 0.1	0.1—0.5	0.5—0.9	> 0.9		< 0.1	0.1—0.5	0.5—0.9	> 0.9
January	23%	42%	22%	13%	July	16%	40%	28%	16%
February	20	42	23	15	August	22	39	28	11
March	25	43	21	11	September	20	38	28	14
April	20	37	26	17	October	13	36	28	23
May	15	33	26	26	November	15	44	27	14
June	16	33	30	21	December	17	40	26	17

Even in the rainy season drizzly weather is rare, and rain falls in short-lived showers, followed by rapid clearing. Data concerning relative humidity and cloudiness have been obtained from the original records of the Meteorological Service, Hato, Curaçao, for the years 1947—1951.

C. Wind

The prevailing trade winds, to which the islands are greatly exposed, are easterly, varying from east-north-east to east-south-east. These sea-winds blow very steadily, with only slightly diminished force even during the night, rendering the heat less oppressive than the high daily temperatures would suggest. The islands are situated just south of the most southerly hurricane track, and consequently are not subject to these disturbances. The mean wind velocity in metres per second at three Curaçao localities is given in the following table.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Fort Amsterdam	3.5	3.7	4.4	4.5	4.8	5.3	4.8	4.1	3.6	2.7	2.2	2.8
Cas Chiquito	4.5	4.5	5.3	6.1	6.5	6.3	5.9	5.5	4.7	3.5	3.1	3.5
Hato	6.5	7.3	7.7	7.4	7.5	8.4	7.5	6.7	6.5	5.7	6.0	5.9

The data for Fort Amsterdam were obtained during the years 1910—1921; however, the surrounding buildings made the site of observations unfavourable. Those for Cas Chiquito (which is in a more favourable position than Fort Amsterdam) were taken during the years 1921—1926 (B r a a k 1935). Data for Hato come from the original records of the Meteorological Service, Hato, during the years 1947—1952; the high figures for this station are due to the fact that Hato is situated on the north coast of Curaçao and is therefore extremely exposed to the trade winds.

D. Rainfall

The Leeward Islands fall within the area of low rainfall which extends along the north coast of South America between the mouth of the Rio Orinoco and that of the River Magdalena. The climate of this isolated dry region belongs to the "steppe climate" of Köppen, and is defined by the formula BShs'n''i. However, several small areas on the islands are certainly drier than the rest, and may qualify for definition as "desert climate" according to Köppen's classification. The highest point of Curaçao may receive more rain, but no accurate data are available. Rainfall is very irregular in quantity as well as in distribution during the year. Generally speaking, it is scanty from February until September. The total amount of precipitation during these months is about 200 mm in Curaçao and Bonaire, and less than 150 mm in Aruba. In the rainy season, from October till January, the average precipitation amounts to 300—350 mm.

The mean monthly rainfall in mm during the years 1947—1952 is given in the following table. The figures represent the average of observations at 17 stations in Curaçao, 3 stations in Bonaire and 4 in Aruba. (Original records of the Meteorological Service.) Data quoted from B r a a k are given between brackets. These data were obtained during the years 1901—1933 (Aruba), 1905—1933 (Bonaire) and 1894—1933 (Curaçao).

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Aruba	57.1	28.8	6.4	3.7	19.6	19.1	10.3	21.4	9.0	32.4	58.3	93.0	359.1
	(50)	(14)	(14)	(14)	(11)	(13)	(23)	(23)	(35)	(67)	(109)	(74)	(447)
Bonaire	60.4	45.6	32.5	9.5	8.0	30.2	22.4	29.1	13.7	77.4	107.1	89.2	525.1
	(55)	(27)	(15)	(16)	(12)	(16)	(26)	(24)	(39)	(70)	(122)	(90)	(511)
Curaçao	65.9	32.3	14.5	10.8	14.4	39.1	33.2	38.9	18.3	61.5	88.9	98.8	516.6
	(55)	(26)	(22)	(21)	(12)	(22)	(30)	(34)	(32)	(90)	(126)	(89)	(559)

According to Molengraaff (1929), in Curaçao the number of rainy seasons in which precipitation is less than average, is greater than those in which it is more. If, during the rainy season, precipitation is less than average, these four months could be added to those of the dry season, to form one long "dry period" which lasts at least 8 + 4 + 8 months. A succession of poor rainy seasons may cause such a dry period to extend over several years (Wagenaar Hummelinck 1940). In this way Molengraaff determined for Curaçao 3 dry periods of 68 months, 3 of 56 months, 3 of 44 months, 3 of 32 months and 10 of 20 months, largely on the basis of rainfall observations covering the last 200 years.

The rain falls chiefly in heavy, short-lived showers, which are often only of local importance. The number of days per annum in which rain falls varied between 62 in 1900 and 168 in 1910; the number per month varied between 0 and 28 (Braak 1935).

Visser (1949) supposes that there is a regularity in the variation of the precipitation, which might be connected with the occurrence of solar spots.

GEOLOGY

The data in this paragraph have been taken from Westermann (1949).

Aruba, Bonaire and Curaçao have much in common as regards geological features. Their basement consists of a series of volcanic and sedimentary rocks deposited in Upper Cretaceous time. Diabases are widely distributed in all three islands. Among the sediments tuffs, tuffites, cherts, conglomerates, sandstones and shales are common. At the beginning of the Tertiary (during the Laramide folding) a dioritic magma intruded into these Upper Cretaceous and early Tertiary formations. Owing to general uplift and subsequent denudation the older series has been partly removed and the diorite batholith has become exposed in various places. In this respect, however, there has been a distinct divergence in developments in the three islands.

The folding of the Cretaceous strata and the tectonic uplift have been paramount in the case of Aruba. As a consequence, the Cretaceous roof of the batholith has been removed to a great extent, and the diorite batholith with its differentiates has become exposed over a large area. In Curaçao the processes of folding and uplift have been less pronounced.

The Cretaceous roof is still intact, and the diorite batholith outcrops solely as dioritic and porphyritic dikes, piercing through the Cretaceous rocks in various places. The main body of the batholith has remained covered. In Bonaire folding and uplift have been relatively weak, and appear to have occurred in late Cretaceous time, i.e., before these processes took place in Aruba and Curaçao. Only a single dike of porphyritic diorite in the north-western part of the island testifies to the presence of the deep-lying batholith.

After a period of denudation the islands were repeatedly submerged during the Tertiary. During a partial transgression in the early Pleistocene all three of them were covered by a cap of reef limestone. This transgression was followed by a slight upwarping and subsequent denudation of the limestone covering and the underlying older rocks. Glacial movements of the sea-level and tectonic movements of the islands themselves, during Pleistocene and Holocene, caused the deposition of young limestone reefs and their subsequent emergence. The peculiar hand-shaped landlocked bays, connected with the sea by narrow gorges, owe their existence to the same movements. Intermittent elevation has shaped the sea-cut terraces of the older limestone.

PHYSIOGRAPHY

A. ARUBA

The western part of the island, outside the limestone district, consists of quartz-diorite and its derivatives. This area is generally flat, and the Hooiberg rises from the landscape like a big cone, to a height of 164 m. East of the quartz-diorite area, in the triangle between Matavidiri, Fontein and Spaans Lagoen, a diabase-schist-tuff formation is found, forming the hilly part of the island. Here the highest points occur (Jamanota 188 m, Arikok 185 m, Seroe Kabaai 170 m, and Gran Tonel 155 m). The higher hilltops mainly consist of metamorphosed and therefore more resistant diabase.

A limestone formation partly encircles these older formations, especially along the south-western coast and in the eastern part of the island. It often forms rather conspicuous table mountains.

Alluvial formations are found along the south-western coast near Savaneta, Spaans Lagoen and Oranjestad; along the western coast between Manchebo and Malmok; and very locally along the north and east coasts, where they result in dune formation.

Along the south-western coast, about 1 km offshore, lies a frequently interrupted wall of coral shingle and sand rising to a height of as much as 3 m above sea-level.

The greater part of the island has been, or is still, under cultivation. The limestone area along the south-western coast is for the greater part occupied by fields of aloes, many of which, however, are abandoned and overgrown by Cactaceae, Euphorbiaceae, Rubiaceae, etc. The western

part of the island, i.e. west of Arikok and Jamanota, is under cultivation, and here houses are scattered over the whole area — a typical feature of Aruba. The more or less abandoned plantations are overgrown with Cactaceae, Euphorbiaceae and Mimosaceae, in which latter family *Prosopis juliflora* plays an important role.

B. Bonaire

The island of Bonaire consists for the most part of limestone, which encircles the older formations and occupies nearly two-thirds of the total island surface. In the southern part this limestone formation forms a low tableland, not rising above 1.5 metres in height. In some places it is covered by debris. North of this tableland a higher plateau, up to 6.5 m above sea-level, is found at "Lima". An extensive tableland, known locally as "Bolivia Plantation", is also to be found in the north-east of the island, where it reaches a height of about 22 m. It gradually rises in a south-western direction, and reaches its highest point at the fourth terrace, at "Columbia Plantation" (110 m). From there it gradually slopes down to about 6 m above sea-level near Barcadera.

The hilly part of the island, in the north-west, consists of the Washikemba formation, which is intruded in several places by porphyrite and diabase. Here, the highest point on Bonaire occurs (Brandaris, 240 m). The Washikemba formation comprises diabase and porphyrite, lavas and tuffs, with intercalations of cherts and limestone. This formation is also found in the centre of the island.

The Rincón formation and Soebi Blanco formation occupy comparatively small areas: they are series of limestones and conglomerates in the central part of the island. A deposit of Upper Eocene marl south-east of Fontein is also of minor importance.

A few hand-shaped landlocked bays occur in the north-west. They are separated from the sea by a wall of coral shingle and may be either dry or of considerable depth (e.g. Goto and Slagbaai). Quaternary alluvial deposits are to be found in the vicinity of Kralendijk, the principal village; north of the lagoon of Lac; and near Salinja Mathijs. Dune formation has taken place on a small scale near Manparia Goetoe, south of Lac.

The greater part of the island outside the limestone region was under some kind of cultivation in former times. Nowadays the non-calcareous soils in the centre and near Rincón (the second largest village) are under cultivation, whilst a considerable part of the limestone is covered by fields of aloes.

C. Curaçao

The interior of the western and eastern parts of the island consists mainly of diabase, which is usually deeply weathered and much denuded. Several low, gently sloping hills are to be found in this area. The higher points of the island occur in the western part (Christoffelberg and

surroundings), and are formed from cherts and tuffs, which here compose what is known as the "Knip formation"; several very steep slopes occur in this area. The "Midden Curaçao" beds occupy the western part of the central area of the island, and consist of sandstone, shales and conglomerates. Coral limestone — making up approximately one-fourth of the island — partly encircles these older formations, and becomes prominent in the central part of the island and along the north and north-east coasts. It forms conspicuous table mountains (St. Hyronimus Berg, Tafelberg of Sta. Barbara) and plateaus (along the north coast; near Santa Martha; Willemstad). Several hand-shaped, landlocked bays occur along the north-eastern and south-western coasts (St. Joris Baai; Spaanse Water; Schottegat; Santa Martha Baai). Alluvial deposits are found along these bays and along the edges of the salinas.

There is very little agricultural development; however, much of the original vegetation was removed in former times. The "hofjes" — irrigated areas, usually small, planted with fruit-trees — are typical of Curaçao; they are rarely found in the other islands. Fields of aloes, such as can be seen in the islands of Aruba and Bonaire, are absent in Curaçao.

ECONOMIC DEVELOPMENT

Curaçao was discovered by Alonso de Ojeda in 1499. At that time the islands were inhabited by South American Indians of the Arowak tribe. They practised a little shifting cultivation and lived in settlements along the coast. During the period of Spanish rule, the Indians began to breed cattle. In 1634 Curaçao was seized by the Dutch. The most important products of the islands at that time were salt, logwood (*Haematoxylon brasiletto*) and guatapana (*Caesalpinia coriaria*). Much of the vegetation was carelessly cut down.

Curaçao very soon became a centre of illicit trading and a slave-market, owing to its favourable situation and good anchorage. A number of slaves were employed on plantations and in salt-making. Land clearance probably reached its maximum in this period.

After the emancipation of the slaves in 1862, many experiments were carried out to improve agriculture and cattle-breeding, but without lasting success. Only the growing of aloes has continued to be a prominent means of subsistence, but the export trade in this product is of little importance nowadays. The mining of phosphate and gold opened up a fresh source of profits; but all such activities ceased in 1916. Only shipping remained important, especially after the opening of the Panamá Canal, while the establishment of oil refineries in Curaçao and Aruba brought a certain measure of prosperity. Many male inhabitants of Curaçao, as well as men from Bonaire and other islands, find employment in these refineries.

The export of divi-divi (*Caesalpinia coriaria*), aloes, salt, sheep and goats still constitutes a small source of income for Bonaire. Of these, Aruba

exports only a certain quantity of aloes. The economy of the islands is, in fact, largely based on the refining of Venezuelan crude oil.

Livestock	Horses	Donkeys	Cattle	Goats	Sheep	Pigs
Aruba (1947)	10	435	160	2,900	5,080	1,340
Bonaire (1950)	3	950	99	41,000	9,000	350
Curaçao (1947)	32	600	2,550	26,000	5,700	1,800

Population (approx.)	1937	1949	1952	1955
Aruba	24,000	55,000	56,000	55,000
Bonaire	5,500	5,000	5,000	5,500
Curaçao	61,000	90,000	111,000	116,000

CHAPTER II

THE FLORA

BOTANICAL COLLECTIONS

As Linnaeus, in his *Species Plantarum*, mentions 21 species as occurring in Curaçao, a collection of Curaçao plants must have been made before 1753.

Urban (*Symbolae Antillanae*) mentions the following botanical visits to Curaçao: N. J. Jacquin, between 1755 and 1757; J. von Rohr, 1786; F. Bredemeyer, 1788; J. Read, ?; W. F. R. Suringar, 1885; H. von Eggers, 1893. Suringar was probably the first of these botanists to visit Aruba and Bonaire as well. From the evidence of his collections it appears that a great part of the Aruba specimens were collected by Father van Koolwijk.

Other collections have been made by: F. A. F. C. Went, 1901; Miss A. D. Lens, 1907; Aschenberg, ?; W. Versluys, 1907 (especially grasses); I. Boldingh, 1909—1910; N. L. Britton and J. A. Shafer, 1913; P. Wagenaar Hummelinck, 1930 and 1936—1937 (mainly Cactaceae and *Agave*); Brother M. Arnoldo, since 1945; A. C. J. Burgers, 1948; A. L. Stoffers, 1952—1953.

ANALYSIS OF THE FLORA

In the present work only phanerogams and ferns are taken into account.

The flora comprises 467 species and varieties, divided up as follows: ferns 7, angiosperms 460 (with 113 monocotyledons and 347 dicotyledons). The ferns are represented by 7 genera.

The monocotyledons number 15 families, with 54 genera, 110 species and 3 varieties. The grasses and sedges account for 82 species and 3 varieties. However, many of these species have been introduced. The dicotyledons comprise 75 families, with 231 genera, 346 species and 1 variety. The Euphorbiaceae and Fabaceae are represented by 37 genera and 69 species, i.e. respectively 16 and 20% of the dicotyledon genera and species.

The following list contains the families occurring on the islands of the Leeward Group, and gives the number of genera and species in these families. Varieties are given as additions to the species. At the same time the main geographical distribution of the family is given between brackets, viz. *C:* cosmopolitan, *Tr:* predominantly tropical, *T:* predominantly temperate.

Monocotyledons

Families	*Genera*	*Species*
Agavaceae (*Tr*)	1	5
Alismataceae (*C*)	1	1
Araceae (*Tr*)	1	1
Arecaceae (*Tr*)	2	2
Bromeliaceae (*Tr*)	3	5
Commelinaceae (*Tr*)	2	2
Cyperaceae (*C*)	7	25 + 2
Hydrocharitaceae (*C*)	2	2
Lemnaceae (*C*)	2	2
Najadaceae (*C*)	1	1
Orchidaceae (*C, Tr*)	3	3
Poaceae (*C*)	25	57 + 1
Pontederiaceae (*Tr*)	1	1
Potamogetonaceae (*C*)	2	2
Typhaceae (*C*)	1	1

Dicotyledons

Families	*Genera*	*Species*
Acanthaceae (*Tr*)	3	4
Aizoaceae (*Tr*)	4	4
Amaranthaceae (*C, Tr*)	6	9
Annonaceae (*Tr*)	1	1
Anacardiaceae (*Tr*)	2	2
Apocynaceae (*Tr*)	1	1
Asclepiadaceae (*Tr*)	4	4
Asteraceae (*C*)	17	19
Batidaceae (*Tr*)	1	1
Bignoniaceae (*Tr*)	2	2
Boraginaceae (*C*)	4	10
Burseraceae (*Tr*)	1	3
Cactaceae (*Tr*)	7	9
Capparidaceae (*Tr*)	6	10
Celastraceae (*C, Tr*)	2	3
Chenopodiaceae (*C, Tr*)	3	4
Clusiaceae (*Tr*)	1	1
Cochlospermaceae (*Tr*)	1	1
Combretaceae (*Tr*)	2	2
Convolvulaceae (*C, Tr*)	4	16
Cucurbitaceae (*C, Tr*)	4	6
Cuscutaceae (*C*)	1	3
Elatinaceae (*C, Tr*)	1	1
Erythroxylaceae (*Tr*)	1	1
Euphorbiaceae (*C, Tr*)	12	28
Fabaceae (*C*)	25	41
Flacourtiaceae (*Tr*)	3	3
Gentianaceae (*C, Tr*)	1	1
Hydrophyllaceae (*T*)	1	1
Lamiaceae (*Tr*)	4	6
Lauraceae (*Tr*)	1	1
Loasaceae (*Tr*)	1	1
Loganiaceae (*Tr*)	1	1
Loranthaceae (*C, Tr*)	1	1
Lythraceae (*C, Tr*)	1	3
Malpighiaceae (*Tr*)	2	3
Malvaceae (*C, Tr*)	10	16
Meliaceae (*Tr*)	1	1
Menispermaceae (*Tr*)	1	1
Mimosaceae (*Tr*)	7	10
Moraceae (*Tr*)	3	3
Moringaceae (*Tr*)	1	1
Myoporaceae (*Tr*)	1	1
Myrtaceae (*Tr*)	2	2 + 1
Nyctaginaceae (*Tr*)	3	6
Nymphaeaceae (*C*)	1	1
Olacaceae (*Tr*)	2	2
Onograceae (*C*)	1	1
Papaveraceae (*C*)	1	1
Passifloraceae (*Tr*)	1	3
Phytolaccaceae (*Tr*)	1	1
Piperaceae (*Tr*)	1	1
Plumbaginaceae (*C*)	1	1
Polygalaceae (*C*)	1	1
Polygonaceae (*C*)	3	4
Portulacaceae (*C*)	2	5
Rhamnaceae (*C, Tr*)	3	3
Rhizophoraceae (*Tr*)	1	1
Rubiaceae (*C, Tr*)	11	13
Rutaceae (*Tr*)	3	4

Families	*Genera*	*Species*
Sapindaceae (*Tr*)	3	4
Sapotaceae (*Tr*)	1	1
Scrophulariaceae (*C*)	3	5
Simaroubaceae (*Tr*)	2	2
Solanaceae (*C*)	5	11
Sterculiaceae (*Tr*)	4	4
Theophrastaceae (*Tr*)	1	1
Tiliaceae (*C, Tr*)	1	3

Families	*Genera*	*Species*
Turneraceae (*Tr*)	2	4
Ulmaceae (*C, Tr*)	1	1
Urticaceae (*C, Tr*)	1	1
Verbenaceae (*C, Tr*)	7	10
Violaceae (*C, Tr*)	1	1
Vitaceae (*Tr*)	1	2
Zygophyllaceae (*Tr*)	4	6

The family of the Poaceae is the largest with 57 species and 1 variety, followed by the Fabaceae with 41 species. Families with over 20 species are: Euphorbiaceae and Cyperaceae. Nearly 40% of the families are represented by a single species, whilst 204 genera, i.e. over 70%, are represented by one species. It seems to be impossible to explain why the number of families and genera should be so high in proportion to the number of species.

According to Asprey & Robbins, the same phenomenon can be seen in Jamaica. They suggest the following reasons for it:

1. A number of the families are naturally small and often of restricted distribution;
2. A few families, though large, are represented by a single, wide-ranging genus;
3. Others are temperate families represented in montane regions in the tropics. Asprey & Robbins continue (p. 365): "Nevertheless, there still remain large tropical families of wide distribution that are barely represented in Jamaica...."

In the case of the islands of the Leeward Group the first reason holds good; the second and third can be left out of consideration. An important cause of it is probably that a number of species were formerly cultivated and nowadays run wild, while others have been introduced and become naturalized.

The table shows that 40 families are considered to be cosmopolitan. Seventeen of these have a predominantly tropical, and only 2 a predominantly temperate distribution. Of the 90 families present in the islands, 48 appear to be tropical. Two families have affinities predominantly with the southern hemisphere (Myrtaceae and Rutaceae), whilst 4 families (Papaveraceae, Ulmaceae, Polygonaceae and Nymphaeaceae) have predominantly northern-hemisphere affinities. The following families have their distribution mainly in America: Cactaceae, Erythroxylaceae, Hydrophyllaceae, Loasaceae, Lythraceae, Malpighiaceae, Malvaceae, Nyctaginaceae, Phytolaccaceae, Pontederiaceae, Portulacaceae, Theophrastaceae, Turneraceae and Verbenaceae.

In order to collect complete records concerning the distribution of the plant species of the Netherlands Antilles, it is necessary to delve deeply in a great number of monographs and "Floras", of which mention may be made of *Symbolae Antillanae, The Flora of Jamaica, The Flora of Trinidad and Tobago, Flora of Puerto Rico and the Virgin Islands, Flora of Surinam.*

The five main groups into which the flora may be divided are: 1. the introduced element, 2. the cosmopolitan element, 3. the West Indian element, 4. the endemic element, 5. the continental element.

The introduced element

This element contains species cultivated formerly and running wild nowadays, as well as introduced species which were subsequently naturalized. The group comprises 49 species, of which the following may be mentioned: *Antigonon leptopus, Calotropis procera, Chenopodium murale, Eragrostis ciliaris, Indigofera tinctoria, Panicum maximum, Sesbania bispinosa, Cryptostegia grandiflora, Balanites aegyptica, Clitoria ternatea, Dactyloctenium aegyptium, Luffa cylindrica, Polanisia viscosa, Tamarindus indica, Albizzia lebbeck, Cassia obovata, Eleusine indica, Gynandropsis gynandra, Moringa oleifera, Ricinus communis.*

These species usually play a role of minor importance in the vegetation aspect of the islands. Many of them are common weeds.

The cosmopolitan element

This group comprises widely distributed species, mainly pan-Tropic and pan-American or Caribbean plants. Altogether 309 species were counted in the group.

The West Indian element

The species of this group occur in the West Indies only. West Indian species with a distribution extending westwards to Florida and southwards as far as northern South America are excluded. The majority of the species are more or less common to all West Indian islands. However, some of them are restricted to either the Greater Antilles or the Lesser Antilles. It is not necessary in this case to keep the two groups separated. The following species are considered to make up the West Indian element: *Adelia ricinella, Antirrhoea acutata, Argithamnia candicans, Aristida suringari, Aristida swartziana, Borreria podocephala, Bourreria succulenta, Bouteloua heterostega, Bumelia obovata, Castela erecta, Coccoloba diversifolia, Cypselea humifusa, Cyperus planifolius, C. swartzii* var. *granularis, Egletes prostrata, Eragrostis urbaniana, Erythroxylon brevipes, Fagara flava, Gundlachya corymbosa, Halophila baillonis, Jacquinia barbasco, Lithophila muscoides, Morinda royoc, Paspalum bakeri, Paspalum laxum, Paspalum secans, Phoradendron trinervium, Phyllanthus polycladus, Pilocarpus racemosa, Piriqueta obovata, Pisonia fragrans, Rauwolfia lamarckii, Samyda dodecandra, Setaria distantiflorum, Torulinium ferax.*

The endemic element

Endemism is very slight in each of the islands. Only one endemic species is found in Bonaire, 5 species in Curaçao and 2 species in Aruba. However, if the islands off the Venezuelan coast are considered as one unit, the following list might be compiled:

Agavaceae	*Agave arubensis*	Aruba		
	A. boldinghiana	Aruba	Bonaire	Curaçao
	A. rutteniae	Aruba		
	A. vivipara	Aruba	Bonaire	Curaçao Los Hermanos Margarita Blanquilla
Asclepiadaceae	*Metastelma boldinghii*		Bonaire	Curaçao
Asteraceae	*Melampodium bonairensis*		Bonaire	Curaçao
Burseraceae	*Bursera bonairensis*	Aruba	Bonaire	Curaçao
Cactaceae	*Cereus repandus*	Aruba	Bonaire	Curaçao
	Opuntia curassavica	Aruba	Bonaire	Curaçao Tortuga
Celastraceae	*Maytenus versluysii*		Bonaire	Curaçao
Cyperaceae	*Bulbostylis floccosa* var. *pumilio*	Aruba	Bonaire	Curaçao
Fabaceae	*Peltophorum suringari*	Aruba		Curaçao Margarita
Flacourtiaceae	*Xylosma arnoldii*			Curaçao
Moraceae	*Ficus brittonii*		Bonaire	Curaçao
	Sorocea arnoldii			Curaçao
Myrtaceae	*Aulomyrcia curassavica*			Curaçao
	A. curassavica var. *acutata*			Curaçao
Nyctaginaceae	*Pisonia bonairensis*	Aruba	Bonaire	Curaçao
Poaceae	*Aristida arubensis*	Aruba		Curaçao
	Chloris suringari			Curaçao
	Paspalum bonairense		Bonaire	
	Paspalum curassavicum			Curaçao
Rhamnaceae	*Condalia henriquezii*		Bonaire	Curaçao
Verbenaceae	*Lantana arubensis*	Aruba		
Zygophyllaceae	*Kallstroemia curta*	Aruba	Bonaire	Curaçao

The percentage of endemism, regarded in this way, is still low and amounts to only slightly more than 5%.

THE CONTINENTAL ELEMENT

The total number of continental species amounts to 42, 2 of which are to be found from the southern United States southward. There are no distinct North American species present. Only one species occurs in the southern U.S. and Central America. Three species are Central American in origin, while 14 species occur in Central America and northern South America. Twenty-two species are clearly South American. This is shown in the next list:

From the southern U.S. southward: *Ruellia nudiflora* var. *insularis, Digitaria californica.*

Southern U.S. and Central America: *Margaranthus solanaceus.*

Central America: *Eragrostis diversiflora, Acacia villosa, Mimosa distachya.*

Central America and northern South America: *Aphragmia inundata, Alternanthera brasiliana, Acalypha poirettii, Aeschynomene falcata, Ayenia magna, Bouteloua aristoides, Cenchrus pilosus, Euphorbia cotonifolia, Euphorbia graminea, Haematoxylon brasiletto,*

Luffa operculata, Manihot carthaginensis, Pithecellobium platylobum, Schomburgkia tibicinis.

South America: *Agave cocui, Amyris simplicifolia, Bromelia lasiantha, Bursera tomentosa, Capparis linearis, Cephalocereus lanuginosus, Cuscuta partita, Dalea carthaginensis, Ipomoea incarnata, Jacquemontia evolvuloides, Lantana canescens, Lemairocereus griseus, Machaonia ottonis, Mammillaria simplex, Marsilia ernestii, Omphalophthalmum ruber, Opuntia elatior, Opuntia wentiana, Passiflora foetida* var. *moritziana, Portulaca venezuelensis, Scoparia annua, Tabebuia chrysantha.*

As it is difficult to estimate the number of introduced species, it is possible that some species considered as "cosmopolitan" ought to be classified as "introduced". Nevertheless, even the number given clearly reflects the 300 years of Europe's intercourse with the Caribbean. Of the species with a more restricted distribution, the West Indian plants are the most numerous (35), the South American element being represented by only 22 species. The vegetation of the Leeward Group therefore resembles the flora of the Antilles rather than that of South America, at least from a floristic point of view. However, physiognomically the vegetation corresponds more with that of the dry region of northern South America.

ECOLOGICAL SPECIALIZATION

In general, specialization characterizes communities lying far from the optimum. Communities close to the optimum possess many species without special forms, and these species range through many different associations. For instance, the species of a rain forest are evergreen, unarmed, have mesophyllous, thin leaves, a smooth bark, and lack breathing or stilt roots. Special forms such as succulents, palms, tree ferns and bamboos are not common in this community. The special characteristics render the plants more successful in the struggle for existence in a special habitat. Beard (1946) states that specialization for a particular environment also has a tendency to restrict the species to that environment, and, with increasingly adverse conditions, one finds not only more specialized types, but species of very restricted ranges, confined to particular associations. In this respect four specialization groups may be distinguished: a. Root specialization, b. Leaf specialization, c. Propagation specialization, d. Special life-forms.

Root specialization

The most common forms of this specialization group are buttresses, stilt roots, and pneumatophores or breathing roots. Plank-buttresses are only to be seen in these islands in a cultivated species, *Ceiba pentandra,* and so are of little importance to us. Stilt roots or aerial roots are given off from the trunk of the tree, or even from the branches, i.e. at some distance above the ground. They follow a free aerial course, and are frequently very whimsical in form. This character is often associated with a swampy habitat, and it is found to a great extent in *Rhizophora mangle.* On the other hand, stilt roots are in some cases evidently a remnant of epiphytic habit, as in *Clusia rosea* and *Ficus brittonii.* Pneumatophores are also a feature of some swamp species. In Bonaire, near Lac, whole fields of small, erect, breathing-roots of *Avicennia nitida* occur.

Leaf specialization

This type of specialization is an expression of xeromorphy. Xeromorphic characters are exhibited by a vegetation as the environment becomes unfavourable from the point of view of moisture supply. Such characters are associated with a dry environment, but it is not always clear how they assist the plants in surviving in an unfavourable habitat, if indeed they actually do have such a function.

The principal types of leaf specialization are:

1. Deciduousness: the complete or partial shedding of leaves at a definite season of the year. It has long been held that this feature was directly related to seasonal drought. Another hypothesis is that deciduousness in the tropics may be a sexual character connected with reproduction. Reasons put forward for this hypothesis are the fact that the leaf-fall does not always coincide with the dry season, but often coincides with the flowering of the tree. However, the evidence for a sexual causation of deciduousness is not very strong. In the case of Trinidad B e a r d (1942) states that:
a. About half the deciduous species flower during the rains (when in leaf) and fruit during the dry season (when out of leaf);
b. About a quarter of the deciduous species flower during the dry season, and fruit during the same or the following dry season;
c. About a quarter of the deciduous species flower during the dry season and drop fruit during the next rainy season;
d. A negligible proportion of the deciduous species both flower and fruit in the rainy season.

Flowering is therefore equally divided between the dry and the rainy seasons, viz., between the in-leaf and out-of-leaf phases.

The deciduous species may be divided into three groups:
a. Species, the leafless period of which is very short, lasting from a few days to a few weeks;

b. Obligate deciduous species;

c. Facultative deciduous species.

However, it is difficult to say with certainty whether a species is deciduous or not. Obligate deciduous species in these islands are: *Spondias mombin, Tabebuia chrysantha, Bursera simaruba, B. tomentosa* and *B. bonairensis.* Probable examples of facultative deciduous species are *Haematoxylon brasiletto, Chlorophora tinctoria* and *Vitex compressa.*

2. Leaf-thickening. The leaves may be either thickened and fleshy or thin and brittle, while the upper surface is either very shiny and cutinized or roughened and scabrous. Apart from light effects, the presumed function of this feature is to protect the leaf against wilting in circumstances where the evaporating capacity of the air may be higher than the ability of the plant to transpire. Examples of species exhibiting this character are: *Coccoloba diversifolia, Coccoloba uvifera, Clusia rosea, Antirrhoea acutata, Erithalis fruticosa,* etc.

3. Leaf-curling. This characteristic is more xeromorphic than the one mentioned above. The leaf-margins curl down towards the midrib, to protect the stomatal surface. This is found, for instance, in *Capparis indica.*

4. Leaf-movement: movement of the pinnae to regulate transpiration (apart from the effect upon light factors). This is found in a number of Fabaceae and Mimosaceae, e.g. in *Pithecellobium* spp., *Prosopis juliflora.*

Propagation specialization

This is to be seen, for example, in *Rhizophora mangle,* and is a form of adaptation to swampy habitat. The seed germinates before the fruit is dropped and seedlings 15 cm in length are often found hanging from the branches.

SPECIAL LIFE-FORMS

Thorniness characterizes extreme seasonal types of vegetation. Thorny species are very common in secondary communities. The following types of thorniness might be distinguished:

1. Embossed prickles on stems and twigs: *Erythrina velutina, Fagara monophylla;*
2. Spines on stems and twigs: *Acacia tortuosa, Prosopis juliflora;*
3. Stem-spines: *Condalia henriquezii, Balanites aegyptica, Ximenia americana;*
4. Hooked prickles: *Mimosa distachya, Lantana camara.*

Succulents are characteristic of extreme types of vegetation: Cactaceae and some Euphorbiaceae.

Water-storing trunks are to be found in, for instance, *Bursera* and *Pisonia.*

CHAPTER III

DESCRIPTION OF THE REGIONS INVESTIGATED

ARUBA

The north coast between Matavidiri and Fontein [1]. Here the ground is absolutely bare, and this part of the island presents a really desert-like aspect; consequently vegetation must be classified as "Desert" [VI]. Only a few, widely scattered plants, mainly grasses, are found, most of which are annuals.

The following species were collected: *Anthephora hermaphroditica, Aristida suringari, A. swartziana, Bouteloua heterostega, Cassia obovata, Cenchrus pilosus, Croton flavens, C. ovalifolius, Cyperus confertus, Eragrostis ciliaris* var. *brachystachya, Euphorbia thymifolia, Marsypianthes chamaedrys, Melocactus, Mollugo verticillata, Opuntia wentiana, Phyllanthus euwensii, Spigelia anthelmia, Sporobolus pyramidatus, Tragus berteronianus.*

If the biological spectrum is compiled on the basis of these data, the following percentual composition is found:

Therophytes : chamaephytes : nanophytes : succulents, 48.5 : 30.5 : 10.5 : 10.5

On climbing the hills along this coast, it will be seen that the general aspect remains the same, and only a very few other species are noted between Matavidiri and Uti: *Ricinus communis, Stylosanthes hamata* and *Acanthocereus tetragonus.* Further inland — generally speaking, behind the third row of hills — the vegetation changes into a denser type, that will be described elsewhere.

However, this "desert" is interrupted in some places by coconut plantations, at Andicouri, Daimari and near Prins. Another aspect is found at some points where "rooien" (gullies) debouch into the sea [2]. Here some scattered shrubs grow: *Tournefortia gnaphalodes, Coccoloba uvifera* and *Conocarpus erecta,* whilst near Dos Playa some small trees even occur (*Hippomane mancinella*). It is regarded as being a remnant of the strand scrub community [XV] and littoral woodland [XI]. This vegetation is very luxuriant near Fontein [3], where, besides the species named, *Bontia daphnoides* is also found. *Hippomane* reaches a height of 6—7 m here. This community is classified as belonging to Hippomane woodland [XVI].

In this region dunes also occur near Fontein [4]. They consist of sand, and are rather sparsely overgrown with *Tournefortia gnaphalodes* and *Euphorbia thymifolia:* Tournefortia facies of strand scrub comunity [XVA].

The part of the north coast east of Fontein [5] is covered with scanty vegetation. The soil consists of limestone, but the crevices are filled up with debris. Here are found scattered shrubs of *Croton flavens, Cordia cylindrostachya, Trianthema portulacastrum, Bontia daphnoides, Corchorus hirsutus,* and *Desmanthus depressus,* as well as *Euphorbia thymifolia, Dactyloctenium aegyptium, Sporobolus virginicus, Anthephora hermaphroditica, Sporobolus pyramidatus, Cenchrus pilosus, Lithophila muscoides* and *Evolvulus nummularius,* between dense clumps of shrubs up to 1½ m high and with an average area of 8 sq.m. These clumps are made up of *Prosopis juliflora, Cordia cylindrostachya, Croton flavens, Acacia tortuosa, Opuntia* spp. and a few grasses.

Along the east coast, i.e. south of Rincón, the vegetation is essentially the same, but special attention may be paid to a few localities.

The "Pitch Field", a dumping-place for waste from the oil refinery, forms a large black spot, where hardly any plant life is found.

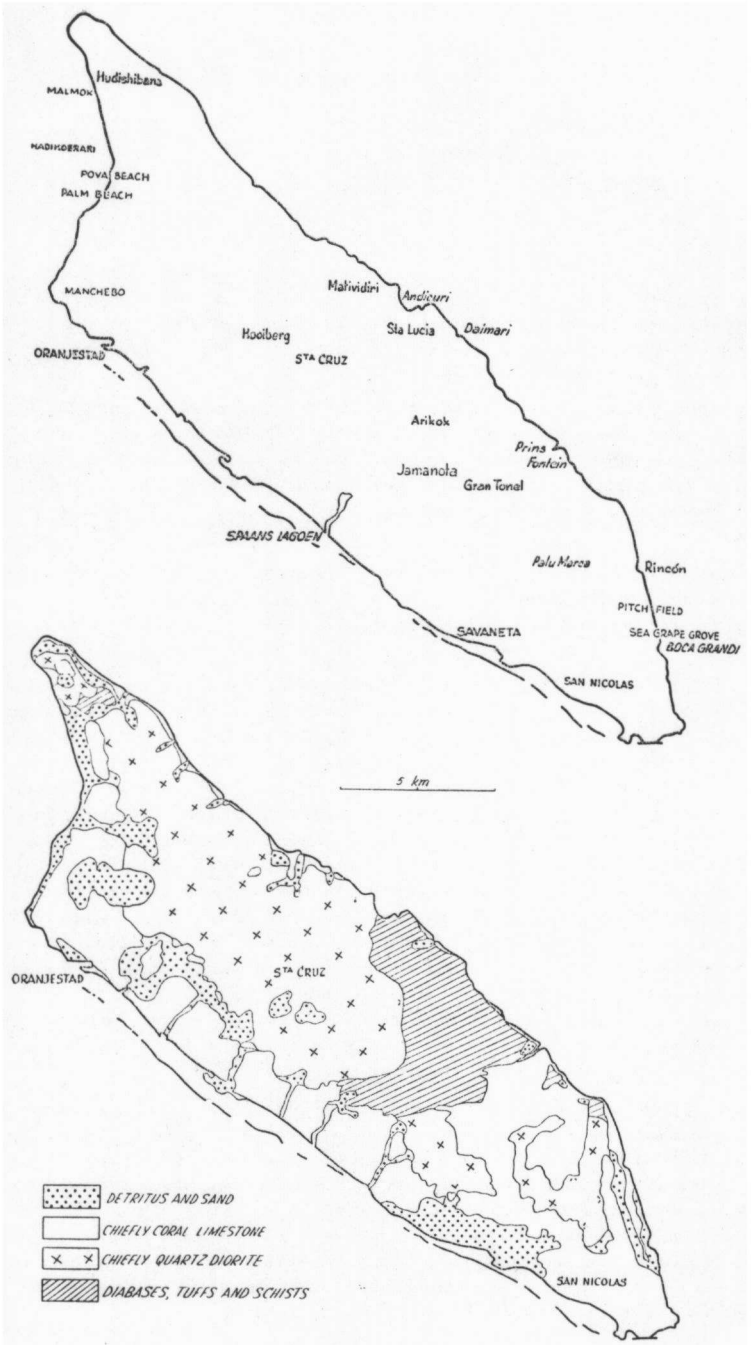

Fig. 2. Sketch map of A r u b a, with localities.
Fig. 3. Geological sketch map of A r u b a.

South of Rincón [6] in some places where more sand has been deposited, a rather dense vegetation may exist, forming a ground cover of about 75% and consisting only of *Tournefortia gnaphalodes*. This vegetation is classified as Tournefortia facies of the strand scrub community [XVA].

The vicinity of Boca Grandi [7] is of more importance. Here a strand community occurs in which pioneer vegetation (*Ipomoea pes-caprae* and *Sporobolus virginicus*) plays an important role. Although this vegetation has been modified by human interference, it will be described in more detail, as it is still the best example of this community in the island.

Going inland from the coast, the following zones may be distinguished:

[7a] A sandy wall about 1 m in height, on which *Sesuvium portulacastrum* dominates, occupying about 90% of the wall's surface. *Sporobolus virginicus* is present and covers about 5—10% of the wall.

[7b] Behind this wall the soil is approximately at sea-level, and covers a strip 25 m wide. *Sesuvium portulacastrum* decreases in number, whilst *Suriana maritima, Tournefortia gnaphalodes* and *Euphorbia buxifolia* appear, and *Sporobolus virginicus* increases. The ground is covered less than 75%, *Sesuvium* forming 50% and *Sporobolus* 40% of the total vegetation.

[7c] In the following strip, about 50 m wide, *Sesuvium* practically disappears, whilst *Suriana, Tournefortia* and *Euphorbia* continue to be represented by a few specimens. *Fimbristylis spathacea* appears in great quantities, forming about 70% of the total vegetation, whilst *Ipomoea pes-caprae* also appears and makes up 5—10% of it. Ground cover varies between 50 and 80%.

[7d] In the next zone *Sporobolus* strongly increases, and becomes dominant. *Ipomoea pes-caprae* increases in number, *Heliotropium curassavicum* appears, and *Sesuvium portulacastrum* reappears. *Fimbristylis spathacea* strongly decreases in number. Ground cover amounts to about 50% and consists of: *Sporobolus virginicus* 60% (of the whole), *Ipomoea pes-caprae* 35%, *Suriana maritima, Euphorbia buxifolia, Sesuvium portulacastrum, Heliotropium curassavicum, Fimbristylis spathacea.*

[7e] The following strip, about 40 m wide, is only scantily overgrown and has a cover of 5—10%. The vegetation consists merely of scattered specimens of the following species: *Sesuvium portulacastrum, Tournefortia gnaphalodes, Sporobolus virginicus, Lithophila muscoides, Euphorbia buxifolia* and *Ipomoea pes-caprae.*

[7f] In the next strip, 15 m wide, *Ipomoea* dominates, and provides a varying cover. Some scattered specimens of *Euphorbia buxifolia, Corchorus hirsutus* and *Capraria biflora* occur, with a few small clusters of *Lithophila muscoides.*

[7g] The next zone, 40 m wide, has a very scanty vegetation, and the ground cover does not exceed 5%. Here the following species were noted: *Lithophila muscoides, Euphorbia buxifolia, Capraria biflora, Tournefortia gnaphalodes, Euphorbia thymifolia* and *Corchorus hirsutus.*

[7h] Increasing ground cover is to be found in the following strip, which is 25 m wide. *Ipomoea pes-caprae* appears again, but *Corchorus hirsutus* dominates and forms 60% of the total cover, which amounts to about 30%. Besides these two species *Lithophila muscoides, Capraria biflora* and *Euphorbia thymifolia* were noted.

[7i] In the following strip, 60 m wide, *Coccoloba uvifera* appears, and the ground cover amounts to 30—40%. The species noted include *Erithalis fruticosa, Antirrhoea acutata, Cenchrus echinatus* and *Cenchrus pilosus.* Here the vegetation gradually passes into that of the limestone region, in which *Antirrhoea acutata* is a prominent species. But, owing to the considerable amount of sand, strand scrub species are still present: *Suriana maritima* and *Tournefortia gnaphalodes.*

[7j] Behind the road the vegetation is very open, and the landscape's appearance is determined by the scattered shrubs of *Coccoloba uvifera, Tournefortia gnaphalodes, Erithalis fruticosa, Corchorus hirsutus, Gundlachya corymbosa, Euphorbia buxifolia*

and *Capraria biflora*. Besides these species *Euphorbia thymifolia* and *Lithophila muscoides* are noted. Near the escarpment of the second limestone terrace a considerable number of *Coccoloba uvifera* trees are found, especially near "Sea Grape Grove". However, the condition of the trees is very bad, a great part of the branches are dead. They may be considered as being remnants of a littoral woodland [XI].

After climbing the limestone terrace a vegetation is encountered which is typical of the limestone region, on account of the presence of a large number of *Antirrhoea acutata* shrubs. This vegetation corresponds closely with that of Paloe Marca.

The south-western coast. As has already been said, a reef consisting of coral shingle and sand extends along this coast, about 1 km offshore [8]. Here a mangrove woodland [XIII] has developed, consisting of *Rhizophora mangle*. In the more open and higher places *Suriana maritima* and *Sesuvium portulacastrum* are observed. Epiphytes are absent.

This mangrove woodland is also found in the muddy places along the coast west of Savaneta [9] and along Spaans Lagoen [10]; it consists of *Rhizophora mangle* and only a few specimens of *Laguncularia racemosa, Avicennia nitida* being entirely absent in the island. The mangrove woodland may reach a height of 4½ m and is confined to points which are regularly flooded at high tide. In the drier places along the Rhizophora belt *Batis maritima* is frequently met with, whilst some *Bontia daphnoides* occur on the inland side of Spaans Lagoen, representing vegetation of the salt flats and salinas [XVII].

Along the west coast more types of strand vegetation are encountered.

Palm Beach [11]. Unfortunately from a botanical point of view, this wonderful beach is a recreation resort. Of the herbaceous strand community only *Ipomoea pescaprae* is present. The strand scrub community [XV] is represented by *Tournefortia gnaphalodes, Suriana maritima* and *Euphorbia buxifolia*. Other plants include *Corchorus hirsutus, Cassia obovata, Capraria biflora, Anthephora hermaphroditica, Tephrosia cinerea, Eragrostis ciliaris* var. *brachystachya, Euphorbia thymifolia* and *Rhynchosia minima*.

Near Pova Beach [12] a bare, 5 m-wide strip is found, which is bounded by the high-water mark. Behind this comes a strip 10 m wide, with a plant cover varying between 5 and 10%, in which *Euphorbia buxifolia* is the dominant species and accounts for about 60% of the total cover: the Euphorbia buxifolia facies of the strand scrub community [XV C]. Associated with it is *Cyperus planifolius* var. *brunneus* (accounting for about 30% of the total), and a few specimens of *Tournefortia gnaphalodes*. In the next strip *Suriana maritima* is intermingled with *Rhacoma crossopetalum*, a species occurring mainly on the limestone plateaus in Bonaire and Curaçao. It appears in great quantities, and takes up about 20% of the total cover. The latter varies between 50 and 70%. *Suriana maritima* dominates (80% of the total) and some tussocks of *Cyperus planifolius* var. *brunneus* are to be found: Suriana facies of the strand scrub community [XV B]. Behind this strip an open shrub vegetation is encountered in which *Rhacoma crossopetalum* predominates. This vegetation is classified as Rhacoma type of littoral woodland [XI B]. The shrubs generally reach a height of 1½ m. In places where sand is absent 50—80 cm-high shrubs of *Erithalis fruticosa* occur. Here the following species were noted: *Rhacoma crossopetalum, Erithalis fruticosa, Corchorus hirsutus, Suriana maritima, Cyperus planifolius* var. *brunneus, Condalia henriquezii, Bumelia obovata, Lithophila muscoides* and *Croton flavens*.

Near Hadikoerari [13] nearly the same vegetation is found, but here it reaches a height of 2½ m, and *Cordia cylindrostachya* is present, sometimes even in rather large quantities.

Between Palm Beach and Malmok several salinas occur on the low limestone plateau [14]. They are flooded at times, and may contain *Ruppia maritima*. The best developed salina vegetation, near Palm Beach, consists of *Batis maritima*, occupying 80—90% of the surface, and *Sporobolus virginicus*. *Conocarpus* is represented

by a few scattered, 1½ m-high shrubs. This vegetation belongs to the vegetation of the salt flats and salinas [XVII].

The salina near Hadikoerari [15] was dry when examined, and a few patches of *Batis maritima* and *Sporobolus virginicus* represented the halophytic flora in its lowest parts. In the somewhat higher parts some complexes were found formed by *Conocarpus erecta* and *Cordia cylindrostachya*, in varying ratios, together with *Croton flavens*, *Jatropha gossypifolia* and *Euphorbia thymifolia*. These complexes are also found without *Conocarpus*, when *Opuntia wentiana* generally also occurs. Apart from these complexes, plants are nearly absent. Only the following species were noted: *Sporobolus pyramidatus*, *Euphorbia thymifolia*, *Dactyloctenium aegyptium*, *Eragrostis ciliaris* var. *brachustachua*. *Cassia obovata* and *Cereus repandus*.

The north-western part [16] is desert-like in aspect. Hardly any plant cover occurs, except for some complexes formed by *Prosopis juliflora*, *Cordia cylindrostachya*, *Opuntia wentiana*, *O. elatior*, *Cereus repandus* and *Lemairocereus griseus*. Among the herbs are found: *Boerhavia erecta*, *Stylosanthes hamata*, *Cassia obovata*, *Aristida adscencionis*, *Sporobolus pyramidatus*, *Tragus berteronianus*, *Bouteloua heterostega*, *B. aristoides*. Outside these complexes an occasional specimen of the following species was noted: *Cereus repandus*, *Lemairocereus griseus*, *Opuntia wentiana*, *O. elatior*, *Melocactus*, *Euphorbia thymifolia*, *Lithophila muscoides*, *Anthephora hermaphroditica*, *Sporobolus pyramidatus*, *Eragrostis ciliaris* var. *brachystachya*, *Aristida adscencionis*, *A. swartziana*, *Tragus berteronianus*, *Bouteloua heterostega*, *B. aristoides*, *Sporobolus virginicus* and *Paspalum laxum*. Classification of this region is "desert" [VI]. Along the west coast, a few *Conocarpus erecta* and *Coccoloba uvifera* trees were seen west of Hudishibana [16a].

The vegetation of the dunes near Hudishibana [17] consists entirely of scattered shrubs of *Tournefortia gnaphalodes*. The density of the plant cover increases in a south-eastern direction until it attains about 20%. It is regarded as belonging to the Tournefortia facies of the strand scrub community [XV A].

The quartz-diorite regions, mainly in the western half of the island, are for the most part under cultivation. Some of these "plantations" have been abandoned, and are overgrown to a lesser or greater degree with *Croton flavens*, *Jatropha gossypifolia*, *J. urens*, *Lantana*, Cactaceae and *Prosopis juliflora*. The presence of gigantic diorite blocks is very characteristic of this region. Plant growth is chiefly confined to solitary trees and shrubs, among which *Caesalpinia coriaria*, *Prosopis juliflora*, *Acacia tortuosa*, *Opuntia*, *Cereus*, *Jatropha gossypifolia*, *J. urens* and *Phyllanthus euwensii* were noticed.

On climbing the hills near Matavidiri [18] a rather scanty vegetation is encountered on the western slope. Above the shrub layer some solitary trees of *Capparis indica*, *C. cynophallophora*, *Caesalpinia coriaria*, *Prosopis juliflora* and *Cereus repandus* occur. In the shrub layer *Croton flavens*, *C. ovalifolius*, *Lantana*, *Heliotropium angiospermum*, *Opuntia* and *Jatropha gossypifolia* were noted, forming a Croton-Lantana-Cordia thicket [V]. *Croton ovalifolius* and *Opuntia* are abundant, especially in the lower regions. Among the herbs *Tragus berteronianus*, *Anthephora hermaphroditica*, *Aristida swartziana*, *Cenchrus pilosus*, *Bouteloua heterostega*, *Eragrostis ciliaris* var. *brachystachya*, *Bouteloua aristoides*, *Physalis angulata* and *Euphorbia thymifolia* occur. In the higher parts *Opuntia* remains prominent, and here a few scattered specimens of *Acacia tortuosa* are also found. The above-mentioned herbs are still present, and besides these some other species were noted: *Jatropha urens*, *Pectis febrifuga*, *Cyperus confertus*, *Dactyloctenium aegyptium* and *Sporobolus pyramidatus*. At the top of Matavidiri [18 a] this vegetation disappears and a very scanty vegetation is found, consisting of *Jatropha gossypifolia* and a few grasses and herbs: *Tragus berteronianus*, *Cenchrus pilosus*, *Anthephora hermaphroditica*, *Cyperus confertus* and *Jatropha urens*, forming the Jatropha facies of the Croton-Lantana-Cordia thicket [V B]. The top having been passed, the desert region along the north-east coast, which has been previously described, ensues. As will be seen from the list of species occurring there, the vegetation has suffered very badly from human interference.

North of Sta. Lucia [19], near Andicouri, a much denser vegetation is found. In some places it even forms a nearly closed canopy of trees 3½ to 4 m high, mainly consisting of *Caesalpinia coriaria*, together with a few *Capparis indica*, *Bourreria succulenta* and a great number of *Cereus repandus*. Here, *Phyllanthus euwensii* occasionally reaches a height of as much as 3 metres. It is difficult to pass through this bush, owing to the great number of *Opuntia*, which constitutes 60 to 75% of the shrub layer. Apart from these two species, the shrub layer exhibits only a few specimens of *Croton flavens* and *Jatropha gossypifolia*, here less than 75 cm high. Among the herbs *Elytraria imbricata*, *Bidens cynapiifolius*, *Cyperus confertus*, *Jatropha urens*, *Euphorbia thymifolia*, *Sida salviaefolia*, *Anthephora hermaphroditica*, *Bouteloua aristoides*, *Dactyloctenium aegyptium*, *Cenchrus pilosus*, *Chloris mollis*, *Aristida swartziana* and *Mitracarpum hirtum* were noted. This vegetation belongs to the cactus-thorn scrub [III].

Hooiberg [20]. Owing to the trade winds, the windward side of the Hooiberg is scantily covered with scattered shrubs and solitary trees. Complexes of *Agave vivipara* are conspicuous. Among the trees the following species were noted: *Caesalpinia coriaria*, *Prosopis juliflora*, *Acacia tortuosa*, *Capparis cynophallophora*, *Croton niveus*, *Bourreria succulenta*, *Malpighia punicifolia*, *Pisonia bonairensis*, *Bursera simaruba*, *Cereus repandus* and *Lemairocereus griseus*. Many of these trees have become shrubby. The following shrubs were seen and collected: *Casearia tremula*, *Lantana canescens*, *Croton flavens*, *C. ovalifolius* and *Opuntia*. Herbs are represented by a rather large number of species: *Argemone mexicana*, *Euphorbia thymifolia*, *Mitracarpum hirtum*, *Spermacoce confusa*, *Chloris mollis*, *Anthephora hermaphroditica*, *Eragrostis ciliaris*, *E. ciliaris* var. *brachystachya*, *Marsypianthes chamaedrys*, *Cyperus confertus*, *Bidens cynapiifolius*, *Pectis linifolia* and *Physalis angulata*.

The leeward side of the Hooiberg is much more densely overgrown, and whole fields of *Opuntia* occur, forming a dense, impenetrable cover, together with some *Croton flavens*, *Casearia tremula* and *Phyllanthus euwensii*. *Agave rutteniae* occurs in small quantities. Above this shrub layer a dense woodland is seen, in which *Cereus repandus* dominates. Among the *Cereus*, many *Pithecellobium unguis-cati*, *Caesalpinia coriaria*, *Prosopis juliflora*, *Bourreria succulenta*, *Acacia tortuosa* and *Tabebuia chrysantha* are to be found, while *Pisonia fragrans* is frequent. Only a few herbs were collected here: *Tragus berteronianus*, *Aristida swartziana* and *Cyperus confertus*. This vegetation belongs to the cactus-thorn scrub [III].

The limestone region along the south-western coast [21]. The greater part of this region is occupied by aloe fields, of which several have been (temporarily) abandoned. In many of these fields trees are still to be seen which are probably relics of the original vegetation: *Caesalpinia coriaria*, *Jacquinia barbasco*, *Haematoxylon brasiletto*, *Pithecellobium unguis-cati*, *Capparis cynophallophora*, *C. indica*, *Bourreria succulenta*, *Crescentia cujete*, *Cereus repandus* and *Lemairocereus griseus*.

Many of the abandoned fields are now overgrown with shrubs, among which *Erithalis fruticosa* and *Antirrhoea acutata* are the most important species, apart from *Opuntia*. *Cordia cylindrostachya* seems to be of more importance in this area than *Croton flavens*, while *Phyllanthus euwensii* plays a dominant role in places. The following list shows the species in the area, more or less in order of abundance: *Erithalis fruticosa*, *Antirrhoea acutata*, *Cordia cylindrostachya*, *Opuntia* spp., *Lantana camara*, *Lantana canescens*, *Phyllanthus euwensii*, *Croton flavens*, *Jatropha gossypifolia*, *J. urens*, *Calotropis procera* and *Cryptostegia grandiflora*. Among the herbs many weeds occur: *Paspalum* spp., *Eragrostis ciliaris*, *E. ciliaris* var. *brachystachya*, *Cyperus* spp., *Euphorbia thymifolia*, *Spermacoce confusa*, *Borreria ocimoides*, *B. laevis*, etc. This secondary vegetation is considered as belonging to the Croton-Lantana-Cordia thicket derived from dry evergreen formations [X]. Locally it may be differentiated into Cordia, Phyllanthus or Antirrhoea facies [X A], [X B], [X C].

A good example of the vegetation of the less disturbed limestone is found on the limestone plateau near Paloe Marca [22]. The vegetation is shrubby, and in

several places it consists almost entirely of *Antirrhoea acutata*, forming the Antirrhoea facies of the Croton-Lantana-Cordia thicket [X C]. A few scattered trees rise above this layer, among which *Jacquinia barbasco* and *Bourreria succulenta* are conspicuous. Other trees are: *Bursera simaruba, Caesalpinia coriaria, Acacia tortuosa, Cereus repandus, Cephalocereus lanuginosus* and *Lemairocereus griseus*. The shrubs include, besides many *Antirrhoea acutata*, also *Opuntia, Lantana camara, Croton flavens*, and *Morinda royoc. Melocactus* occurs everywhere. Other species noted are: *Eragrostis ciliaris* var. *brachystachya, Cenchrus pilosus, Eragrostis urbaniana, Paspalum laxum, Euphorbia thymifolia, Bulbostylis floccosa* var. *pumilio, Lithophila muscoides* and *Cyperus confertus*. The limestone exhibits the karren habit.

The same karren habit is to be found south of Fontein [23], but here the vegetation is denser, and in many places trees and high shrubs prevail. The vegetation has a more or less mosaic structure, as a low-shrub vegetation — Croton-Lantana-Cordia thicket [X] — alternates with the tree and high shrub vegetation. The latter belongs to dry evergreen woodland [VII] and consists, inter alia, of the following species: *Pithecellobium platylobum, P. unguis-cati, Peltophorum suringari, Prosopis juliflora, Bumelia obovata, Metopium brownei, Crescentia cujete, Jacquinia barbasco, Bursera simaruba, Bourreria succulenta, Croton niveus* and *Tabebuia chrysantha*. The species of the lower shrubs vary widely in ratio of occurrence.

The Jamanota-Arikok region [24]. A good impression of the vegetation of this region is obtained in going from Sta. Cruz to Fontein. The vegetation varies very strongly from scanty to dense thorny woodlands. In open places it is usually possible to find, besides some scattered shrubs of *Lantana* and *Croton*, several herbs and undershrubs such as *Pectis linifolia, Digitaria californica, Spigelia anthelmia, Elytraria imbricata, Chloris mollis, Jatropha gossypifolia, Stylosanthes hamata, Mollugo verticillata, Polygala bryzoides*, etc.

On some of the slopes of the low hills Croton thickets occur, consisting of a pure *Croton flavens* vegetation, sometimes intermixed with a few specimens of *Lantana, Jatropha, Cordia* and some weeds. They belong to the Croton facies of Croton-Lantana-Cordia thicket [V A]. These thickets are overtopped by some solitary trees, *Caesalpinia coriaria, Capparis* spp., *Prosopis juliflora*, etc. The greater part of the region, however, is overgrown with a dense shrub layer, 0.75 to 1.25 m high, in which *Croton, Lantana, Opuntia, Jatropha, Cordia, Phyllanthus euwensii* and *Melochia* are abundant: Croton-Lantana-Cordia thicket [V]. It is overtopped by small trees and high shrubs, which are usually scattered but can also form dense complexes of variable height: thorny woodland [II]. These thorny woodlands consist, inter alia, of the following species: *Acacia tortuosa, Pithecellobium unguis-cati, P. platylobum, Prosopis juliflora, Crataeva tapia, Malpighia punicifolia, Pisonia bonairensis, P. fragrans, Capparis* spp., *Bursera simaruba, B. bonairensis, B. tomentosa, Casearia tremula, Bourreria succulenta, Morisonia americana, Cereus repandus, Lemairocereus griseus, Cephalocereus lanuginosus* and *Schoepfia schreberi*. Herbs and undershrubs are often present: *Digitaria, Chloris, Pectis, Sida, Bidens, Euphorbia, Boerhavia, Portulaca, Tragus*. Epiphytes are generally absent and, when present, are found only in the valleys between the higher hills. The composition of the plant cover varies strongly from point to point.

The higher parts are generally scantily covered with vegetation; for instance, on the slope of the Jamanota [25], apart from a few high shrubs and an occasional small tree, such as *Coccoloba diversifolia, Capparis, Caesalpinia coriaria, Pithecellobium unguis-cati*, only a few small shrubs are found, e.g., *Cordia cylindrostachya, Croton flavens, Heliotropium angiospermum*, and several herbs. This vegetation belongs to the Croton-Lantana-Cordia thicket [V]. The following species were collected here: *Euphorbia thymifolia, Anthephora hermaphroditica, Bouteloua heterostega, Pectis linifolia, Spigelia anthelmia, Elytraria imbricata, Alternanthera brasiliana, Bidens cynapiifolius, Chloris mollis, Cyperus confertus, Hyptis suaveolens, Evolvulus argyreus, Pectis prostrata, Tragus berteronianus, Boerhavia caribaea, Heliotropium ternatum* and *Spermacoce confusa*. On the top of the Jamanota a few small specimens of *Agave*

vivipara were noted. Vegetation on the slope of the Jamanota is very scanty, and ground cover does not exceed about 30%.

A dense plant cover — belonging to the cactus-thorn scrub [III] — is developed in the valley between the Jamanota and Gran Tonel [26]. In a dense mass of Opuntia scrub, nearly 1 m in height, *Croton flavens, Cordia cylindrostachya, Phyllanthus euwensii* and *Melochia tomentosa* are found. Above this layer a nearly closed canopy occurs at a height of between 3 and 5 m, in which *Capparis linearis* is conspicuous and *Pithecellobium unguis-cati* and *P. platylobum* are frequent, as well as *Capparis indica, Acacia tortuosa, Caesalpinia coriaria* and *Casearia tremula.* Candle cacti are very conspicuous. Trees reaching a greater height are *Bursera tomentosa, B. simaruba, B. bonairensis, Croton niveus, Tabebuia chrysantha, Crataeva tapia. Morisonia americana* and *Bourreria succulenta* are present, but are represented by only a few specimens. Epiphytes are rather abundant: *Tillandsia recurvata* and *T. utriculata. Serjania curassavica* is the only liana. Several herbs and undershrubs were collected: *Euphorbia thymifolia, Physalis angulata, Mentzelia aspera, Dactyloctenium aegyptium, Malvastrum spicatum, Cenchrus pilosus, Cyperus confertus, Amaranthus dubius, Sida procumbens.*

In conclusion it can be said that the following types of vegetation may be distinguished in the island of Aruba:

CLIMATIC COMMUNITIES

Seasonal formations
- Thorny woodland [II]
- Cactus-thorn scrub [IV]
- Croton-Lantana-Cordia thicket [V]
  - Croton facies [V A]
  - Jatropha facies [V B]
- "Desert" [VI]

Dry evergreen formations
- Evergreen woodland [VII]
- Croton-Lantana-Cordia thicket [X]
  - Croton facies [X A]
  - Phyllanthus facies [X B]
  - Antirrhoea facies [X C]
- Littoral woodland [XI]
  - Coccoloba uvifera type [XI A]
  - Rhacoma crossopetalum type [XI B]
- Vegetation of the rock pavement [XII]

EDAPHIC COMMUNITIES
- Mangrove woodland [XIII]
- Herbaceous strand community [XIV]
  - Sesuvium facies [XIV A]
  - Fimbristylis facies [XIV B]
  - Sporobolus facies [XIV C]
  - Ipomoea facies [XIV C]
- Strand scrub community [XV]
  - Tournefortia facies [XV A]
  - Suriana facies [XV B]
  - Euphorbia facies [XV C]
- Hippomane woodland [XVI]
- Vegetation of salt flats and salinas [XVII]

BONAIRE

The southern part (south of the imaginary line from Punt Vierkant to the southern part of Lac) mainly consists of the lowest limestone plateau [1]. It is either absolutely bare or covered by a Conocarpus community which greatly varies

in density from point to point. Whole fields are covered by a thin sinter deposit, often broken up by the temporary root-action of *Conocarpus*. Between the *Conocarpus* shrubs — pressed down by the wind — some scattered tussocks of *Cyperus planifolius* var. *brunneus, Cyperus fuligineus, Fimbristylis ferruginea, Sporobolus pyramidatus* and *Lithophila muscoides* occur.

Between Willemstoren and Oranjepan [2], sand is deposited on the limestone, and here only *Sporobolus virginicus* is found. Near Punt Vierkant [3] the soil consists of mud and tuff deposits, and there a somewhat denser vegetation is observed. Between the scattered shrubs of *Conocarpus erecta* specimens of *Metopium brownei, Bursera simaruba, Crescentia cujete* and *Haematoxylon brasiletto* occur. Two species of sedges are present: *Cyperus planifolius* var. *brunneus* and *C. fuligineus*. Besides these, *Lithophila muscoides* and *Euphorbia thymifolia* appear in small numbers. An occasional specimen of *Avicennia nitida* is noted. This plateau is frequently flooded with fresh or brackish water during the rainy season. The vegetation of [1] and [3] belongs to the Conocarpus community [XII A].

Along the west coast there is a wall of coral debris, overgrown by a low shrub vegetation including *Lantana canescens, Suriana maritima, Waltheria americana* and some scattered high shrubs: *Conocarpus erecta, Metopium brownei* and *Coccoloba diversifolia*. Herbs: *Cyperus planifolius* var. *brunneus, Sporobolus pyramidatus, Lithophila muscoides, Euphorbia thymifolia* and *Cyperus fuligineus*. This vegetation has been strongly affected by human interference.

Remnants of a halophytic vegetation comprise patches of *Sesuvium portulacastrum, Salicornia ambigua* and *Batis maritima* beside the salt-pans and Pekelmeer [4]. These remnants are classified in the vegetation of the salt flats and salinas [XVII].

At one spot along the east coast — near Manparia Goetoe [5] — dune formation has taken place. Where the limestone becomes covered with sand, the pioneer *Sporobolus virginicus* appears, and is replaced by *Tournefortia gnaphalodes* where the sand layer becomes thicker: Tournefortia facies of the strand scrub community [XV A]. The latter becomes intermingled with *Suriana maritima* and soon disappears: Suriana facies of the strand scrub community [XV B]. Behind the dunes the presence of *Conocarpus erecta* gives the landscape the normal aspect of the lowest limestone plateau. On the sandy part *Euphorbia buxifolia* and *Lithophila muscoides* occur.

North of Punt Vierkant and west of the road to the salt-pans [6], the lowest limestone plateau carries a very scanty vegetation, consisting of widely scattered small trees, shrubs and Cactaceae. The limestone is covered by a thin layer of sinter deposits. In a plot 400 × 10 m in area, the following species were counted:

Opuntia wentiana	15 (37%)	*Lemairocereus griseus*	2 (5%)
Coccoloba diversifolia	12 (30%)	*Haematoxylon brasiletto*	2 (5%)
Conocarpus erecta	5 (12%)	*Crescentia cujete*	1 (2%)
Cereus repandus	3 (7%)	*Acacia tortuosa*	1 (2%)

The following species are present, also in very small numbers: *Euphorbia thymifolia, Lithophila muscoides, Cyperus fuligineus, C. planifolius* var. *brunneus, Sporobolus pyramidatus, Paspalum laxum* and *Melocactus*. It is classified as belonging to the vegetation of the rock pavement [XII].

Between Lima Plantation and the airfield [7] a denser, but still open vegetation, consisting of solitary trees and shrubs, is to be found. Herbs are absent, except for some grasses grazed by the goats. Lower shrubs are represented by a few scattered specimens. The average height of the trees and high shrubs is from 4 to 4½ m. In a plot 250 × 10 m the following species were counted:

Coccoloba diversifolia	84 (45%)	*Crescentia cujete*	3 (2%)
Antirrhoea acutata	43 (23%)	*Condalia henriquezii*	2 (1%)
Haematoxylon brasiletto	28 (15%)	*Bumelia obovata*	2 (1%)
Metopium brownei	15 (8%)	*Conocarpus erecta*	1 (1%)
Bourreria succulenta	8 (4%)		

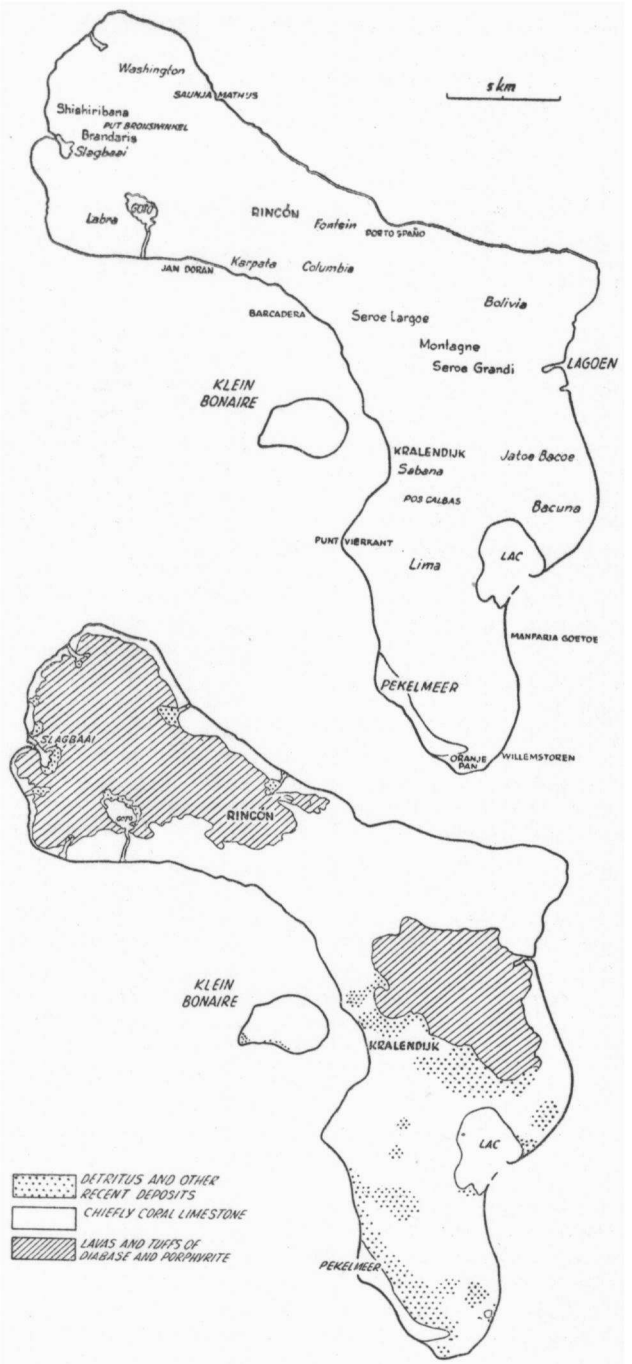

Fig. 4. Sketch map of Bonaire, with localities
Fig. 5. Geological sketch map of Bonaire.

Lower shrubs: *Cordia cylindrostachya, Lantana canescens, Croton flavens, Jatropha gossypifolia, Cassia obovata, Opuntia* and *Melocactus*. Only a few specimens of *Euphorbia thymifolia, Cyperus planifolius* and *C. planifolius* var. *brunneus* were seen. This vegetation belongs to dry evergreen bushland [IX].

North-east of Pos Calbas [8], the lower shrub layer is much better developed. Here *Croton flavens* is dominant and covers about 50% of the surface. Higher shrubs and small trees are scattered, and comprise the same species as in the preceding example. The limestone has the karren habit, and soil is only present in the crevices. The trees and high shrubs reach a height of 3½ to 4 m, whilst the lower shrubs do not exceed 1 metre in height. In a plot 200 × 10 m, the following species were recorded:

Coccoloba diversifolia	42 (43%)	*Condalia henriquezii*	4 (4%)
Metopium brownei	26 (27%)	*Haematoxylon brasiletto*	4 (4%)
Bourreria succulenta	8 (8%)	*Caesalpinia coriaria*	2 (2%)
Cereus repandus	6 (6%)	*Cephalocereus lanuginosus*	1 (1%)
Randia aculeata	5 (5%)		

Among the lower shrubs, *Croton flavens* occupies 60% of the surface and *Jatropha gossypifolia, Opuntia* and *Melocactus* frequently occur. *Antirrhoea acutata* and *Lantana canescens* are present in small numbers. Only a few herbs were found: *Lithophila muscoides, Euphorbia thymifolia, Phyllanthus polycladus, Paspalum bonairense* and *Aristida adscencionis*. This vegetation corresponds with the Croton-Lantana-Cordia thicket derived from dry evergreen formations [X].

The greater part of the rest of south Bonaire is known as Lima Plantation, [9]. It occupies a higher limestone terrace, about 6 to 7 m above sea-level. The limestone has the karren habit and soil is absent, except for that deposited in crevices. Vegetation is affected by the large number of half-wild goats, and rejuvenation does not take place as far as can be seen. The vegetation consists of a shrub layer about 2 m high, in which *Coccoloba diversifolia, Haematoxylon brasiletto* and *Metopium brownei* are the prominent species. On the other hand parts are found in which the plant cover is very open and the low shrubs comprise *Lantana camara, L. canescens, Croton flavens, Jatropha gossypifolia, Cordia cylindrostachya* and *Opuntia*. In co-operation with Brother M. Arnoldo and Dr. J. H. Westermann, a strip was enumerated nearly 1,500 m long and 10 m wide. In this strip only shrubs 1½ m and higher were counted, and only a few notes were made concerning the undergrowth. However, within these limitations all species seen by us were recorded or collected. The following data were obtained:

Coccoloba diversifolia	223 (34%)	*Crescentia cujete*	6 (1%)
Haematoxylon brasiletto	205 (31%)	*Cereus repandus*	2 (0.5%)
Metopium brownei	148 (22%)	*Bursera simaruba*	1 (0.5%)
Antirrhoea acutata	60 (9%)	*Casearia tremula*	2 (0.5%)
Bourreria succulenta	13 (2%)		

In the lower shrub layer *Lantana camara, L. canescens* and *Croton flavens* occur abundantly. Less abundant are *Opuntia, Jatropha gossypifolia* and *Antirrhoea acutata. Melocactus, Melochia tomentosa* and *Cordia cylindrostachya* are frequent, whereas *Waltheria americana, Corchorus hirsutus, Krameria ixina* and *Phyllanthus euwensii* are rare. Only a few herbs were noted: *Phyllanthus polycladus, Cyperus planifolius* var. *ottonis, Cyperus fuligineus, Eragrostis ciliaris, Lithophila muscoides* and *Euphorbia thymifolia*. Outside this strip one specimen of an unidentified species of the palm genus *Sabal* and a few specimens of *Bumelia obovata, Condalia henriquezii, Jacquinia barbasco* and *Acacia tortuosa* were seen, whereas *Randia aculeata* is sometimes very frequent.

Of the above-mentioned species only one is deciduous (*Bursera simaruba*), whilst *Coccoloba, Bourreria, Crescentia, Antirrhoea* and *Jacquinia* are evergreen. Few of the component species are thorny, and three have compound leaves. In consequence, this

type of vegetation is more dry-evergreen than seasonal in character. In the classification it forms part of the dry evergreen bushland [IX].

The lagoon of Lac [10], in the eastern part of south Bonaire, is surrounded by dense mangrove vegetation, consisting of *Rhizophora mangle* and *Avicennia nitida*. Of these species *Rhizophora* occupies the belt of constant inundation — Rhizophora consocies [XIII] — whereas *Avicennia* is more or less confined to the zone of temporary inundation — Avicennia consocies [XIII]. Epiphytes are absent. *Bursera simaruba* and *Condalia henriquezii*, of each of which only one specimen was found, have been noted as occasional species. The average height of *Rhizophora* amounts to 5 m, and in some places even to 7 m, whilst *Avicennia* usually does not exceed 4 metres in height. Along the fringe of the mangrove vegetation several patches of *Sesuvium portulacastrum*, *Salicornia ambigua* and *Batis maritima* occur, especially on the north-western and north-eastern sides. *Batis maritima* forms whole fields under *Avicennia*. Near Cay (the entrance to Lac) [11] vegetation has suffered from chopping for firewood. Here some scattered trees of *Conocarpus* are found. On the coral wall north of Cay groups of *Suriana maritima* and *Tournefortia gnaphalodes* shrubs occur, and between these groups some clusters of *Eleocharis caribaea*, *Sporobolus pyramidatus*, *Cyperus planifolius* var. *ottonis* and *Lithophila muscoides*. This vegetation is regarded as belonging to the strand scrub community [XV].

Along the southern side of Lac, vegetation is less developed and consists of a narrow strip of *Rhizophora* and *Avicennia*, interrupted in several places. Besides these two species, *Hippomane mancinella* and *Conocarpus erecta* also occur, intermingled with *Tournefortia gnaphalodes*, *Suriana maritima*, *Croton flavens* and *Cordia cylindrostachya*.

The east coast near Bacuna [12] is the most desolate part of the island. The limestone is absolutely bare, except for a few very widely scattered specimens of *Opuntia* and *Jatropha gossypifolia*. Only a few trees were seen in this area: *Jacquinia barbasco* and *Metopium brownei*. The vegetation is classified as vegetation of the rock pavement [XII].

Sabana [13], south-east of Kralendijk, is frequently inundated after heavy showers during the rainy season. On the limestone a rather thick layer of sand has been deposited. In the dry season, this takes the form of a bare sandy plain, dotted with trees and shrubs, either isolated or in small groups. The following species were collected: *Acacia tortuosa*, *Avicennia nitida*, *Bontia daphnoides*, *Conocarpus erecta*, *Croton flavens*, *Cryptostegia grandiflora*, *Lippia reptans*, *Opuntia* spp., *Lithophila muscoides*, *Phyllanthus euwensii*, *Sesuvium portulacastrum*.

During the rainy season many other species appear, but they never form a closed ground cover: *Ammannia auriculata*, *Ammannia coccinea*, *Bergia capensis*, *Cassia bicapsularis*, *Corchorus aestuans*, *Corchorus orinocensis*, *Cyperus esculentus*, *Eclipta alba*, *Eragrostis pilosa*, *Euphorbia thymifolia*, *Kallstroemia caribaea*, *Kallstroemia curta*, *Marsilia ernestii*, *Pectis prostrata*, *Scoparia annua*, *Tragus berteronianus*.

A great part of the middle region is still, or was recently, under cultivation. Of the localities visited, the following may be mentioned:

Seroe Grandi [14]. Vegetation on the western slope of this hill, which is about 100 m high, is rather scanty [14 a]. *Croton flavens*, *Lantana camara* and *Opuntia* are the prominent species in the shrub layer, which is less than 1 m in height. Among the other shrubs a few specimens of *Phyllanthus euwensii*, *Cassia obovata* and *Solanum argillicolum* may be observed; among the herbs, *Eragrostis ciliaris*, *Anthephora hermaphroditica*, *Euphorbia thymifolia* and *Cyperus confertus*. Solitary trees and high shrubs occur: *Acacia tortuosa*, *Capparis indica*, *Casearia tremula*, *Tabebuia chrysantha*, *Bursera simaruba*, *B. bonairensis*, *Randia aculeata* and *Prosopis juliflora*. This vegetation is classified as Croton-Lantana-Cordia thicket [V]. Along the southern slope vegetation becomes denser, and here an impenetrable growth of shrubby trees, among which *Tabebuia chrysantha* is very conspicuous, is even met with [14 b]. The other species

are the same as those mentioned as occurring on the western slope, and they vary greatly in frequency. This vegetation belongs to thorny woodland [II].

On the lower parts of the hill a very dense scrub is to be found [14 c]. The shrub layer consists of a growth of *Opuntia* 75 cm to 1 m in height, between which only a few shrubs of *Lantana camara* and *Croton flavens* are visible. Herbs are absent as far as can be seen. Above this *Opuntia* growth a tree layer exists, about 4 m in height, varying from open to very dense. It proved to be impossible to enumerate a plot. Only the following species can be mentioned: *Acacia tortuosa, Caesalpinia coriaria, Capparis cynophallophora, C. indica, Cephalocereus lanuginosus, Cereus repandus, Machaonia ottonis, Prosopis juliflora* and *Tabebuia chrysantha.*

This vegetation resembles that of the leeward slope of the Hooiberg, Aruba [20], and that of the valley between Jamanota and Gran Tonel, Aruba [26]. This vegetation belongs to cactus-thorn scrub [III].

Montagne and Seroe Largoe [15]. On Montagne, a 113 m-high limestone tableland, three strips 150 × 10 m were enumerated. The limestone has the karren habit and plant growth is only possible in the crevices. Vegetation reaches a height of 4 to 5 m, and the undergrowth is open. This undergrowth becomes denser in places were the higher layer is more open. *Opuntia* and *Croton flavens* are the most prominent species among the lower shrubs. Besides these a small number of the following species occur: *Lantana camara, Jatropha gossypifolia, Cassia obovata, Prosopis juliflora* and *Melocactus.* Herbs: *Lithophila muscoides, Euphorbia thymifolia,* a few grasses and sedges. The following species were recorded in these strips:

Haematoxylon brasiletto	67	(42%)	46	(29%)	80	(38%)
Condalia henriquezii	42	(26%)	34	(22%)	20	(10%)
Bursera bonairensis	16	(10%)	6	(4%)	5	(2%)
Bourreria succulenta	7	(4%)	8	(5%)	16	(8%)
Prosopis juliflora	6	(4%)	—	—	—	—
Pithecellobium unguis-cati	7	(4%)	5	(3%)	16	(8%)
Guaiacum sanctum	5	(3%)	15	(10%)	6	(3%)
Rhacoma crossopetalum	3	(2%)	6	(4%)	11	(5%)
Randia aculeata	2	(1%)	—	—	—	—
Capparis indica	2	(1%)	3	(2%)	—	—
Acacia tortuosa	1	(0.5%)	—	—	—	—
Bursera tomentosa	1	(0.5%)	—	—	—	—
Bursera simaruba	1	(0.5%)	4	(3%)	1	(0.5%)
Caesalpinia coriaria	1	(0.5%)	—	—	—	—
Coccoloba diversifolia	—	—	15	(10%)	22	(11%)
Crescentia cujete	—	—	6	(4%)	9	(4%)
Casearia tremula	—	—	5	(3%)	11	(5%)
Bumelia obovata	—	—	2	(1%)	5	(2%)
Capparis flexuosa	—	—	1	(1%)	—	—
Guaiacum officinale	—	—	—	—	4	(2%)
Jacquinia barbasco	—	—	—	—	2	(1%)
Fagara flava	—	—	—	—	1	(0.5%)

Outside the enumerated strips two groups of shrubs were seen, one of which comprised 14 specimens of *Casearia tremula* and the other 29 *Casearia tremula* and one *Crescentia cujete.* Other species outside these strips: *Ximenia americana, Cereus repandus, Cephalocereus lanuginosus* and *Phyllanthus euwensii.* The same aspect is presented by Seroe Largoe, but *Ximenia* and *Fagara flava* occur more frequently. This vegetation is classified as belonging to dry evergreen woodland [VII].

The limestone plateau of Bolivia Plantation [16] closely resembles that of Columbia Plantation, in the more affected parts. It produces a more or less mosaic vegetation, in which the lower thickets alternate with a scrub woodland. The latter varies from rather open to very dense, and undergrowth often consists of a pure Opuntia layer, forming in this way a nearly impenetrable growth.

The area has been strongly affected by human action, and cutting takes place. In this layer the following species are frequently encountered: *Prosopis, Acacia, Capparis, Pisonia, Bourreria, Coccoloba diversifolia, Antirrhoea acutata, Bursera, Haematoxylon, Guaiacum, Jacquinia, Crescentia* and *Malpighia.* Some occasional species rise above the layer: *Bumelia obovata* and *Tabebuia chrysantha. Metopium brownei* and *Casearia tremula* occur frequently. In the lower shrub thickets, *Croton flavens, Cordia cylindrostachya, Lantana* spp., *Croton ovalifolius, Opuntia, Krameria ixina, Sida, Malvastrum, Morinda,* etc., are generally found. In these thickets scattered trees and high shrubs occur, all of the same above-mentioned species. In several places *Randia* is very conspicuous. Several grasses and weeds may occur. This vegetation belongs to dry evergreen woodland [VII] and Croton-Lantana-Cordia thickets derived from dry evergreen formations [X].

In one place [17] a pure Haematoxylon thicket, about 4 m high, was found, in which only a very occasional *Capparis, Acacia* or *Caesalpinia* occurred. This thicket has a sub-growth of *Croton, Opuntia, Lantana* and *Cordia.* The number of *Haematoxylon* trees varied between 7 and 43 per plot 10 × 10 m in area. The thicket is regarded as the Haematoxylon facies of thorny woodland derived from dry evergreen formations [VIII A].

The district of Boven Bolivia [18] is characterized by a desert-like vegetation, comparable with that of north-western Aruba and a part of the coastal region near Fontein, Aruba [5] and [16]. The soil is bare, except for complexes a few square metres in area. These complexes consist for the greater part of *Prosopis juliflora,* up to 1½ m high, among which *Jatropha gossypifolia, Croton flavens, Opuntia, Malpighia punicifolia* (very rare), *Cereus repandus, Cyperus planifolius* var. *brunneus* and *Pithecellobium unguis-cati* (rare) are also observed. Between the complexes *Cereus repandus* is scattered in small numbers, whilst *Lithophila muscoides* may also be found. It is classified as "desert" [VI].

The lower limestone plateau of Bolivia [19] is very bare, and only an accidental tree or shrub grows here. These include *Conocarpus erecta, Bumelia obovata* and *Cereus repandus.* There are no more than a few small shrubs: *Strumpfia maritima, Opuntia, Jatropha gossypifolia* and *Sesuvium portulacastrum,* besides a few clusters of *Lithophila muscoides.* This vegetation is called by Beard (1949) "vegetation of the rock pavement" and is considered by him to be a sub-climax community of the littoral woodland [XII].

Near Boca Spelonk, the ground cover is still thin, but more species occur. A few trees are present: *Haematoxylon brasiletto, Capparis indica, Jacquinia barbasco* and *Prosopis juliflora.* Near the escarpment of the higher limestone terrace some other trees appear: *Bursera tomentosa, B. simaruba, Crescentia cujete* and *Casearia tremula. Jatropha gossypifolia* plays an important role in the shrub layer. Other small shrubs are *Lantana involucrata, Croton flavens, Gundlachia corymbosa, Alternanthera brasiliana, Corchorus hirsutus* and *Sida* spp. The following herbs were collected: *Euphorbia thymifolia, Lithophila muscoides, Phyllanthus polycladus, Bulbostylis floccosa* var. *pumilio* and *Cyperus planifolius* var. *ottonis.* This type may be considered to be a transition between the vegetation of the rock pavement and Croton-Lantana-Cordia thicket.

The northern part of Bonaire was under cultivation to a great extent in former times. Nowadays charcoal-burning takes place on a large scale, and a great part of the island's livestock is bred there. Of the localities visited, the following may be mentioned:

Columbia Plantation [20]. Entering Columbia Plantation from Porto Spaño, one ascends two limestone terraces, until the highest point is reached at 110 m above sea-level. From there a gradual descent takes place to about 5 m above sea-level near Barcadera. The limestone has the karren habit and some soil is deposited in the crevices.

In co-operation with Dr. J. H. Westermann and Brother M. Arnoldo a strip along

the path to Barcadera was enumerated, with the object of getting an idea of the composition of this vegetation. The following species were noted in the first strip:

Lemairocereus griseus	15 (22%)	*Bursera tomentosa*	3 (5%)
Cereus repandus	11 (16%)	*Bursera bonairensis*	2 (3%)
Haematoxylon brasiletto	10 (15%)	*Fagara monophylla*	2 (3%)
Bursera simaruba	8 (12%)	*Machaonia ottonis*	2 (3%)
Pithecellobium unguis-cati	7 (10%)	*Tabebuia chrysantha*	2 (3%)
Capparis flexuosa	4 (6%)	*Crescentia cujete*	1 (2%)

The undergrowth consists of *Croton flavens* and *Cordia cylindrostachya*, which are the most abundant species; many *Opuntia* and *Phyllanthus euwensii;* and some *Jatropha gossypifolia.*

The second strip was divided into two parts:

Haematoxylon brasiletto	19 (26%)	65 (15%)	*Cereus repandus*	—	—	56 (13%)
Guaiacum sanctum	12 (16%)	32 (7%)	*Antirrhoea acutata*	—	—	50 (11%)
Pithecellobium unguis-cati	9 (12%)	20 (5%)	*Metopium brownei*	—	—	28 (6%)
Coccoloba diversifolia	8 (11%)	52 (12%)	*Machaonia ottonis*	—	—	16 (4%)
Randia aculeata	7 (10%)	42 (10%)	*Tabebuia chrysantha*	—	—	9 (2%)
Casearia tremula	5 (7%)	10 (2%)	*Bursera bonairensis*	—	—	6 (1%)
Cephalocereus lanuginosus	3 (4%)	20 (5%)	*Lemairocereus griseus*	—	—	4 (1%)
Croton niveus	2 (3%)	1 (0.5%)	*Bourreria succulenta*	—	—	1 (0.5%)
Bursera simaruba	2 (3%)	24 (5%)	*Bumelia obovata*	—	—	2 (0.5%)
Crescentia cujete	2 (3%)	— —	*Bursera tomentosa*	—	—	1 (0.5%)
Capparis flexuosa	1 (1%)	— —	*Coccoloba uvifera*	—	—	1 (0.5%)
Condalia henriquezii	1 (1%)	— —	*Manihot carthaginensis*	—	—	1 (0.5%)
Prosopis juliflora	1 (1%)	— —	*Rhacoma crossopetalum*	—	—	1 (0.5%)
Caesalpinia coriaria	1 (1%)	— —				

Undergrowth: *Cordia cylindrostachya, Croton flavens, Melochia tomentosa, Opuntia.* Epiphytes: *Tillandsia utriculata, Schomburgkia tibicinis.* Climbers: *Cardiospermum corindum, Serjania curassavica, Ipomoea nil, Metastelma boldinghii.*

In the first strip 6 of the 12 species noted have compound leaves, 4 of these species being deciduous; 2 species are succulent, whilst 6, including the Cactaceae, are provided with spines. In the first part of the second strip 6 of the 14 species have compound leaves; 5 species are provided with spines, and only one succulent occurs. Only one species is deciduous. In the second part of this strip 22 species were noted. Eight of them have compound leaves, and 4 of these are deciduous, 8 species, including the Cactaceae, have spines. Consequently, this vegetation is dry evergreen in character: dry evergreen woodland [VII].

Near the coast of B a r c a d e r a [21] another plot was counted. The vegetation consists of a low tree and high shrub layer in which *Haematoxylon brasiletto* plays an important role, and a lower shrub layer 90% of which consists of *Croton flavens.* The ground cover varies between fairly open and rather dense. The limestone has the karren habit. Results of enumerating this plot (100 × 10 m):

Haematoxylon brasiletto	71 (46%)	*Pithecellobium unguis-cati*	3 (2%)
Randia aculeata	26 (17%)	*Tabebuia chrysantha*	3 (2%)
Cereus repandus	24 (15%)	*Jacquinia barbasco*	3 (2%)
Metopium brownei	8 (5%)	*Crescentia cujete*	1 (1%)
Bursera bonairensis	5 (3%)	*Caesalpinia coriaria*	1 (1%)
Coccoloba diversifolia	5 (3%)	*Guaiacum sanctum*	1 (1%)
Bursera simaruba	4 (2%)	*Bumelia obovata*	1 (1%)

Lower shrub layer: *Croton flavens, Opuntia* (abundant), *Cordia cylindrostachya, Opuntia curassavica, Melochia tomentosa, Jatropha gossypifolia, Morinda royoc, Casearia tremula, Cassia obovata, Antirrhoea acutata.* Herbs: *Euphorbia thymifolia, Cyperus planifolius* var. *ottonis.*

Between Rincón and Karpata [22] many aloe fields are found. Some of them have been more or less abandoned, and a regeneration of the vegetation is taking place. *Phyllanthus euwensii* plays an important role here, and forms about 80% of the shrub layer: Phyllanthus facies of Croton-Lantana-Cordia thicket [X B]. Other shrubs are *Casearia tremula, Erithalis fruticosa, Antirrhoea acutata, Croton flavens* and *Opuntia.* Some agaves also occur. However, the composition of the vegetation varies from place to place, and *Antirrhoea acutata* may also become prominent. Scattered trees occur: *Bourreria succulenta, Bursera bonairensis, B. simaruba, Caesalpinia coriaria, Casearia tremula, Cereus repandus, Crescentia cujete, Haematoxylon brasiletto* and *Randia aculeata.* The shrub layer reaches a height of 2 m, and the trees may be as much as 5 metres high.

Along the coast from Jan Doran to Goto [23], the following species were noted in the aloe fields: *Acacia tortuosa, Bumelia obovata, Bursera simaruba, Caesalpinia coriaria, Capparis flexuosa, C. indica, Cephalocereus lanuginosus, Cereus repandus, Coccoloba diversifolia, Conocarpus erecta, Crescentia cujete, Cyperus planifolius* var. *ottonis, C. rotundus, Guaiacum officinale, Haematoxylon brasiletto, Jacquinia barbasco, Lithophila muscoides, Metopium brownei, Morinda royoc, Opuntia* spp., *Paspalum laxum. Erithalis fruticosa* and *Antirrhoea acutata* are particularly abundant.

Labra Plantation [24] is characterized by a shrub vegetation, up to 1 m high, in which *Croton flavens* is the dominant species: Croton facies of Croton-Lantana-Cordia thicket [V A]. It alternates with small areas of thorny woodland [II]. There are many species of trees and high shrubs scattered over the area. Composition varies from place to place, but the following species occur regularly: *Bumelia obovata, Bursera bonairensis, B. simaruba, B. tomentosa, Caesalpinia coriaria, Capparis flexuosa, C. indica, Casearia tremula, Cephalocereus lanuginosus, Cereus repandus, Guaiacum offinale, Machaonia ottonis, Malpighia glabra, M. punicifolia, Melochia tomentosa, Opuntia* spp., *Phyllanthus euwensii, Prosopis juliflora* and *Randia aculeata.* Less frequent are: *Cordia alba, Guaiacum sanctum, Maytenus versluysii* and *Lantana involucrata.* Vines: *Metastelma boldinghii, Ipomoea muricata, Rhynchosia minima* and *Omphalophthalmum ruber.* Herbs are usually absent, except for some common weeds.

Slagbaai Plantation [25] presents this same aspect of low-vegetation alternating with thorny woodland. In the latter *Malpighia punicifolia, Randia aculeata, Caesalpinia coriaria, Bursera simaruba, B. bonairensis, Capparis* spp., *Crescentia cujete* and *Cereus repandus* play an important part. The shrub layer usually contains *Croton flavens, Phyllanthus euwensii, Melochia tomentosa, Corchorus hirsutus* and *Opuntia. Croton ovalifolius* is often present. In other places the vegetation resembles the cactus-thorn scrub occurring very extensively in the Washington Plantation. Composition is very variable owing to cutting operations, mainly for charcoal-burning.

One type of secondary growth that must be mentioned is to be found in the vicinity of Boca Slagbaai. This area, formerly planted with aloes, is overgrown with a secondary thicket of *Phyllanthus euwensii,* up to 2 m high. There are only a few other species present: *Croton flavens, Lantana camara, Opuntia* and *Jatropha gossypifolia.* It is considered to be the Phyllanthus facies of Croton-Lantana-Cordia thicket [X B].

This plantation includes the highest point on Bonaire: the hill of Brandaris [26]. The vegetation on this hill does not differ from that on the other hills. To reach the foot of the Brandaris from Boca Slagbaai it is necessary to pass through a thorny woodland, composed of the common species *Prosopis juliflora, Caesalpinia coriaria, Randia aculeata, Capparis* spp., *Crescentia cujete, Cereus repandus* and *Lemairocereus griseus, Phyllanthus euwensii, Croton flavens,* etc. In a few spots *Agave vivipara* is to be seen. The vegetation on the slopes of the hill is very scanty on the windward side, and varies in density on the leeward side. Besides the species previously mentioned, *Maytenus versluysii, Pisonia bonairensis, Haematoxylon brasiletto, Casearia tremula, Bourreria succulenta* are found here, and, among the lower shrubs,

Phyllanthus euwensii, Croton flavens, Rivina humilis. Herbs: *Portulaca venezuelensis, Euphorbia thymifolia, Cyperus swartzii* var. *granularis, Eragrostis ciliaris, Cyperus amabilis, Sida* spp., *Rhynchosia minima.* In the higher parts *Coccoloba diversifolia* appears, and forms the dominant species on the top of the hill: Coccoloba diversifolia facies of dry evergreen bushland [IX A]. Here *Acalypha poirettii* and a small number of *Lantana camara* also occur. *Doryopteris concolor* var. *concolor* is likewise present, whilst one *Brassavola nodosa* was collected by Brother M. Arnoldo.

A nearly pure stand of *Prosopis juliflora* is to be found near Put Bronswinkel [27], Washington Plantation, reaching a height of 4 metres: Prosopis facies of thorny woodland [II A]. There are only a few other species, represented by a few specimens: *Capparis indica, Crescentia cujete, Cereus repandus* and *Cephalocereus lanuginosus.* Among the lower shrubs scattered specimens of *Croton flavens, Melochia tomentosa* and *Opuntia* occur. The vine *Metastelma boldinghii* was collected.

Near Shishiribana [28] *Cereus* becomes very prominent and rises above the Prosopis layer to a height of 12 m, together with an occasional *Bursera bonairensis. Prosopis* forms over 60% of the total crop. It is intermixed with the following species: *Casearia tremula, Randia aculeata, Acacia tortuosa, Capparis indica* and *Phyllanthus euwensii.* In the lower shrub layer *Croton flavens, Opuntia* and *Melochia tomentosa* are frequent. Epiphytes are represented by *Tillandsia recurvata.* This vegetation belongs to cactus scrub [IV].

In the lower parts of Washington Plantation [29] a high shrub layer, up to 4 m in height is found generally distributed, overtopped by scattered trees and Cactaceae. The latter usually include *Bursera simaruba, B. bonairensis, B. tomentosa, Machaonia ottonis, Cereus repandus, Lemairocereus griseus,* and an occasional *Tabebuia chrysantha.* The highest shrub layer contains *Prosopis juliflora, Acacia tortuosa, Randia aculeata, Caesalpinia coriaria, Capparis indica, Capparis cynophallophora,* and an occasional *Guaiacum officinale.* In the lower shrubs *Croton flavens, Lantana involucrata, Phyllanthus euwensii, Melochia tomentosa* and *Opuntia* spp. generally occur. Herbs are not often found. This whole area is used as grazing land for half-wild goats and cattle. It exhibits a very uniform aspect and belongs to cactus-thorn scrub [III]. In this part of Bonaire, in particular, candle cactuses are very abundant, not only on the lower ground but also on the higher parts of the hills — a feature not often seen in the islands of the Windward group.

Especially in the rainy season, hydrophytes and hygrophytes are sometimes to be found behind the many small dikes and round the tankies (ponds). In and around Put Bronswinkel [30], *Lemna perpusilla, Stemodia durantifolia, Ammannia latifolia* and *Eleocharis mutata* were collected. Behind a dike, with accumulated water, near Jatoe Bacoe [31], Brother Arnoldo and the author collected the following species: *Amaranthus dubius, A. polygonoides, Ammannia coccinea, A. auriculata, Bergia capensis, Cassia nictitans, Cleome stenophylla, Corchorus aestuans, C. orinocensis, Cordia alba, Cyperus esculentus, C. rotundus, Cypselea humifusa, Desmanthus virgatus, Echinodorus cordifolius, Eclipta alba, Eragrostis pilosa, Heteranthera limosa, Jussieua erecta, Kallstroemia caribaea, Leptochloa fascicularis, Marsilia ernestii, Mollugo verticillata, Paspalidium geminatum, Physalis angulata, Portulaca halimoides, P. oleracea, Scirpus micranthus, Scoparia annua, Spigelia anthelmia, Stemodia durantifolia,* and *Trianthema portulacastrum.*

In conclusion it can be said that the following types of vegetation can be distinguished in the island of Bonaire:

CLIMATIC COMMUNITIES

Seasonal formations

Thorny woodland [II]
Prosopis facies [II A]
Cactus-thorn scrub [III]
Cactus scrub [IV]

Croton-Lantana-Cordia thicket [V]
Croton facies [V A]
"Desert" [VI]

Dry evergreen formations
Evergreen woodland [VII]
Thorny woodland [VIII]
Haematoxylon facies [VIII A]
Dry evergreen bushland [IX]
Coccoloba diversifolia facies [IX A]
Croton-Lantana-Cordia thicket [X]
Phyllanthus facies [X B]
Vegetation of the rock pavement [XII]
Conocarpus community [XII A]

EDAPHIC COMMUNITIES
Mangrove woodland [XIII]
Strand scrub community [XIV]
Tournefortia facies [XV A]
Suriana facies [XV B]
Euphorbia facies [XV C]
Vegetation of salt flats and salinas [XVII]
Fresh and oligohalinous water communities [XVIII]

CURAÇAO

Along St. Joris Baai [1] a pure stand of *Rhizophora mangle* is found, encircling the inland side of the bay. It is considered to be the Rhizophora consocies of mangrove woodland [XIII]. *Batis maritima* is associated with it and occurs mainly on the somewhat higher, and consequently drier, alluvial deposits.

Along Spaanse Water [2] a very small fringe of *Rhizophora mangle* and *Laguncularia racemosa* is found. The latter is more abundant, probably owing to repeated cutting.

Mangrove occurs in very small quantities at several places in the island near the inland bays, e.g. west of Willemstad, along the Rif [3], where *Rhizophora mangle, Laguncularia racemosa* and *Avicennia nitida* are found, associated with *Euphorbia buxifolia, Iresine vermicularis, Atriplex cristata* and *Tephrosia cinerea.*

Only a few remnants of strand communities were seen, consisting of some creeping *Ipomoea pes-caprae* intermixed with species of strand scrub: *Tournefortia gnaphalodes, Suriana maritima* and *Euphorbia buxifolia.* These remnants occur near Rif [4], Bullen Baai [5], and along the south-western coast near Willemstad [6].

The best example on the island is probably that near Bullen Baai [5]; there, behind the very open zone of widely scattered *Ipomoea* and shrubs of the strand scrub community [XV], a rather open, 4 m-high belt of *Coccoloba uvifera* occurs, associated with *Rhacoma crossopetalum* and some herbs such as *Cyperus fuligineus, Cyperus planifolius* var. *brunneus, Euphorbia thymifolia* and *Paspalum laxum:* Coccoloba type of littoral woodland [XI A]. Here the following halophytes and strand plants were collected: *Sesuvium portulacastrum, Suriana maritima, Strumpfia maritima, Heliotropium curassavicum, Tournefortia gnaphalodes* and *Batis maritima.* Some other species were also collected: *Lantana canescens, Portulaca phaeosperma, Lithophila muscoides, Tephrosia cinerea, Bourreria succulenta, Sophora tomentosa* and *Lantana camara.*

Hippomane woodlands are to be found along the coast in Curaçao, as well as farther inland. Of the former localities, the following may be mentioned: Westpunt [7], Sta. Martha [8], between Willemstad and Jan Thiel [9]. Of the latter:

north of Spaanse Water (Rooi Manzanielja) [10], west of the airport of Hato [11] and near Savonet [12]. Near Hato the soil consists of limestone, whereas the other two localities are on diabase. In some places the Hippomane woodland reaches a height of 12 metres, but, as a rule, it has been strongly affected by human interference.

East of Sta. Martha [13], on the sea-side of the escarpment of the limestone terrace, *Conocarpus erecta* and *Strumpfia maritima* are found, growing very close to the sea, whilst *Batis maritima* and *Salicornia ambigua* also occur here.

The limestone region. A very poor and scanty vegetation occurs along the north coast of the island [14]. Here are found only widely scattered shrubs of *Cordia cylindrostachya, Antirrhoea acutata, Conocarpus erecta, Tournefortia gnaphalodes, Lippia reptans, Cereus repandus, Lemairocereus griseus,* many *Opuntia* and *Melocactus. Prosopis juliflora* occurs, but as a low shrub, owing to the constant wind. Complexes of these species are often found.

On the limestone terrace, east of Willemstad [15], about 50 m above sea-level, the vegetation is denser and the ground cover amounts to nearly 60%. It is possible to distinguish two shrub layers, to a greater or lesser extent:

1½ m and higher: *Haematoxylon brasiletto* (30%), *Condalia henriquezii* (10%), *Caesalpinia ciliata* (5—10%), *Erithalis fruticosa* (5—10%).
Acacia tortuosa (few), *Bourreria succulenta* (few) and *Caesalpinia coriaria* (few).

Less than ½ m high: *Jatropha gossypifolia* (a), *Melocactus* (a), *Cordia cylindrostachya* (fr), *Croton flavens* (fr), *Lantana involucrata* (fr), *Morinda royoc* (fr), *Opuntia* (fr), and *Heliotropium ternatum* (o).

For the most part, the herbs have been removed by grazing. The vegetation has been strongly influenced by human interference. It is regarded as belonging to thorny woodland derived from dry evergreen formations [VIII].

Sta. Martha, east of the salt pond [16]. The first terrace [16 a] exhibits specimens of *Agave* and *Aloe vera,* i.e. indications that this area was under cultivation in former times. Three strips measuring 25 × 5 m were enumerated:

2—4 m-high shrubs and small trees:

Haematoxylon brasiletto	12 (46%)	8 (42%)	— —
Caesalpinia coriaria	4 (15%)	2 (11%)	2 (11%)
Randia aculeata	4 (15%)	6 (32%)	— —
Cereus repandus	3 (12%)	2 (11%)	5 (26%)
Acacia tortuosa	1 (4%)	— —	12 (63%)
Bumelia obovata	1 (4%)	1 (5%)	— —
Jacquinia barbasco	1 (4%)	— —	— —

1—2 m-high shrubs:

Caesalpinia coriaria	4	6	—	*Lantana involucrata*	r	—	—
Phyllanthus euwensii	4	8	—	*Cereus repandus*	—	2	—
Haematoxylon brasiletto	1	—	—	*Croton flavens*	—	—	fr
Jacquinia barbasco	1	1	—	*Acacia tortuosa*	—	—	3

Less than 1 m high:

Melocactus	fr	—	r	*Phyllanthus euwensii*	r	—	—
Capraria biflora	r	—	—	*Agave vivipara*	—	o	—
Lantana involucrata	r	r	r	*Croton flavens*	—	o	r

Outside these strips, the following species were collected and/or seen: *Guaiacum officinale, Opuntia* spp., *Morinda royoc, Condalia henriquezii, Crescentia cujete, Coccoloba diversifolia, Bursera tomentosa, B. bonairensis* and *Aloe vera.* Epiphyte: *Tillandsia recurvata.* In some places dense complexes of *Opuntia* are found.

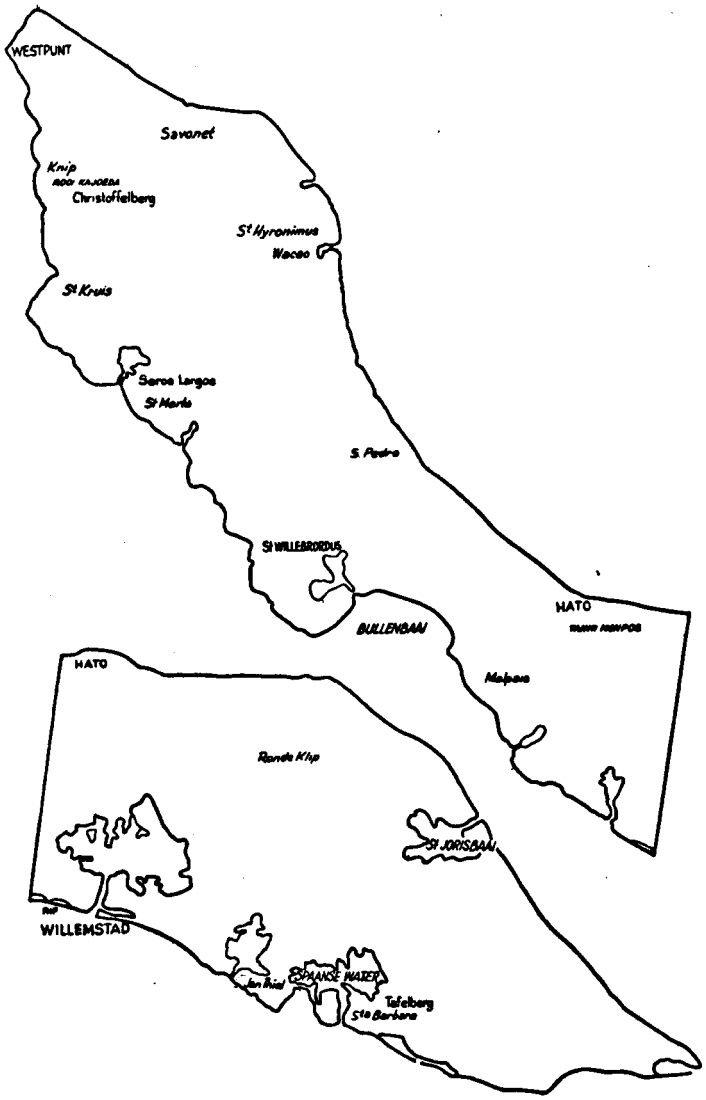

Fig. 6. Sketch map of Curaçao, with localities.

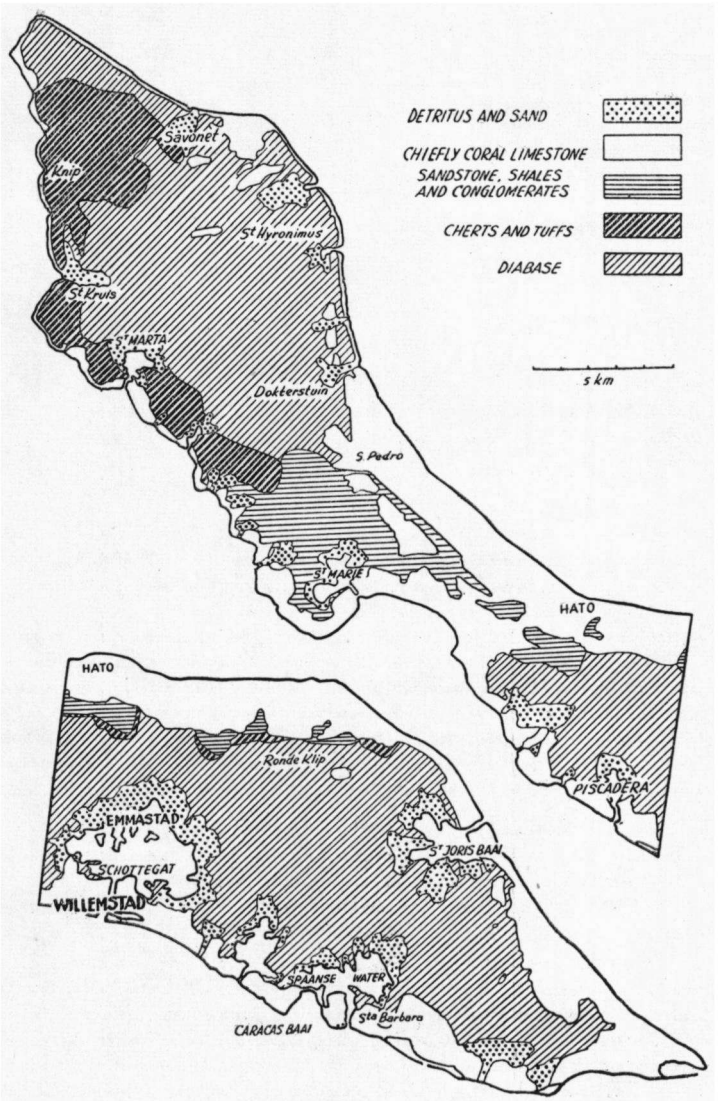

Fig. 7. Geological sketch map of Curaçao.

On the second terrace [16 b] 3 strips measuring 25 × 10 m were enumerated:

Trees 4—5 m high:			
Bursera simaruba	1 (3%)	1 (3%)	1 (2%)
2—4 m high:			
Haematoxylon brasiletto	14 (43%)	15 (57%)	26 (47%)
Randia aculeata	9 (27%)	3 (11%)	20 (37%)
Caesalpinia coriaria	6 (18%)	1 (4%)	3 (6%)
Acacia tortuosa	2 (6%)	2 (8%)	3 (6%)
Phyllanthus euwensii	1 (3%)	2 (8%)	1 (2%)
Guaiacum officinale	— —	2 (8%)	1 (2%)
1—2 m high:			
Acacia tortuosa	3	7	2
Caesalpinia coriaria	2	2	3
Less than 1 m high:			
Croton flavens	fr	a	fr
Randia aculeata	—	—	r

Epiphyte: *Tillandsia recurvata.*

There are some scattered groups of *Agave vivipara. Cereus* occurs sporadically. Outside these strips *Jacquinia barbasco, Bumelia obovata* and *Malpighia glabra* were seen. This vegetation corresponds with the Haematoxylon facies of thorny woodland [VIII A], to a greater or lesser extent.

Along the coast, west of the salt pond, a thorny woodland occurs on the limestone terrace, in which woodland *Prosopis juliflora* and *Haematoxylon* are the dominating species, accounting for approximately 40 and 30% of the whole, respectively. Other species are: *Guaiacum officinale, Capparis indica, Acacia tortuosa,* an occasional *Bursera* and *Bumelia obovata.* In the shrub layer *Croton flavens, Lantana camara, L. involucrata* and *Jatropha gossypifolia* are abundant, while *Antirrhoea acutata* occurs sporadically.

The vegetation of the terrace near Hato [17] consists of a low, rather open shrub layer, overtopped by widely scattered small trees and high shrubs, up to 4 m in height. Ground cover varies strongly from place to place, ranging from 20 to 80%.

The following species, rising above the shrub layer, were collected: *Coccoloba diversifolia, Haematoxylon brasiletto, Cereus repandus, Bumelia obovata, Crescentia cujete, Bursera bonairensis, Bourreria succulenta, Metopium brownei.* Shrubs, up to 1 m high: *Croton flavens* (a), *Cordia cylindrostachya* (a), *Antirrhoea acutata* (v.a), *Erithalis fruticosa* (fr), *Casearia tremula* (fr), *Caesalpinia coriaria* (r) and *Phyllanthus euwensii* (r). Less than ½ m high: *Jatropha gossypifolia* (fr), *Opuntia* (fr), *Melocactus* (fr), *Morinda royoc* (r) and *Acalypha cuspidata* (r). This vegetation forms part of the dry evergreen bushland [IX].

Nearer to the coast [17 a] the higher shrubs become more prominent; *Coccoloba diversifolia* dominates and *Bumelia obovata* occurs more frequently: Coccoloba diversifolia facies of dry evergreen bushland [IX A].

In this neighbourhood the Hippomane woodland, 10—12 m high, which was mentioned above, [11], is also found. Other species collected in this woodland are: *Cordia alba, Chlorophora tinctoria, Acacia tortuosa, Morinda royoc* and *Phyllanthus euwensii.*

Ronde Klip hill [18] is 129 m high and consists of diabase, covered with a limestone cap. The vegetation is very dense, generally reaches a height of 1¾—2

metres, and is overtopped by scattered higher trees, among which *Bursera simaruba, B. tomentosa, Jacquinia barbasco, Bourreria succulenta* and *Bumelia obovata* can be seen. In the shrub layer *Coccoloba diversifolia* and *Cordia cylindrostachya* are the dominant species, but the ratio of occurrence varies strongly from place to place. *Metopium brownei* occurs frequently; *Randia aculeata* and *Rhacoma crossopetalum* are very frequent. The low shrubs include many *Lantana involucrata, L. camara, Melochia tomentosa, Erithalis fruticosa, Croton flavens, Heliotropium angiospermum* and, especially in the more open places, *Opuntia* and *Melocactus. Cereus repandus, Lemairocereus griseus* and *Cephalocereus lanuginosus* are very frequent. The undershrubs and herbs here include *Aristida adscencionis, Heliotropium ternatum, Paspalum pleyostachyum, Isocarpha oppositifolia, Atriplex cristata, Phyllanthus polycladus, Achyranthes halimifolia, Amaranthus* spp. and *Ruellia tuberosa.* The vegetation closely resembles that of Lima Plantation, Bonaire [9] and belongs to dry evergreen bushland [IX].

The vegetation of the Tafelberg of Sta. Barbara [19] is mosaic-like; areas of low shrubs alternate with dense, small thickets of higher shrubs and small trees. The latter thickets [19 a] are usually formed by at least some of the following species: *Ruprechtia coriacea, Bumelia obovata, Caesalpinia coriaria, Haematoxylon brasiletto, Condalia henriquezii, Coccoloba diversifolia, Randia aculeata, Bourreria succulenta* and *Metopium brownei.* They vary strongly in density and composition and belong to dry evergreen woodland [VII]. The lower-shrub thickets [19 b] are usually very open when they are dominated by, or entirely composed of, *Antirrhoea acutata,* and very dense when they are intermingled with *Opuntia.* The vegetation belongs to the Antirrhoea facies of Croton-Lantana-Cordia thickets [X]. The following species often occur between the scattered shrubs of *Antirrhoea acutata: Lantana camara, L. involucrata, Casearia tremula, Jatropha gossypifolia, J. urens, Tephrosia cinerea, Morinda royoc* and *Agave vivipara. Cereus, Lemairocereus* and *Melocactus* also occur frequently. Among the herbs *Lithophila muscoides, Euphorbia thymifolia, Cenchrus echinatus, Pilea tenerrima* and *Phyllanthus polycladus* are found.

It is probable that the greater part of the area outside the limestone region was formerly under cultivation. The rapid run-off of the rainwater and the constant erosion, combined with unjustifiable cutting of the original vegetation, has led in the most serious cases to secondary deserts such as can be seen, for example, along the north-east coast near Savonet [20]. There, plant growth is almost entirely absent except for an occasional species of Cactaceae or *Croton.*

The hills in the eastern part of the island are also very bare [21]. There — e.g., east of Willemstad — only a few scattered shrubs of *Croton, Lantana, Opuntia, Cereus* and some grasses are found. In the eastern part of the island Croton thickets are frequently encountered in which *Croton flavens* is the dominant species, associated with *Opuntia, Lantana, Jatropha* and some grasses. Scattered trees and high shrubs of *Malpighia, Randia, Capparis, Caesalpinia coriaria, Acacia* and candle cactuses may occur. These thickets are considered to represent the Croton facies of Croton-Lantana-Cordia thickets [V A]. As a general rule, the rooien (gullies) contain more vegetation and here dense scrubs are often found, in which *Prosopis, Acacia, Capparis, Randia* and sometimes *Haematoxylon* are dominant, with a shrub layer of *Croton, Phyllanthus, Opuntia* and *Lantana.* Herbs are only to be found in the rainy season. Just as is the case everywhere else in the island, plant cover has suffered from the depredations of the numerous half-wild goats. The vegetation in the gullies is regarded as belonging to thorny woodland [II].

An impenetrable growth of thorny woodland [II] encircles the foot of the Tafelberg of Sta. Barbara [22]. The trees, which are often shrubby, reach a height of 3½ to 4 m, and are composed for the most part of thorny Mimosaceae and Fabaceae: *Prosopis, Acacia, Haematoxylon,* together with *Capparis indica, Celtis iguanaea, Malpighia punicifolia, Bourreria succulenta* and *Casearia tremula.* They are

overtopped by scattered *Bursera simaruba, B. tomentosa, Crescentia cujete* and *Machaonia ottonis. Guaiacum officinale* and *G. sanctum* occur, but sporadically. The undergrowth is formed by *Opuntia,* usually in very dense masses, or, if *Opuntia* is not present in such quantities, by *Croton, Lantana, Corchorus hirsutus, Piriqueta ovata* and *Argithamnia candicans. Cheilanthes microphylla* was found here and, on the calcareous plateau in the neighbourhood, *Mammillaria simplex.*

In Malpais [23], in a rather small area, Croton-Lantana-Cordia thickets, thorny woodland and cactus scrub are found.

The Croton-Lantana-Cordia thickets present a general aspect of shrubs, 30—100 cm high, often dominated by *Croton flavens,* with scattered trees and high shrubs. Here may be found *Capparis indica, Randia aculeata, Caesalpinia coriaria, Acacia tortuosa, Tamarindus indica, Balanites aegyptica, Chlorophora tinctoria, Phoenix dactylifera, Thrinax parviflora,* etc. The vegetation belongs to the Croton facies of the Croton-Lantana-Cordia thickets [V A].

The thorny woodlands are composed of the common species: *Acacia, Prosopis, Caesalpinia, Randia,* etc., but they may also include *Chlorophora tinctoria, Phoenix dactylifera, Crescentia cujete* and an occasional *Hippomane mancinella.* Smaller shrubs often make these thickets absolutely impenetrable: *Croton, Lantana, Opuntia,* and *Phyllanthus.* The following undershrubs and herbs were noted: *Jatropha gossypifolia, J. urens, Commicarpus scandens, Lippia reptans, Egletes prostrata.* Climbers and vines: *Abrus precatorius, Passiflora suberosa, P. foetida* var. *moritziana* and *Ceratosanthes palmata.* The parasite *Cuscuta americana* frequently occurs.

In the cactus scrub [IV] *Cereus repandus* and *Cephalocereus lanuginosus* are the most prominent species, reaching a height of 8 metres or more. Between these Cactaceae are seen *Acacia tortuosa, Morisonia americana, Caesalpinia coriaria, Condalia henriquezii, Malpighia punicifolia, Phyllanthus euwensii, Opuntia, Croton, Melochia tomentosa* and *Randia aculeata.* Climbers and vines: *Abrus precatorius, Tournefortia volubilis, Ipomoea nil, Passiflora foetida* var. *moritziana, Omphalophthalmum ruber* and *Cryptostegia grandiflora. Metastelma boldinghii* is present. *Guaiacum officinale* is to be found as an occasional specimen.

A cactus scrub [IV], with *Acacia tortuosa* and *Prosopis juliflora,* forming complexes a few square metres in area, occurs in Wacao [24]. The soil between these complexes is bare, except for a few grasses: *Aristida swartziana, Anthephora hermaphroditica, Bouteloua heterostega, B. aristoides, Eragrostis ciliaris* and *E. ciliaris* var. *brachystachya.* The complexes mainly consist of low shrubs of *Acacia* and *Prosopis,* not exceeding about 80 cm in height owing to wind influences. Besides these species *Acacia villosa, Jatropha, Croton, Capparis indica, Randia, Cereus, Malpighia, Caesalpinia coriaria, Guaiacum officinale, Crescentia, Omphalophthalmum ruber* and *Cissus sicyoides* occur.

A more luxuriant vegetation is to be found in the western part of the island, especially in the country surrounding the Christoffelberg [25], and on some hills near Sta. Martha [26].

The foot of Seroe Largoe [26 a] is reached through a dense scrub, 3½ to 5 m high, in which *Acacia, Prosopis* and *Capparis* are dominant, besides a few small trees of *Guaiacum,* and an occasional *Machaonia ottonis* and *Cordia alba.* The sub-growth consists of the common species, such as *Croton, Lantana, Jatropha,* and a great number of *Opuntia. Cereus* and *Cephalocereus* are frequent: thorny woodland [II]. In the higher parts [26 b], such taller trees as *Tabebuia chrysantha, Bursera* spp., and occasional *Peltophorum suringari* and, in shrub layer, *Capparis* spp., *Pithecellobium unguis-cati, Coccoloba diversifolia, Erythroxylon* and *Randia* occur. The ground is densely covered by patches of *Bromelia lasiantha, Opuntia* and young specimens of *Lemairocereus griseus.* This vegetation belongs to deciduous seasonal forest [I].

In climbing the Christoffelberg from the Knip Plantation side, a vegetation common to the western part of the island is first traversed.

Near Rooi Kajoeda [27] a strip 100 × 10 m was enumerated, giving the following results:

Caesalpinia coriaria	113 (45.9%)	*Rhacoma crossopetalum*	11 (4.5%)
Acacia tortuosa	48 (19.5%)	*Cordia alba*	3 (1.2%)
Randia aculeata	34 (13.8%)	*Chlorophora tinctoria*	3 (1.2%)
Cereus repandus	18 (7.3%)	*Guaiacum officinale*	2 (0.8%)
Haematoxylon brasiletto	13 (5.2%)	*Crescentia cujete*	1 (0.4%)

Lower shrubs: *Croton flavens* (a), *Phyllanthus euwensii* (a), *Acacia villosa* (a), *Cordia cylindrostachya* (fr), *Jatropha gossypifolia* (fr) and *Tephrosia cinerea* (r). Climbers and vines: *Ipomoea carnea, Passiflora suberosa.* Herbs: *Argemone mexicana, Aristida swartziana, Callisia repens, Euphorbia thymifolia, Leonotis nepetaefolia, Pectis febrifuga* and *Spermacoce confusa.* This vegetation is considered to be a luxuriant thorny woodland.

Outside this strip, the following species were seen: *Machaonia ottonis, Coccoloba diversifolia, Aloe vera, Jatropha urens, Heliotropium angiospermum, Aristida adscencionis, Anthephora hermaphroditica* and *Tillandsia recurvata.*

West of Pos Kajoeda [28 a] a rather dense shrub thicket occurs, 2½ to 3 m high, overtopped by some trees of *Tabebuia chrysantha.* In this thicket *Acacia villosa,* up to 2½ m high, is very conspicuous, whilst the following species are abundant: *Acacia tortuosa, Caesalpinia coriaria, Haematoxylon brasiletto, Cereus repandus, Phyllanthus euwensii, Cordia cylindrostachya* and *Capparis linearis.* Of the lower shrubs, *Opuntia elatior, O. tuna, O. curassavica* and some *Croton flavens* are present. In several places *Coccoloba diversifolia* is conspicuous, often reaching a height of 5 metres. *Solanum argillicolum, Portulaca venezuelensis, Callisia repens* and *Pectis febrifuga* are the herbs. *Serjania curassavica* occurs frequently.

Now and again the vegetation is more open, and here *Haematoxylon brasiletto* and *Cereus* are dominant, whilst an occasional *Bourreria succulenta* also appears.

Higher up *Coccoloba* becomes conspicuous, together with *Casearia tremula, Haematoxylon* and *Maytenus versluysii.* In the shrub layer *Acacia villosa* is very prominent, in addition to *Cordia cylindrostachya, Croton flavens* and *Opuntia.* Climbers and vines: *Serjania curassavica, Jacquemontia nodiflora* and *Ipomoea carnea.* Epiphyte: *Brassavola nodosa.* Herbs: *Callisia repens* and *Isocarpha oppositifolia.*

On the steep slopes [28 b], *Coccoloba diversifolia* is often the dominant species, usually even forming an open, pure stand: the Coccoloba diversifolia facies of dry evergreen bushland [IX A].

In this area the vegetation varies strongly in composition from point to point. The distribution of some species occurring here is confined to this part of the island: *Byrsonima crassifolia, Aulomyrcia curassavica, A. curassavica* var. *acutata, Nephrolepis biserrata, Lygodium venustrum,* a not yet identified species of the genus *Sabal,* and *Sorocea arnoldii.*

The following species are typical of the higher parts of Knip hills [29], near Christoffelberg: *Vitex compressa, Coccoloba diversifolia, Haematoxylon brasiletto, Capparis linearis, C. tenuisiliqua, Erythroxylon, Eugenia rhombea, Ruprechtia coriacea* and *Maytenus versluysii.*

A plot 50 × 10 m was enumerated, giving the following record:

Coccoloba diversifolia	41 (27.9%)	*Capparis indica*	4 (2.7%)
Haematoxylon brasiletto	37 (25.2%)	*Malpighia punicifolia*	4 (2.7%)
Vitex compressa	18 (12.2%)	*Capparis tenuisiliqua*	3 (2.0%)
Caesalpinia coriaria	12 (8.2%)	*Jacquinia barbasco*	2 (1.4%)
Machaonia ottonis	10 (6.8%)	*Bursera simaruba*	2 (1.4%)
Erythroxylon brevipes	8 (5.4%)	*Bumelia obovata*	1 (0.7%)
Capparis linearis	5 (3.4%)		

Only a few shrubs occur:

Phyllanthus euwensii	5	*Cereus repandus*	2
Eugenia rhombea	4	*Opuntia*	fr
Cordia cylindrostachya	2	*Bromelia lasiantha*	few colonies

Epiphytes: *Schomburgkia tibicinis, Brassavola nodosa, Tillandsia recurvata, T. utriculata. Acanthocereus tetragonus* is present, but only in very small quantities.

In other parts the vegetation makes the same impression, but *Bromelia lasiantha* may be very conspicuous, covering whole fields. *Rivina humilis* is present, as well as *Lasiacis harrisii*. Orchids are very abundant. This vegetation is regarded as belonging to deciduous seasonal forest [I].

Against the steep cliff at the top of the Christoffelberg [29], *Clusia rosea, Tillandsia fasciculata, Polypodium aureum, Ficus brittonii* and *Peperomia blanda* var. *langsdorffii* occur. A few specimens of *Spondias mombin* may also be found there.

On the Savonet side, essentially the same vegetation is encountered as on the Knip side. Some species occur here which are unknown in the latter locality: *Doryopteris concolor* var. *concolor* and *Helicteris carthaginensis*.

In conclusion it can be said that the following types of vegetation can be distinguished in the island of Curaçao:

CLIMATIC COMMUNITIES

Seasonal formations

- Deciduous seasonal forest [I]
- Thorny woodland [II]
- Cactus-thorn scrub [III]
- Cactus scrub [IV]
- Croton-Lantana-Cordia thicket [V]
  - Croton facies [V A]
- "Desert" [VI]

Dry evergreen formations

- Evergreen woodland [VII]
- Thorny woodland [VIII]
  - Haematoxylon facies [VIII A]
- Dry evergreen bushland [IX]
  - Coccoloba diversifolia facies [IX A]
- Croton-Lantana-Cordia thicket [X]
  - Antirrhoea facies [X C]
- Littoral woodland [XI]
  - Coccoloba uvifera type [XI A]
- Vegetation of the rock pavement [XII]

EDAPHIC COMMUNITIES

- Mangrove woodland [XIII]
- Herbaceous strand community [XIV]
- Strand scrub community [XV]
- Hippomane woodland [XVI]
- Vegetation of salt flats and salinas [XVII]
- Fresh and oligohalinous water communities [XVIII]

CHAPTER IV

DESCRIPTION OF COMMUNITIES

INTRODUCTION

The vegetation of the islands of the Leeward Group is tropical, but, owing to the very unfavourable rainfall conditions, it has a pronouncedly xerophytic character.

Charter (1941), discussing the relation between soil and vegetation in British Honduras, suggested that there is a critical point in monthly rainfall below which evaporation exceeds precipitation, and plant growth begins to experience drought. He suggested that this point is represented by the figure of 100 mm (4 inches) of rain per month. The figure has been confirmed experimentally by Mohr (1944) in Java, and by Hardy (1946) in Trinidad. It has also been taken by Beard as the critical point (1946). The amount of rain above 100 mm per month is of no consequence, and the excess is discharged into rivers. The total annual amount of rainfall is therefore a meaningless figure in this connection, since it includes moisture that has not been used. Data of monthly rainfall are of more importance. In Aruba, Bonaire and Curaçao there is, in general, only one month in which rainfall exceeds 100 mm (page 18). Accordingly, vegetation suffers from drought for ten or eleven months of the year.

In addition to these very unfavourable climatic conditions, the vegetation has also suffered from human interference. A great part of the original plant cover has been carelessly cut down for private use, commercial use (logwood and charcoal burning) or agriculture. Tens of thousands of goats and sheep are running half wild over the islands. In consequence, much of the exposed soil has been removed by wind and water. In some areas this has led to secondary deserts, e.g. in the north-western part of Curaçao and along the north-east coast of Aruba. It is very unlikely that vegetation will re-establish itself, for much of the land is spoilt, and the voracity of the half-wild goats prevents rejuvenation in those parts where a plant cover is still present.

Boldingh (1914) has described the vegetation of the islands as follows: "The general impression of the vegetation of the islands Curaçao, Aruba and Bonaire is that of a dry country, where thorny shrubs and cactuses predominate and more or less compete with each other". He distinguishes:

1. A Croton vegetation, determined by *Acacia* and *Croton*, and which is either of a *Capparis* or a *Rhacoma crossopetalum* type.
2. A littoral vegetation, difficult to differentiate from the former.

In addition to this, he states that in the higher parts the Croton vegetation changes into a more forest-like type.

The present work shows that it is possible to distinguish more types of vegetation than those given by Boldingh, while an attempt is also made to correlate the vegetation of the islands of the Leeward Group with the vegetation types recognized by Beard in tropical America and especially in the Windward and Leeward Islands (1944, 1949).

CLASSIFICATION

Classification of the plant communities in the islands of the Leeward Group is rendered difficult by lack of knowledge of the extent to which the present vegetation has departed from its original state. Repeated clearance, and the voracity of the half-wild goats, have degraded the vegetation and spoilt the soil. In extreme cases this has led to the existence of secondary deserts, whilst in other parts a cactus scrub has arisen.

The aspect of the vegetation in these islands is determined by only a relatively small number of species. The trees include *Prosopis juliflora, Acacia tortuosa, Haematoxylon brasiletto, Condalia henriquezii, Bumelia obovata, Metopium brownei, Coccoloba diversifolia, Capparis indica, C. cynophallophora, Bourreria succulenta, Malpighia punicifolia, Tabebuia chrysantha, Bursera tomentosa, B. simaruba, Caesalpinia coriaria, Rhacoma crossopetalum* and the candle cacti *Cereus repandus, Cephalocereus lanuginosus* and *Lemairocereus griseus.* The shrubs include *Lantana camara, L. canescens, Croton flavens, Phyllanthus euwensii, Antirrhoea acutata, Melochia tomentosa, Malvastrum spicatum, Cordia alba, C. cylindrostachya, Casearia tremula* and species of *Opuntia.* Besides these species, a number of undershrubs and herbs are generally to be found: *Sida* spp., *Tephrosia cinerea, Euphorbia* spp., *Lithophila muscoides, Morinda royoc, Amaranthus* spp., *Portulaca* spp., *Heliotropium* spp., *Spermacoce confusa, Borreria, Physalis angulata, P. pubescens* and *Mentzelia aspera.*

In appearance the vegetation strongly resembles that of the coastal regions of the adjacent mainland (Pittier 1926, 1939; Tamayo 1941; Marcuzzi 1954) and the lower parts of Margarita (Johnston 1909; Marcuzzi 1950).

The following communities may be distinguished in the islands of Aruba, Bonaire and Curaçao:

PRIMARY CLIMAX COMMUNITIES	SECONDARY AND SUB-CLIMAX COMMUNITIES
CLIMATIC CLIMAX COMMUNITIES	
Seasonal formations	
Deciduous seasonal forest [I]	Thorny woodland [II]
	Prosopis facies [II A]
	Cactus-thorn scrub [III]
	Cactus scrub [IV]

Croton-Lantana-Cordia thicket [V]
Croton facies [V A]
Jatropha facies [V B]
"Desert" [VI]

Dry evergreen formations
Dry evergreen bushland [IX]
Coccoloba diversifolia facies [IX A]
Dry evergreen woodland [VII]
Thorny woodland [VIII]
Haematoxylon facies [VIII A]
Croton-Lantana-Cordia thicket [X]
Cordia facies [X A]
Phyllanthus facies [X B]
Antirrhoea facies [X C]
Littoral woodland [XI]
Coccoloba uvifera type [XI A]
Rhacoma crossopetalum type [XI B]
Vegetation of the rock pavement [XII]
Conocarpus community [XII A]

EDAPHIC CLIMAX COMMUNITIES
Mangrove woodland [XIII]
Herbaceous strand community [XIV]
Sesuvium facies [XIV A]
Fimbristylis facies [XIV B]
Sporobolus facies [XIV C]
Ipomoea facies [XIV D]
Strand scrub community [XV]
Tournefortia facies [XV A]
Suriana facies [XV B]
Euphorbia facies [XV C]
Hippomane woodland [XVI] ?
Vegetation of salt flats and salinas [XVII]
Fresh and brackish water communities [XVIII]

CLIMATIC CLIMAX COMMUNITIES

Seasonal formations

Deciduous seasonal forest [I]

It appears (Chapter III) that the best developed, but probably nevertheless disturbed, vegetation is to be found on the Christoffelberg and its surroundings [Curaçao 29], and on some hills near Sta. Martha [Cur. 26]. Here, colonies of *Bromelia lasiantha* are conspicuous, constituting a feature characteristic of the deciduous seasonal forest. This type of forest has been described by Beard (1944, p. 139): "A two-storied forest with canopy formed by the lower stratum between 3 and 10 m and an upper layer of scattered trees attaining 20 m. There are very few stout trees. Stems fork and branch low down.... Lianas and arboreal epiphytes are rare. Trees are not buttressed, stilt roots are absent, but there are a few important armed species. Ferns and mosses are noticeable absentees.... Over two-thirds of the individuals composing the upper

story are deciduous, though those confined to the lower story are almost evergreen.... Compound and simple leaves are about equally distributed in the upper story and simple leaves predominate in the lower. The lower story is largely mesophyllous, though containing many microphyllous species, and these two leaf characters are evenly divided in the upper story.... Ground vegetation is remarkably scarce, the soil being commonly bare, except where societies of terrestrial bromeliads cover the ground for scores of square yards".

Only an occasional tree of *Bursera, Spondias, Tabebuia* or *Bumelia* overtops the 4—5 m-high layer of small trees and high shrubs [Cur. 29]. Three of these four species are deciduous. The species of the more or less closed shrub layer are mainly evergreen, and xerophytic characters are in evidence — microphylly, leaf-movement and leaf-curling — while certain species are thorny. Some species of the dry evergreen forest and bushland types occur, but physiognomically there is no resemblance between these two formations and the actual vegetation here.

There is another feature to support the view that this vegetation must have belonged to a deciduous seasonal forest. Other parts of the island of Curaçao, such as for instance, Seroe Largoe near Sta. Martha [Cur. 26 b], present nearly the same aspect, e.g. conspicuous growths of *Bromelia lasiantha,* covering the ground, intermingled with *Opuntia.* Above this layer a shrub layer occurs, very dense at several points, in which *Erythroxylon, Randia, Capparis, Pithecellobium, Cereus,* etc. are found. This layer is overtopped by higher, often more or less shrubby trees, *Bursera, Tabebuia,* etc., the majority of which are deciduous. This vegetation clearly resembles the deciduous seasonal forest, although it has undoubtedly been modified by human agency. In the case of the vegetation of the Christoffelberg it must be concluded that the upper layer has probably disappeared.

Thorny woodland [II]

Further degradation of the deciduous seasonal forest leads to the "thorny woodland" or "thorny thicket". This has been described by Beard (1944): "A scrubby type, varying from fairly open to more or less closed, with hard-leaved, microphyllous, evergreen spiny trees, 3—10 m high. Leaves often show adaptations additional to reduction in size for decreasing transpiration. The soil is not grassed, ground vegetation being practically absent save for rare bromeliads and succulents. Most of the thorny trees belong to the Mimosaceae and Caesalpiniaceae".

In this type of vegetation, as occurring in the islands of the Leeward Group, a predominant part is played by *Caesalpinia coriaria, Acacia tortuosa, Haematoxylon brasiletto, Prosopis juliflora, Pithecellobium unguiscati, Capparis* spp. and *Malpighia punicifolia.* More or less occasional and scattered species are often present, e.g. *Bursera* spp., *Pisonia, Machaonia, Guaiacum officinale* and *G. sanctum.*

Thorny woodland occurs on limestone as well as in the non-calcareous regions. However, species associated with the former habitat are different from those in the latter, as will be shown under "Dry evergreen formations". Consequently this type of vegetation should be named "thorny woodland derived from deciduous seasonal forest".

It is found to a great extent in the islands of the Leeward Group and has been described in Chapter III as occurring in the following localities: Aruba [24]; Bonaire [25]; Curaçao [21], [22], [23], [26 a] and [27].

Prosopis facies [II A]

A special sub-type of this woodland occurs, for instance, in Bonaire [27], where a nearly pure stand of *Prosopis juliflora* is to be seen. Most of the trees are shrubby and branch close to the ground. Only a few other trees are to be found, more or less occasionally: mainly *Acacia tortuosa, Caesalpinia coriaria* and *Capparis indica.* In the lower shrub layer *Croton flavens* and *Opuntia* usually occur. This type of woodland generally follows on abandonment of cultivated areas, outside the limestone region. It resembles the thorn scrub of Asprey & Robbins (1953).

Cactus-thorn scrub [III]

A type not mentioned by Beard, but proposed by Asprey & Robbins (1953). It consists of Cactaceae, *Acacia tortuosa, Prosopis juliflora,* and other species of the thorny woodland. The candle cactuses are very conspicuous and rise above the layer of other species, which is 3—4 m high and usually very dense.

The type has been described as occurring in the following localities: Aruba [19], [20], [26]; Bonaire [14 c], [25], [29].

Cactus scrub [IV]

An "open vegetation dominated by columnar cacti and prickly pears, with scattered gnarled bushes, micro- and leptophyllous, often thorny, and terrestrial bromeliads. The main characteristics are extreme reduction and specification of leaves, spines, low growth and disproportionately strong development of the root-system. The ground is not grassed, but frequently shows bare soil" (Beard 1944).

It generally follows on abandonment of cultivated areas, outside the limestone region. However, it is not clear under what conditions this type is formed, as other types can also be found following on cultivation. In addition to the numerous Cactaceae, such as *Cereus repandus, Lemairocereus griseus, Cephalocereus lanuginosus* and *Opuntia,* the following species are also frequently encountered: *Prosopis juliflora, Acacia tortuosa, Caesalpinia coriaria, Capparis indica, Croton, Lantana, Cordia* and *Pithecellobium.* Asprey & Robbins (1953) consider it to be a littoral faciation of thorn scrub.

The type has been described as occurring in the following localities: Bonaire [28]; Curaçao [23], [24].

Croton-Lantana-Cordia thicket [V]

It is preferred to regard this as one group, since the thicket is generally composed of *Croton, Lantana* and *Cordia* species, associated with others. The layer is overtopped by small trees and high shrubs, such as *Randia, Bursera, Capparis,* candle cacti, *Acacia, Guaiacum,* etc. It occurs on limestone as well as in the non-calcareous regions, frequently following the abandonment of land after cultivation. As has already been said, it is not clear under what conditions such types as cactus scrub or this type develop. Since this thicket also occurs on limestone, and must therefore be considered to be derived from dry evergreen formation, the actual thicket should be named "Croton-Lantana-Cordia thicket derived from deciduous seasonal forest".

The type has been described as occurring in the following localities: Aruba [18], [24], [25]; Bonaire [14 a], [25]; Curaçao [21].

Croton facies [V A]

Sometimes these thickets develop into nearly pure Croton thickets, which are regarded as a faciation of the Croton-Lantana-Cordia thickets.

The type has been described as occurring in the following localities: Aruba [24]; Bonaire [24]; Curaçao [21], [23].

Jatropha facies [V B]

Near the top of Matavidiri, Aruba [18 a], a nearly pure low thicket of *Jatropha gossypifolia* is to be encountered. It is considered to be a faciation of the Croton-Lantana-Cordia thicket. Associated species: *Tragus, Cenchrus, Anthephora, Cyperus confertus* and *Jatropha urens.*

"Desert" [VI]

An exceedingly impoverished vegetation consisting mainly of thorny shrubs, succulents and therophytes frequently occurs on the windward coasts of the islands of the Leeward Group. It is classified as "desert" and as being due to human activities in former times. It occurs outside the limestone region. Its aspect is either that of a bare plain with scattered small shrubs and herbs, or of a bare plain with scattered complexes of Mimosaceae and Cactaceae, between which scattered herbs and some succulents are found. The former type is to be met along the windward coasts of Curaçao [20] and Aruba [1], whilst the latter occurs at several points along the north and east coasts of Bonaire [18] and Aruba [5] and [16].

Dry evergreen formations

Dry evergreen woodland [VII]

It appears from the plots enumerated (Chapter III) that the following species are conspicuous on limestone: *Coccoloba diversifolia, Metopium*

brownei, Haematoxylon brasiletto, Antirrhoea acutata, Bourreria succulenta, Condalia henriquezii, Guaiacum, Rhacoma crossopetalum, Bursera simaruba, B. tomentosa and *Bumelia obovata.* These species, with a few exceptions, have hard, shiny or rough, mesophyllous leaves, and are usually evergreen. Over half of them have simple leaves and tend to microphylly. The dry evergreen woodland occurs on limestone. It is clearly a secondary vegetation and is considered to be derived from dry evergreen forest. Physiognomically it corresponds with "scrub woodland derived from dry evergreen forest" (B e a r d 1949).

The best example of dry evergreen woodland is to be found at Columbia Plantation, Bonaire [20]. In the first strip 6 of the 12 species noted have compound leaves, 4 of these being deciduous; 2 species are succulent, whilst 6, including the Cactaceae, are provided with spines. In the first part of the second strip 6 of the 14 species have compound leaves; 5 species are provided with spines, and only one succulent occurs. Only one species is deciduous. In the second part of this strip 22 species were noted. Eight of them have compound leaves, and 4 of these are deciduous; 8 species, including the Cactaceae, have spines. The vegetation mentioned is of variable growth from point to point. The higher shrub layer is overtopped by scattered trees, such as *Bursera, Tabebuia, Bumelia* and candle cacti. Undergrowth consists of shrubs such as *Antirrhoea acutata, Cordia cylindrostachya, Lantana, Croton,* etc.

This vegetation has been described as occurring in the following localities: Aruba [23]; Bonaire [15], [16], [20]; Curaçao [19 a].

T h o r n y w o o d l a n d [VIII]

As has already been said, this type of vegetation occurs on both limestone and diabase. The latter manifestation of it has been assumed to be derived from deciduous seasonal forest. Assuming that in former times the non-calcareous regions were covered by a vegetation which was seasonal in character, whereas the limestone areas were covered by a low forest or woodland belonging to the dry evergreen formations, this type should be named "thorny woodland derived from dry evergreen forest". Although spiny species are not characteristic of dry evergreen formations, various thorny thickets seem to be derivatives from these formations as a result of human destruction (B e a r d 1949).

This vegetation has been described as occurring in: Curaçao [15], [16 a], [16 b].

Haematoxylon facies [VIII A]

A special sub-type of thorny woodland is the Haematoxylon thicket, in which *Haematoxylon brasiletto* dominates, forming over 80% of the total crop. *Prosopis, Acacia tortuosa, Pisonia* and *Capparis* may occur, whilst in the undergrowth *Antirrhoea acutata, Lantana, Croton flavens* and *Opuntia* are especially to be found, besides *Phyllanthus euwensii* and

Cordia cylindrostachya. The Haematoxylon facies is known only from occurrences on limestone. It is not certain whether it is due to previous repeated cutting or planting of the trees.

This type of vegetation has been described as occurring in: Bonaire [17]; Curaçao [16 b].

Dry evergreen bushland [IX]

This vegetation, 2 to 3 m in height, consists of a dense or open growth of gnarled, small trees and shrubs with hard evergreen leaves. Sometimes the layer is overtopped by widely scattered higher trees, such as *Bumelia* and *Bursera*. *Coccoloba diversifolia* is very conspicuous and forms about 45% of the total crop in Bonaire [7]. *Metopium brownei* is prominent (8%). *Antirrhoea* constitutes 23% of the crop in Bonaire [7]. In the lower shrub layer *Antirrhoea, Lantana, Croton, Cordia* and *Opuntia* occur. Of the species enumerated in Lima Plantation only *Bursera simaruba* is deciduous.

This type of vegetation has been described as occurring in: Bonaire [7], [9]; Curaçao [17], [18].

Coccoloba diversifolia facies [IX A]

Thickets of Coccoloba diversifolia cover areas on limestone, which are usually rather small; but such thickets are also found on the steep parts of the non-calcareous regions, e.g. the very steep slopes of certain hills in Knip Plantation, Curaçao [28 b], and in the Joewa hills and on Brandaris in Bonaire [26]. In the limestone region the shrub occurs more frequently in rather small clans, e.g. on the limestone plateau of Columbia Plantation and Lima Plantation, Bonaire [20] and [9], near Hato, Curaçao [17 a] and on the tableland of Ronde Klip, Curaçao [18]. Its ecological significance is unknown and needs further investigation.

Croton-Lantana-Cordia thicket [X]

This thicket resembles the one previously described, derived from deciduous seasonal forest [V]. It seems that *Cordia* and *Lantana* often become more prominent on limestone. Another feature of this thicket in the limestone areas is the occurrence of *Antirrhoea* in it. *Rhacoma* and *Metopium* are often associated. The thicket is assumed to be derived from dry evergreen forest and bushland and consequently it should be named "Croton-Lantana-Cordia thicket derived from dry evergreen formations".

It has been described as occurring in: Aruba [21], [23]; Bonaire [8].

Sometimes these thickets develop into nearly pure Cordia, Phyllanthus, or Antirrhoea thickets:

Cordia facies of the Croton-Lantana-Cordia thicket [X A]. This has been described as occurring in: Aruba [21].

Phyllanthus facies of the Croton-Lantana-Cordia thicket [X B]. This has

been described as occurring in: Aruba [21]; Bonaire [22], [25].
Antirrhoea facies of the Croton-Lantana-Cordia thicket [X C]. This has been described as occurring in: Aruba [21], [22]; Curaçao [19].

Littoral woodland [XI]

This type of vegetation has been described by Beard (1949, p. 84): "Littoral woodland is not strictly a single formation but rather a series of closely allied associated formations, grouped together for convenience.... It includes the 'littoral hedge' of stunted and windswept bushes which fronts upon the ocean, and all the transitions from this to relatively tall evergreen woodland behind, where growth is sheltered from the wind.... The littoral hedge consists of a dense matted, and interlaced, woody growth of gnarled bushes usually of distorted form. Their height is variable, from a few inches to several feet, depending upon the force of the wind and available soil depth". Typical species of the littoral hedge are: *Coccoloba uvifera, Chrysobalanus icaco, Conocarpus erecta, Erithalis fruticosa, Jacquinia barbasco* and *Plumiera alba.* In the taller woodland, several other species are typical: *Tabebuia, Pisonia, Coccoloba diversifolia,* etc.

Davis (1942) and Asprey & Robbins (1953) classify this vegetation as "strand woodland association". Raunkiaer (1934) and Stehlé (1935) call it the "Coccoloba uvifera formation", and Marshall (1934) "beach forest". The species of the littoral woodland have simple, usually mesophyllous, stiffened and thickly cutinized leaves. In this way they are enabled to withstand both the mechanical force and the evaporating power of strong wind, as well as the destructive effect of salt spray. Consequently, the type has been allocated to the dry evergreen formation.

From Chapter III, Aruba [2], [7 j], [12], [13] and Curaçao [5], it appears that the following species are common to all occurrences of the littoral woodland: *Coccoloba uvifera, Rhacoma crossopetalum, Conocarpus erecta, Erithalis fruticosa, Corchorus hirsutus, Cyperus planifolius* var. *brunneus, C. fuligineus* and *Paspalum laxum.* Some species of the strand scrub community may be found: *Suriana, Tournefortia gnaphalodes:* Curaçao [5]; *Suriana:* Aruba [12]; *Tournefortia gnaphalodes* and *Euphorbia buxifolia:* Aruba [7 j]; *Tournefortia gnaphalodes:* Aruba [2]. Occasionally other species are to be found: *Lantana, Bourreria, Sophora tomentosa, Portulaca phaeosperma, Lithophila, Tephrosia cinerea:* Curaçao [5]; *Croton flavens, Bumelia, Lithophila:* Aruba [12]; *Cordia:* Aruba [13].

Two types of littoral woodland may be distinguished:

Coccoloba uvifera type [XI A]

The most common association of the littoral woodland is the Coccoloba uvifera type, dominated by *Coccoloba uvifera* (and *Thespesia populnea*) and associated with one or more of the species mentioned above. It has been described as occurring in: Aruba [2] and [7 j]; Curaçao [5].

Rhacoma crossopetalum type [XI B]

This type of littoral woodland is only known to occur in Aruba, and presents either an open shrubby vegetation, Aruba [12], or a dense shrubby woodland, Aruba [13]. *Rhacoma crossopetalum* dominates and is associated with *Erithalis, Corchorus hirsutus, Cyperus planifolius* var. *brunneus* and *Bumelia obovata,* whilst *Cordia cylindrostachya, Lithophila muscoides, Croton flavens* and *Condalia henriquezii* may also be present.

The fact that *Rhacoma* plays an important role in the strand vegetation was mentioned by Raunkiaer (1934) with regard to Sandy Point, St. Croix, and by Asprey & Robbins (1953) with regard to the coastal ledge near Falmouth, Jamaica. Raunkiaer notes an abundance of the following species, among others: *Corchorus hirsutus, Bumelia obovata, Cyperus planifolius* var. *brunneus,* which species also occur in the littoral woodland near Pova Beach [12] and Hadikoerari [13].

Vegetation of the rock pavement [XII]

Where conditions are very unfavourable — as, for example, on parts of the lower calcareous plateau at Bolivia Plantation, Bonaire — it is possible to find widely scattered small shrubs of *Conocarpus erecta, Strumpfia maritima, Antirrhoea acutata, Opuntia, Melocactus* and *Cereus repandus,* as well as patches of *Sesuvium portulacastrum, Lithophila muscoides* and tufts of sedges and grasses. Beard (1949) calls this "vegetation of the rock pavement". It is considered to be a sub-climax community of littoral woodland.

The type has been described as occurring in: Aruba [16 a]; Bonaire [6], [12], [19]; Curaçao [14].

Conocarpus community [XII A]

Conocarpus erecta occupies a very peculiar place. Some authors, such as, for instance, Raunkiaer (1934) and Chapman (1944), regard *Conocarpus* as belonging to the mangrove woodland. Davis (1940, 1942) regards the species as belonging to a transitional community between mangrove and the strand communities. Chapman (1940, 1944) prefers to regard the "Conocarpus associes" as a serial community. Lindeman (1953) states that the Conocarpus associes of Chapman and Davis succeeds the mangrove, replacing the "Hibiscetum tiliacei" of Danserau in the Caribbean.

Conocarpus does not possess stilt roots or pneumatophores, nor does it exhibit vivipary, and is regarded by some as not being a true mangrove species. It appears to be very tolerant of a variety of conditions. It occurs in littoral woodland [XI], in the Hippomane woodland [XVI], and in Bonaire it constitutes a typical feature of the landscape, as it occupies the greater part of the southern, lowest plateau. Here, the Conocarpus community generally consists of scattered shrubs, varying strongly in density from point to point. Associated are the following species: *Cyperus*

planifolius var. *brunneus, C. fuligineus, Fimbristylis ferruginea, Sporobolus pyramidatus* and *Lithophila muscoides.* Occasionally *Metopium, Bursera, Crescentia* and *Haematoxylon* are to be found besides the species mentioned: Bonaire [3]. In the present work, the Conocarpus community is considered to be a faciation of the "vegetation of the rock pavement" [XII].

EDAPHIC CLIMAX FORMATIONS

These formations include the coastal communities, the vegetation of salt flats and salinas, Hippomane woodland, and the fresh and brackish-water communities.

The coastal communities may be divided into two groups: mangrove and strand communities. As the islands are encircled for the most part by a limestone plateau, and this plateau descends perpendicularly into the sea nearly everywhere, the coastal communities are confined to a few, rather small localities. Moreover, these communities have been badly affected by human interference — the mangroves by cutting to obtain firewood, the beaches by often being a popular resort in these densely inhabited islands.

Mangrove woodland [XIII]

The common New World mangrove species, *Rhizophora mangle, Avicennia nitida* and *Laguncularia racemosa,* are present on all the islands except Aruba, where Avicennia is absent.

The mangroves are restricted to a few localities occurring especially along landlocked bays, and in Aruba along the south-western coast. They do not occupy vast regions, and consequently the mangrove woodland possesses a rather simple structure. The best developed example is to be found in Bonaire, near Lac [10], where the general aspect is determined by *Rhizophora mangle,* with its prop roots and viviparous habit. This species occupies the pioneer zone in the shallow, calm water, and reaches a height of about 6 m. Behind the Rhizophora belt, which varies considerably in width, a belt of *Avicennia nitida* occurs, on the higher soil, which is flooded only at high tide. This species possesses pneumatophores, and is therefore adapted to the swamp habitat. An occasional specimen of *Conocarpus* and *Laguncularia* may occur. The latter species is important in the mangrove vegetation in Curaçao near Rif [3] and Spaanse Water [2]. Both these habitats, however, are very disturbed, and the importance of *Laguncularia* is possibly due to the disturbances.

Only a few species are associated with the mangrove: *Batis maritima, Salicornia ambigua, Sporobolus virginicus, Sesuvium portulacastrum* and, in Curaçao [3], *Iresine vermicularis.* Within the woodland these species are entirely absent, owing to the lack of light; they grow only in or along the margin. Epiphytes are also absent.

The mangrove woodland on the islands of Aruba and Curaçao is even simpler, and consists mainly of pure Rhizophora woodland with some scattered shrubs or trees of *Avicennia* and *Laguncularia.*

Stehlé (1935) describes mangrove as occurring on Guadeloupe and Martinique. He mentions the occurrence of the epiphyte *Tillandsia polystachya* on *Avicennia nitida,* and he also mentions the following associates: *Rhabdadenia biflora, Montrichardia arborescens, M. aculeata, Sesban sericea, Cyperus ligularis* and *Eleocharis caribaea.* Stehlé regards the American mangrove as a single association, dominated by *Rhizophora* and *Avicennia,* contrary to most other ecologists, who assume separate communities and recognize different belts in the mangrove, each with its own conditions of life. From Puerto Rico Gleason & Cook report mangrove consisting of *Rhizophora, Avicennia, Conocarpus* and *Laguncularia.* They state that the presence of additional species probably always indicates a reduction in the salinity of the water. Raunkiaer (1934), discussing the mangrove of St. Thomas and St. John, distinguished two formations: a mangrove formation and a Conocarpus formation, the former divided into:
a Rhizophora facies with *Rhizophora*;
an Avicennia facies with *Avicennia,* either alone or in company with *Rhizophora*;
a Laguncularia facies with *Laguncularia* and *Avicennia.*

He does not mention accompanying species or epiphytes in this mangrove formation. The Conocarpus formation contains *Conocarpus erecta* and, facultatively, *Salicornia ambigua, Batis maritima* and *Sesuvium portulacastrum.*

In Jamaica, Chapman (1944) recognizes four types of mangrove, in different habitats: mud, reef, sand and peat mangrove.

The mangroves of the islands of the Leeward Group are all of the mud type.

Davis (1940) and Chapman (1944) consider several communities in succession:

1. The pioneer Rhizophora family, which is hardly present at all in Jamaica as the young mangroves form only a narrow fringe in front of or beneath the existing mangrove trees.

2. A mature Rhizophora consocies between mean low water and neap tide level.

3. An Avicennia consocies, identical with the Avicennietum nitidae in South America (Lindeman 1953).

4. Mature mangrove associes, consisting of large trees of *Rhizophora* and *Avicennia.*

5. Laguncularia consocies, to be found on the landward side of Avicennia swamps.

6. Conocarpus associes.

Lindeman (1953) correlates his "mixed mangrove forest" in Surinam with the "mature mangrove associes" of Davis.

Only two communities of the series proposed by Davis are present in the islands of the Leeward Group: the mature Rhizophora consocies, here reaching a height of only about 6 metres, and the Avicennia consocies.

Strand communities

As has already been said, the strand vegetation has been influenced by human agencies to an extreme degree, and consequently it can only be considered fragmentary.

Davis (1942) suggests a simple classification on a serial basis:

1. Strand beach associes.
2. Strand dune associes.
3. Strand scrub associes.
4. Strand woodland association.

1. The strand beach associes is characterized by *Ipomoea pes-caprae* and *Canavalia maritima*, whilst *Euphorbia buxifolia, Sesuvium portulacastrum* and a few grasses may frequently occur. This pioneer associes begins above the tidal limits and is often affected by winds and storms. Raunkiaer (1934) calls it the Pes-caprae formation and distinguishes three facies:
Sesuvium facies, dominated by *Sesuvium portulacastrum*;
Pes-caprae facies, dominated by *Ipomoea pes-caprae*;
Sporobolus facies, dominated by *Sporobolus virginicus.*

Stehlé (1935) calls it "formation à Ipomoea pes-caprae et Canavalia maritima"; Gleason & Cook (1926) describe it as "beach vegetation" in Puerto Rico; and Chapman (1944) describes it as "Sesuvium-Sporobolus-Ipomoea associes" in Jamaica. Beard (1949) considers it to be the pioneer of the "sand-dune vegetation", a sub-climax community of the littoral woodland. Børgesen calls it "Pes-caprae formation", and also includes the following strand dune associes.

2. Strand dune associes. This is the second phase in the succession, and is characterized by being a closer and predominantly herbaceous community. It is well developed in Jamaica (Asprey & Robbins 1953), where the most important plants of the associes are: *Sporobolus virginicus, Spartinia patens, Cenchrus, Cyperus brunneus, Fimbristylis, Sesuvium, Iresine vermicularis,* etc. A few occasional shrubs of the following strand scrub associes may be present: *Scaevola plumieri, Tournefortia gnaphalodes, Borrichia arborescens, Suriana maritima, Coccoloba uvifera,* etc.

3. Strand scrub associes. Usually there is no sharp dividing-line between this associes and the preceding one, as the strand dune associes generally merges gradually into the strand scrub associes as a result of an increase in the shrub vegetation. Dominant species are *Suriana maritima, Tournefortia gnaphalodes, Borrichia arborescens* and *Scaevola plumieri.* This associes is comparable with the Tournefortia facies of Raunkiaer

(1934). According to Asprey & Robbins (1953) the associes is seldom well developed on the beaches in Jamaica, owing to their limited width and to human interference, and it is best seen on sand overlying raised shelves of coral rock.

4. Strand woodland association. For discussion of this type of vegetation reference should be made to the description of the littoral woodland [XI].

In the islands of the Leeward Group, these strand communities are less well developed. The beaches consist either of sand, or of calcareous rocks or small boulders. The beach sands are highly calcareous, and there is practically no difference between the sandy and calcareous beaches. Only three species, *Strumpfia maritima, Gundlachya corymbosa* and *Erithalis fruticosa* characterize the rocky beaches of the reef type, and are not seen on sandy beaches. However, the latter two species occur frequently in other, more inland parts of the islands. One of the species typical of the herbaceous strand community, *Canavalia maritima,* is absent. This species has only once been collected in Aruba, at a great distance from the sea, and at an altitude of about 70 m above sea-level (Coll. Brother M. Arnoldo, No. 2178).

On the basis of the observations made in the islands, the following strand communities may be distinguished:

1. The herbaceous strand community [XIV].
2. The strand scrub community [XV].
3. The littoral woodland [XI].

The herbaceous strand community [XIV]

This resembles the strand beach associes and strand dune associes of Davis.

The type is very poorly developed and nearly always intermingled with species of the strand scrub community: *Suriana maritima, Euphorbia buxifolia* and *Tournefortia gnaphalodes.*

In Curaçao it is to be found near Rif [4], Bullen Baai [5] and along the south-western coast near Willemstad [6]. In Aruba it is encountered near Boca Grandi [7] and Palm Beach [11]. In the latter locality it has been influenced by human agencies, as the beach is a recreation resort. Near Boca Grandi the strips [7 a] to [7 f] are regarded by the writer as belonging to the herbaceous strand community, in which four facies can be distinguished:

a. Sesuvium facies [XIV A], dominated by *Sesuvium portulacastrum:* [7 a].
b. Fimbristylis facies [XIV B], dominated by *Fimbristylis spathacea:* [7 c].
c. Sporobolus facies [XIV C], dominated by *Sporobolus virginicus:* [7 d]. This facies also occurs in Bonaire [5].
d. Ipomoea facies [XIV D], dominated by *Ipomoea pes-caprae:* [7 f].

The herbaceous strand community occupies the front line. Although one of the species common to the Ipomoea pes-caprae community, *Canavalia maritima,* is absent in the islands, the herbaceous strand community may be recognized as belonging to the Ipomoea-Canavalia association. I can fully agree with Lindeman (1953), who assumes one wide association for the herbaceous strand vegetation on sandy beaches. He states that *Ipomoea pes-caprae* and *Canavalia maritima* are prominent along tropical beaches, associated with typical plants such as *Sporobolus virginicus, Fimbristylis spathacea,* etc. The strand vegetation of tropical America comprises, besides these widely distributed species, also a number of American species: *Batis maritima, Heliotropium curassavicum, Capraria biflora,* etc. Lindeman therefore calls this association Ipomoeeto-Canavalietum americanum, to distinguish it from the strand vegetation of the Old World.

The strand scrub community [XV]

The herbaceous strand community is succeeded on higher ground by a vegetation dominated by *Tournefortia gnaphalodes* and *Suriana maritima,* associated with *Euphorbia buxifolia, Cyperus planifolius* var. *brunneus,* etc., forming the strand scrub community. In Aruba it is encountered near Boca Grandi [7], where *Tournefortia, Euphorbia buxifolia, Capraria biflora, Lithophila muscoides,* and *Corchorus hirsutus* were noted: [7 g], [7 h]. In [7 i] it is intermingled with species of the littoral woodland and the limestone vegetation: *Coccoloba uvifera* and *Antirrhoea acutata.* At Palm Beach [11] the following species were noted: *Tournefortia, Suriana, Euphorbia buxifolia, Corchorus hirsutus, Cassia obovata, Capraria, Anthephora hermaphroditica, Tephrosia cinerea, Euphorbia thymifolia* and *Rhynchosia minima.* The community is found in Bonaire near Lac [11], associated with *Eleocharis caribaea, Sporobolus pyramidatus, Cyperus planifolius* var. *ottonis,* and *Lithophila muscoides.* In Curaçao only a few remnants of this type of vegetation are to be encountered: at Bullen Baai [5] and near Willemstad [6].

Tournefortia facies of the strand scrub community [XV A]

In Aruba and Bonaire, where some dunes have been formed, the strand scrub community leads to the Tournefortia facies, especially in the higher parts. It may be either a pure growth of *Tournefortia,* or intermingled with other species such as *Euphorbia thymifolia, Suriana maritima, Euphorbia buxifolia* and *Lithophila muscoides:* Aruba [4], Bonaire [5].

Suriana facies of the strand scrub community [XV B]

In the strand scrub *Suriana maritima* may dominate, forming the Suriana facies. It is encountered in Aruba [12] and Bonaire [5].

Euphorbia buxifolia facies of the strand scrub community [XV C]

This third facies is formed where *Euphorbia buxifolia* is the dominant species. It is encountered in Aruba [12] and Bonaire [5].

Littoral woodland

This type of strand vegetation is regarded as belonging to the dry evergreen formation, and reference should therefore be made to [XX].

Hippomane woodland [XVI]

In several places along the coast, especially where the gullies debouch into the sea, a growth of *Hippomane mancinella* is found. Børgesen (1909) records *Hippomane* at St. Croix, where it is the second most abundant species in the Coccoloba uvifera formation. Raunkiaer also regards it as belonging to the Coccoloba uvifera formation. Stehlé (1935) mentions the species as sometimes occurring in his "formation à Coccoloba uvifera", but as usually forming pure growths. Beard (1949) mentions the species as occurring in the vegetation of the salt flats, where it forms a tall woodland, 20 m high, composed almost exclusively of *Hippomane mancinella*. He regards it as a sub-climax community of the littoral woodland. According to Asprey & Robbins (1953) the species occurs as an important constituent in the strand woodland association. All the authors record its occurrence on sandy plains.

In the islands of the Leeward Group, however, it also forms nearly pure woodlands along the coast as well as in the interior of the islands, especially in Curaçao. It occurs in more or less sandy places, Aruba [3], Curaçao [9], on diabase, Curaçao [10], [12], and on the bare limestone, Bonaire [9], Curaçao [11]. Usually it is confined to the lower parts, Curaçao [10], [11], [12]. It often occurs accompanied by more or less halophytic species (*Bontia daphnoides, Conocarpus erecta, Batis maritima*), but also by species such as *Phyllanthus euwensii, Croton flavens, Lantana, Acacia tortuosa, Prosopis juliflora* and *Cordia alba*. It would appear to be impossible to classify this community with certainty as long as knowledge of the ecology of *Hippomane mancinella* is incomplete.

The Hippomane woodlands have been described as occurring in the following localities: Aruba [2], [3]; Curaçao [7], [8], [9], [10], [11] and [12].

Vegetation of the salt flats and salinas [XVII]

In the brackish and salty pools *Ruppia maritima* and *Najas guadelupensis* are generally found. These pools are surrounded by scattered patches of *Sesuvium portulacastrum, Batis maritima, Sporobolus virginicus* and *Salicornia ambigua*. Species of cactus scrub and thorny woodland sometimes penetrate into this area; they include *Opuntia, Prosopis, Croton* and *Acacia tortuosa*. Occasionally stands of *Hippomane mancinella* are also found here, but, as has already been said, it is very doubtful whether the tree is typical of these habitats, at least on these islands.

This vegetation has been described as occurring in the following habitats: Aruba [10], [14], [15]; Bonaire [2], [4].

Fresh and oligohalinous water communities [XVIII]

Such communities are extremely scarce in these dry islands, and their existence is generally confined to the wet season. *Lemna perpusilla, Stemodia durantifolia, Ammannia latifolia* and *Eleocharis mutata* occur in the permanent pool of Put Bronswinkel, Bonaire; *Echinodorus cordifolius* and *Stemodia maritima* are to be found in Tanki Monpos, Curaçao. During the rainy season fresh-water communities also appear behind the numerous dikes. Of the species collected here only the following will be mentioned: *Ammannia coccinea, A. latifolia, Bergia capensis, Jussieua erecta, Heteranthera limosa, Marsilia ernestii, Cypselea humifusa* and *Echinodorus cordifolius.*

These communities have been described as occurring in Bonaire [30], [31].

CORRELATION OF THE COMMUNITIES

In the previous section an attempt has been made to distinguish several types in the vegetation of the islands of the Leeward Group. However, this does not mean that all the types concerned are sharply differentiated from each other. This is a feature of the secondary and strongly degraded plant covers. Except for the small number of species typical of the limestone region, no differentiating species can be recognized.

As the Pan-Caribbean Forestry Meeting in 1946 adopted Beard's system until "further work should confirm or decry its utility", this system has been followed as far as possible. The greatest deviation from it here is to be found with respect to the sub-climax communities of the littoral woodland. The herbaceous strand vegetation and the strand scrub community are considered as edaphic communities, whereas Beard regards them as belonging to the "sand dune vegetation", a sub-climax community of the littoral woodland. The vegetation of the salt flats and salinas is also considered to be an edaphic community.

The Prosopis and Haematoxylon thickets are considered as faciations of the thorny woodland. One community concept, the cactus-thorn scrub, has been introduced, as intermediate between thorny woodland and cactus scrub. The Croton and Cordia thickets are grouped together with Phyllanthus and Antirrhoea thickets in one Croton-Lantana-Cordia thicket, derived either from seasonal formations or from dry evergreen formations. Under certain circumstances it gives place to nearly pure thickets of *Croton, Cordia* or *Phyllanthus.* An Antirrhoea thicket has been assumed to occur on limestone, and a Coccoloba thicket both on limestone and on the steep slopes outside the limestone region. These thickets are not mentioned by Beard.

THE WINDWARD GROUP

CHAPTER V

ENVIRONMENTAL FACTORS

GEOGRAPHICAL POSITION

The islands of St. Martin, Saba and St. Eustatius form part of the Lesser Antilles island arc. The southern part of St. Martin (St. Maarten) belongs to the territory of the Netherlands Antilles, whereas the northern part is French territory and belongs to the "Département de la Guadeloupe".

The islands of Saba and St. Eustatius form part of the inner arc of the Lesser Antilles, whereas St. Martin belongs to the outer arc. The former arc is characterized by the presence of Tertiary, Quaternary or recent volcanoes; these volcanoes are absent in the islands of the outer arc.

	Situation	Greatest length	Greatest width	Approximate land area	Highest point
St. Martin	18°0′ — 18°8′ N. 63°1′ — 63°10′ W.	15 km	14 km	85 sq.km	400 m
Saba	17°37′ — 17°39′ N. 63°13′ — 63°15′ W.	5 km	4 km	12 sq.km	900 m
St. Eustatius	17°28′ — 17°32′ N. 62°56′ — 63°0′ W.	8 km	3¾ km	21 sq.km	600 m

Saba lies south-west of St. Martin, at a distance of 45 km, and is separated from it by a stretch of sea reaching a maximum depth of 500 m. It lies 4 km north-east of the Saba bank, a submarine plateau 20—50 m below sea-level. St. Eustatius lies 25—30 km south-east of Saba, from which it is separated by a channel more than 500 m deep.

St. Martin, St. Barthélemy, Anguilla and a few other small islets are grouped together on a submarine plateau which is 35 m below sea-level. St. Eustatius, St. Kitts and Nevis are also based on a shallow submarine plateau.

CLIMATE

A. TEMPERATURE

Only one maximum occurs in the course of the year. The months of July, August and September are the hottest, January and February the coolest. The average monthly maximum temperature shows a range of 3.2° C, between 30.6° in August/September and 27.4° in January/February. The average minimum temperature varies by 3.2°, between 25.9° in August and 22.7° in February. Conditions are thus very equable.

Temperature of Philipsburg, St. Maarten, and of Oranjestad, St. Eustatius
from Braak, 1920—1933 (in °C)

St. Maarten	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean	24.7	24.7	25.0	25.9	26.9	27.5	27.7	27.9	27.7	27.5	26.5	25.5	26.5
Mean max.	27.4	27.4	28.0	28.5	29.5	30.0	30.2	30.6	30.6	30.5	29.3	28.1	29.2
Mean min.	22.8	22.7	22.9	23.7	24.8	25.3	25.7	25.9	25.5	25.4	24.6	23.5	24.4
Abs. max.	30.2	30.4	31.0	31.8	32.8	33.0	32.5	34.0	33.6	33.8	33.2	31.8	34.0
Abs. min.	19.2	18.5	19.8	20.2	21.0	20.8	21.5	22.8	22.0	21.2	20.5	19.2	18.5
St. Eustatius													
Mean	24.2	24.0	24.2	24.8	25.7	26.4	26.6	27.0	27.0	26.6	26.1	25.1	25.6

Unfortunately no data are available for Saba. The data are especially inadequate for St. Eustatius, as the island is characterized by differences in height of as much 600 metres between its lowest and highest points.

B. Humidity

The mean relative humidity in St. Maarten is lower than in Curaçao.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Rel. Humid. %	71	69	68	68	70	71	71	72	74	74	73	71	71
Abs. Min. Rel. Humid. %	45	44	40	47	49	50	53	52	52	52	39	46	39
Mean Min. Rel. Humid. %	52	50	49	52	55	57	57	57	59	57	55	55	55

Cloudiness in St. Maarten (Philipsburg) is less than in Curaçao, in spite of the higher rainfall. The rain falls in short-lived showers and is followed by rapid clearing. In the following table the cloudiness at Philipsburg (scale 0—10) is compared with that in Curaçao.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
St. Maarten (Philipsburg)	3.4	3.6	3.3	3.4	3.8	3.9	3.8	3.6	4.2	3.9	3.9	3.5	3.7
Curaçao (Willemstad)	4.3	4.1	3.9	4.4	4.3	4.7	4.5	4.2	4.4	4.8	5.0	4.5	4.4

The above data concerning relative humidity and cloudiness were also obtained over the years 1920—1933 (Braak 1935).

C. Wind

The trade wind is predominantly easterly, varying between north-east and south-east. According to Braak (1935), the mean wind velocity

in Philipsburg amounted to 3.5 m/sec in 1928—1933 and in Oranjestad (St. Eustatius) to 4.6 m/sec in 1910—1919. However, no recent data are available, whilst data for Saba are completely lacking.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Philipsburg	3.9	3.3	3.3	3.5	3.1	3.7	4.1	3.7	3.3	3.0	3.3	4.1	3.5
Oranjestad	5.3	4.9	4.5	4.9	4.7	5.1	5.3	4.9	4.1	3.3	3.9	4.3	4.6

The islands are situated in the hurricane region. The hurricane period usually lasts from July until September. This island of St. Martin was badly hit in 1819 and 1950. During the years 1887—1925, ten hurricanes passed in the vicinity of Saba.

D. Rainfall

The following data concerning the rainfall of the islands of the Windward Group are the averages of the records obtained by the Meteorological Service during the years 1947—1952. Braak's data are given between brackets; those for St. Maarten (Philipsburg) were collected during the years 1879—1889 and 1892—1933; those for Saba (The Bottom) during 1891—1898 and 1901—1933; and those for St. Eustatius (Oranjestad) during the years 1881—1933.

	Jan.	Feb.	March	Ap.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
St. Maarten	79.3	36.4	37.2	47.3	84.1	144.5	93.9	118.0	176.2	146.8	87.7	75.6	1027.0
	(61)	(48)	(41)	(61)	(96)	(87)	(80)	(107)	(142)	(130)	(148)	(81)	(1083)
Saba	98.9	56.4	48.5	62.4	53.6	68.5	95.0	115.7	172.4	117.6	117.7	126.8	1133.5
	(81)	(57)	(46)	(52)	(94)	(71)	(94)	(109)	(144)	(132)	(150)	(94)	(1124)
St. Eustatius	92.5	37.2	51.2	58.7	77.2	91.8	112.2	118.5	165.5	128.9	99.3	77.6	1110.6
	(66)	(48)	(49)	(56)	(85)	(90)	(104)	(111)	(127)	(131)	(133)	(90)	(1089)

Precipitation is very erratic from year to year and month to month, and long droughts may occur. Ballou (1934) says justly: "any wet month may be dry and any of the dry months may be wet". In general, the data show that the climate in the lower parts of the islands is of a seasonal character. However, parts of the islands — in particular, parts of the volcanic islands — rise somewhat abruptly to fairly considerable altitudes. This causes an upward deflection of the air currents; moisture is condensed and clouds are formed. Beard (1949) says: "A typical feature of the mountain peaks in these [Caribbean] islands is a great billowy mass of "trade wind cloud" which remains upon them, masking their summits day after day and only dissipated in very dry or very still weather". This is especially true of Saba.

The climate lies somewhere between that of the savanna (Aw) and monsoon forest (Am) climatic zones in Köppen's system. Mean annual rainfall is 1,000—1,125 mm; but the rainfall actually varies between 800 and 1,300 mm over a number of years (1947—1952). In the dry season, the average monthly rainfall is, however, usually far below 50 mm, and even goes down to 8 mm on occasion. Precipitation is higher on windward slopes than on leeward slopes. Veenenbos (1955) states: "In Cul-de-Sac valley (St. Maarten) it has often been noticed that clouds discharged on the western slopes, facing eastward, while there was no rain a few hundred yards to the east. Both in St. Maarten and Saba the windward slopes are cultivated more intensely and to a greater height than the leeward slopes.... Precipitation is heaviest high up the slopes of the Quill and the Mountain of Saba. Annual precipitation reaches 60—80 inches [1,500—2,000 mm] on the Quill and surpasses 80 inches on the Mountain.... During most of the year the top of Saba is hidden by a cloud cap. The lowest rainfall is presumably found in the Low Lands of St. Maarten....".

GEOLOGY

The data in this paragraph are mainly taken from Westermann (1949) and Christman (1953).

A. St. Martin

The island of St. Martin forms part of the non-volcanic arc of the Lesser Antilles. The oldest formation, known from St. Martin, is the Pointe Blanche formation, which consists of series of tuffs and tuffoid rocks of early Tertiary age. A diorite batholith has intruded into this series. Subsequent denudation exposed both the folded Pointe Blanche beds and the diorite batholith with its differentiates. A marine transgression occurred in early Miocene time, depositing marls and limestones: Simson Bay limestones and Low Land formation. During the glacial epoch St. Martin, Anguilla, St. Barthélemy and a few other islets formed one land mass. Owing to the rise in the sea-level during post-glacial time, this land mass became partly submerged. Quaternary limestone was formed at several places along the coast during the Holocene. Nowadays, these limestone formations reach a height of 5—6 m, due to a recent fall in the sea-level. The youngest geological formations are the recent sand bars in several bays, shutting the latter off from the sea.

B. Saba

The island of Saba is the northernmost island of the volcanic inner arc of the Lesser Antilles. It is of Pleistocene origin, and is the top of an extinct volcano resting on a sea-bottom more than 600 m deep.

C. St. Eustatius

The island of St. Eustatius is also part of the volcanic inner arc. It consists of a volcanic complex in the north-west and a main volcano in the south-east. The former is of Pleistocene age and is composed of andesitic lavas and tuffs. The main volcano in the south-east, The Quill, is of Holocene origin and is composed of andesitic tuffs and pumice stone. These two groups are separated by a slightly sloping plain which is actually the base of The Quill. On the south coast, a peculiar steeply dipping wall of Quaternary organogenic and volcanic sediments rests against The Quill: White Wall and Sugar Loaf. There is reason to assume that the island is in a period of descent.

PHYSIOGRAPHY

A. St. Martin

The greater part of the island is occupied by hills and low mountains. One of the two main mountain ranges stretches along the eastern coast from Pointe Blanche to Oysterpond; its highest point is Oostenberg or Naked Boy Hill (300 m). The highest point of the western ridge, Mount Paradis (400 m), is in the French part of the island, while several hills are to be found in the Dutch part: Cole Bay Hill (215 m), Sentry Hill (344 m) and St. Peter Hill (317 m). These hills consist partly of hard, erosion-resistant Pointe Blanche rocks. Diorite is found in the wide valleys. The western part of the island is generally flat: the Low Lands. The windward coast is steep and rugged in many places, whereas along the leeward side several beautiful beaches and bays are found. Sand bars occur at several points along the coast, e.g. in Great Bay and near Simson Bay. The main village, Philipsburg, is built on a sand bar.

The island was formerly under very active cultivation, and consequently the present vegetation is secondary, except for some scattered remnants of the original vegetation in the highest parts, e.g. the top of Sentry Hill. The beach vegetation is very well developed along several bays. The secondary communities are characterized by the absence of a definite structure and great variation in composition.

B. Saba

The island is mountainous and has very steep cliffs; comparatively flat areas are small in area and few in number (The Bottom and Rendez Vous). Narrow valleys, locally named "guts", run down from the top of The Mountain to the sea. Besides the highest point, Mount Scenery, better known as "The Mountain" (about 850 m), there are some lower hills, e.g. Great Hill (450 m), Kates Hill (520 m), Booby Hill. From the main village, The Bottom, a steep road leads down to the landing place of Fort Bay. The coast is very steep, except near Flat Point. There are only a few beaches, and these are covered with boulders.

The island shows wide climatic variations, owing to the great differences in height. Destruction of the original vegetation has taken place in the course of time, but to a lesser extent than in St. Maarten. Consequently, the various ecological circumstances have led to the existence of communities ranging from very dry to cloud forest or elfin woodland. However, the typical rain forest is absent, owing to the steepness of the mountain slopes. At the top of The Mountain, only three tree species common to the montane flora of the other islands of the Lesser Antilles are present: *Freziera undulata, Rapanea ferruginea* and *Euterpe globosa.* On the other hand, several species of the rain forest are present.

The level parts of the island are still under cultivation, as well as some more gently sloping areas, e.g. near Santa Cruz and Rendez Vous. Bananas are even planted in the very steep "guts" and at high altitudes, e.g. near Santa Cruz (about 700 m) and in the depression on the top of The Mountain (about 800 m).

C. St. Eustatius

The island is dominated by the strato-volcano of The Quill, whose sloping, regular glacis covers the southern part of the island. The rim of the crater varies between 391 and 601 m in height. The bottom of the crater lies about 270 m above sea-level, is rather flat, and has a diameter of about 300 metres. Its inner slope is very steep. The outer slope is cut by a large number of narrow, deep ravines ("guts"). The regularity of the cone is interrupted in the south by the White Wall and Sugar-loaf.

The north-western part is hilly, the hills being generally separated by deep ravines. The highest point is Boven (295 m). Other high points are Bergje, Gilboa Hill and Signal Hill. The horse-shoe-shaped ridge of Panga, north-west of Oranjestad, is a remnant of a crater.

The centre of the island is formed by a flat plain, the "Cultuurvlakte", rising 30—40 m above sea-level. Along the north-eastern coast two beaches are found: Concordia Bay and Turtle Bay.

The Cultuurvlakte, the northern part of the island, and the lower part of The Quill were formerly under very active cultivation, and consequently the present vegetation is secondary in these areas.

ECONOMIC DEVELOPMENT

In pre-Columbian times the islands were inhabited by Indians of the Carib tribe. Subsequently Spaniards, British, French and Dutch appeared in the area, and the Lesser Antilles became one of the most valuable and most bitterly contested corners of the world. St. Martin developed into an important island for salt-making. St. Eustatius became a centre of trade and a slave depot; in the eighteenth century it was a storehouse of European and American goods. In addition to salt-making and trading,

agriculture was also an important means of subsistence. In the middle of the seventeenth century St. Martin, St. Eustatius and even Saba had extensive sugar plantations. Teenstra (1836) reports that, at the beginning of the nineteenth century, sugar cane was grown almost to the top of the hills in St. Martin and St. Eustatius. After the abolition of slavery, sugar cultivation decreased considerably, and eventually ceased. Early in the twentieth century, sea-island cotton was planted in St. Martin and St. Eustatius, but it disappeared in the twenties owing to diseases attacking the crop. Afterwards, attempts were made to grow sisal in St. Eustatius, but these attempts were given up in 1928. Agricultural activities further declined as a result of the emigration of many male inhabitants of the islands, who found employment in the oil refineries in Curaçao and Aruba. Nowadays only small patches of land are in use, for the production of subsistence crops. Cattle-raising has been somewhat on the increase during the last few years.

Livestock	Horses	Donkeys	Cattle	Goats	Sheep	Pigs
St. Maarten (1947)	75	60	719	315	612	170
Saba (1947)	12	72	88	1,145	165	137
St. Eustatius (1947)	53	530	685	643	834	83

Population (approx.)	1937	1949	1952
St. Maarten	2,350	1,500	1,550
Saba	1,250	1,100	1,000
St. Eustatius	1,200	950	1,100

CHAPTER VI

THE FLORA

BOTANICAL COLLECTIONS

The following botanists have visited St. Maarten, Saba and St. Eustatius (according to Urban, *Symbolae Antillanae,* and Boldingh, 1909): N. J. Jacquin, between 1755 and 1757, St. Maarten and St. Eustatius; F. Masson, 1780, St. Eustatius; B. A. Euphrasen, about 1788, St. Eustatius; J. E. Forström, between 1805 and 1812, Saba; F. L. l'Herminier, 1815, St. Eustatius; A. Plée, 1821, St. Maarten; M. D. Teenstra, about 1836, St. Maarten, Saba and St. Eustatius; P. D. de Fontbressis, about 1848, Saba; O. Kuntze, 1874, Saba; W. F. R. Suringar, 1885, St. Maarten, Saba and St. Eustatius; J. J. Walch, about 1889, St. Maarten and St. Eustatius; F. A. F. C. Went, 1902, St. Maarten, Saba and St. Eustatius; Mrs. J. van Grol-Meyers, 1904—1906, St. Eustatius; I. Boldingh, 1906, St. Maarten, Saba and St. Eustatius; A. C. W. Lionarons, 1907, Saba.
More recently, collections have been made as follows:
Brother M. Arnoldo, 1947 and 1950, St. Maarten, Saba and St. Eustatius; P. Wagenaar Hummelinck, 1949, St. Maarten, Saba and St. Eustatius; A. C. J. Burgers, 1949, St. Maarten, Saba and St. Eustatius; Father C. Le Gallo, 1952, St. Maarten; A. L. Stoffers, 1953, St. Maarten, Saba and St. Eustatius.

ANALYSIS OF THE FLORA

In the present work only ferns and phanerogams are taken into account.

The following list shows the families occurring in the islands of the Windward Group, and gives the number of genera and species in those families. Varieties are given as additions to the species. The main geographical distribution of the family is given between brackets, viz. *C*: cosmopolitan, *Tr*: predominantly tropical, and *T*: predominantly temperate.

	St. Maarten		*Saba*		*St. Eustatius*	
	Genera	Species	Genera	Species	Genera	Species
Monocotyledons:						
Agavaceae (*Tr*)	1	1	—	—	1	1
Amaryllidaceae (*C*)	3	3	4	4	4	4
Araceae (*Tr*)	1	1	2	4	2	4
Arecaceae (*Tr*)	1	1	2	2	—	—
Bromeliaceae (*Tr*)	4	6	6	10	4	6
Commelinaceae (*Tr*)	3	3	3	3	2	2
Cyperaceae (*C*)	4	11 + 1	6	9	3	6
Dioscoreaceae (*Tr*)	—	—	1	1	—	—

	St. Maarten		*Saba*		*St. Eustatius*	
	Genera	Species	Genera	Species	Genera	Species
Hydrocharitaceae (*C*)	1	1	—	—	—	—
Lemnaceae (*C*)	1	1	—	—	—	—
Musaceae (*Tr*)	—	—	1	1	1	1
Orchidaceae (*C, Tr*)	4	6	4	10	8	14
Poaceae (*C*)	23	38	25	41	23	31
Potamogetonaceae (*C*)	2	2	—	—	—	—
Smilacaceae (*Tr*)	1	1	1	1	1	2
Dicotyledons:						
Acanthaceae (*Tr*)	6	6	5	6	5	5
Aizoaceae (*Tr*)	2	2	1	1	3	3
Amaranthaceae (*C, Tr*)	6	12	6	10	5	9
Anacardiaceae (*Tr*)	3	3	4	4	4	4
Annonaceae (*Tr*)	1	1	1	4	1	4
Apiaceae (*T*-subtr)	1	1	2	2	—	—
Apocynaceae (*Tr*)	5	5	5	5	5	5
Aristolochiaceae (*Tr*)	1	1	—	—	—	—
Asclepiadaceae (*Tr*)	4	4	2	2	3	3
Asteraceae (*C*)	20	26	25	35	20	21
Batidaceae (*Tr*)	1	1	—	—	—	—
Begoniacea (*Tr*)	—	—	1	1	1	1
Bignoniaceae (*Tr*)	4	4	4	4	4	4
Bombacaceae (*Tr*)	1	1	—	—	2	2
Boraginaceae (*C*)	4	10	4	10	5	10
Brassicaceae (*T*)	2	2	3	3	3	3
Burseraceae (*Tr*)	1	1	1	1	1	1
Cactaceae (*Tr*)	3	6	2	4	3	6
Canellaceae (*Tr*)	1	1	—	—	—	—
Capparidaceae (*Tr*)	4	7	4	7	4	7
Caryophyllaceae (*T*)	—	—	1	1	—	—
Celastraceae (*C, Tr*)	4	4	2	2	4	4
Chenopodiaceae (*C, T*)	2	3	1	1	1	2
Clusiaceae (*Tr*)	2	2	3	4	2	2
Combretaceae (*Tr*)	2	2	—	—	1	1
Convolvulaceae (*C, Tr*)	4	10	3	6	5	11
Crassulaceae (*T-Tr*)	1	1	1	1	1	1
Cucurbitaceae (*C, Tr*)	1	1	1	3	3	3
Cuscutaceae (*C*)	1	1	1	2	1	1
Erythroxylaceae (*Tr*)	1	2	1	1	1	1
Euphorbiaceae (*C, Tr*)	14	26	10	17	14	21
Fabaceae (*C*)	20	32	17	27	22	33
Flacourtiaceae (*Tr*)	2	3	2	2	3	3
Gentianaceae (*C, T*)	—	—	1	1	1	1
Gesneriaceae (*Tr*)	—	—	2	2	2	2
Goodeniaceae (*Tr*)	1	1	—	—	—	—
Hydrophyllaceae (*T*)	—	—	—	—	1	1
Lamiaceae (*C, Tr*)	7	8	7	8	6	7
Lauraceae (*Tr*)	2	2	2	3	3	4
Lentibulariaceae (*C*)	—	—	1	1	—	—
Loganiaceae (*Tr*)	1	1	1	1	1	1
Loranthaceae (*C, Tr*)	1	1	1	1	1	1
Lythraceae (*C, Tr*)	1	1	—	—	—	—
Malpighiaceae (*Tr*)	4	7	3	3	4	4

	St. Maarten		*Saba*		*St. Eustatius*	
	Genera	Species	Genera	Species	Genera	Species
Malvaceae (*C, Tr*)	7	18 + 1	6	10 + 1	6	13 + 1
Marcgraviaceae (*Tr*)	—	—	1	1	—	—
Melastomataceae (*Tr*)	1	1	4	4	2	3
Meliaceae (*Tr*)	1	1	2	2	2	2
Menispermaceae (*Tr*)	1	1	2	2	2	2
Mimosaceae (*Tr*)	6	8	5	5	6	9
Moraceae (*Tr*)	2	3	2	5	2	4
Moringaceae (*Tr*)	1	1	1	1	1	1
Myrsinaceae (*Tr*)	—	—	2	2	1	1
Myrtaceae (*Tr*)	5	14	4	9	4	11
Nyctaginaceae (*Tr*)	3	7	2	5	2	6
Ochnaceae (*Tr*)	—	—	1	1	—	—
Olacaceae (*Tr*)	—	—	1	1	1	1
Oleaceae (*Tr*)	2	2	1	1	1	1
Oxalidaceae (*Tr*)	1	1	1	1	1	1
Papaveraceae (*C*)	1	1	1	1	1	1
Passifloraceae (*Tr*)	1	2	1	3	1	2
Phytolaccaceae (*Tr*)	5	5	4	4	4	4
Piperaceae (*Tr*)	2	5	3	12	2	9
Plantaginaceae (*T*)	—	—	1	1	—	—
Plumbaginaceae (*C*)	1	1	1	1	1	1
Polygonaceae (*C*)	2	4	2	4	2	4
Portulacaceae (*C*)	2	6	2	4	2	4
Rhamnaceae (*C, Tr*)	3	3	2	2	2	2
Rhizophoraceae (*Tr*)	1	1	—	—	—	—
Rosaceae (*C*)	1	1	3	3	2	2
Rubiaceae (*C, Tr*)	11	13	16	21	16	20
Rutaceae (*Tr*)	3	5	2	2	2	3
Sapindaceae (*Tr*)	4	4	3	3	5	5
Sapotaceae (*Tr*)	1	1	4	4	3	3
Scrophulariaceae (*C*)	1	1	2	2	2	2
Simarubaceae (*Tr*)	3	3	1	1	2	2
Solanaceae (*C*)	4	12 + 1	6	12 + 1	4	9 + 1
Sterculiaceae (*Tr*)	4	5	3	3	4	5
Symplocaceae (*Tr*)	—	—	1	1	1	1
Theaceae (*Tr*)	1	1	1	1	1	1
Theophrastaceae (*Tr*)	1	2	—	—	1	1
Thymelaeaceae (*Tr-T*)	1	1	1	1	1	1
Tiliaceae (*C, Tr*)	2	3	2	3	2	5
Turneraceae (*Tr*)	1	1	1	1	2	2
Ulmaceae (*C, Tr*)	1	1	2	3	2	3
Urticaceae (*C, Tr*)	2	2	5	8	4	5
Verbenaceae (*C, Tr*)	7	8	6	7	7	8
Vitaceae (*Tr*)	1	2	1	1	1	1
Zygophyllaceae (*Tr*)	3	3	1	2	1	1

A. St. Maarten

The flora comprises 450 species and varieties, divided up as follows: ferns 16, angiosperms 434, made up of 76 monocotyledons and 358 dicotyledons. The ferns are represented by 8 genera in 1 family (Polypodiaceae).

The monocotyledons number 13 families, with 49 genera, 75 species, and 1 variety. The grasses and sedges account for 49 species and 1 variety. The dicotyledons comprise 77 families, with 241 genera, 356 species, and 2 varieties. The family of the Poaceae is the largest with 38 species, followed by the Fabaceae. Families with 20 and more species are: Poaceae (38), Fabaceae (32), Euphorbiaceae (26), and Asteraceae (26).

Thirty-nine families are represented by only a single genus, 35 are represented by only a single species. The larger families of 10 and more genera are Asteraceae (20), Fabaceae (20), Euphorbiaceae (14), Poaceae (23), and Rubiaceae (11). The number of genera represented by only one species amounts to 220, whilst 33 genera are represented by 2 species.

Of the 90 angiosperm families, 52 have a predominantly tropical distribution, and only one family has a temperate distribution. Thirty-four families appear to be cosmopolitan; 16 of these have their main distribution in the tropics. Three are predominantly distributed in the subtropics or temperate to tropical regions. Five families have predominant affinities with the southern hemisphere: Canellaceae, Goodeniaceae, Myrtaceae, Oxalidaceae, and Rutaceae, while 5 families have predominantly northern-hemisphere affinities: Apiaceae, Brassicaceae, Papaveraceae, Polygonaceae, Rosaceae, and Ulmaceae. Seventeen families have their main distribution on the American continent: Agavaceae, Aristolochiaceae, Bromeliaceae, Cactaceae, Erythroxylaceae, Malpighiaceae, Malvaceae, Melastomataceae, Nyctaginaceae, Passifloraceae, Phytolaccaceae, Portulacaceae, Theophrastaceae, Turneraceae and Verbenaceae.

B. SABA

The flora comprises 485 species and varieties, divided up as follows: ferns 50; angiosperms 435, made up of 86 monocotyledons and 349 dicotyledons. The ferns are represented by 22 genera in 8 families.

The monocotyledons number 11 families, with 55 genera and 86 species. The grasses and sedges account for 50 species. The dicotyledons comprise 79 families, with 244 genera, 347 species and 2 varieties. The family of the Poaceae is the largest with 41 species, followed by the Asteraceae. Families with 20 species and more are: Asteraceae (35), Fabaceae (27), Poaceae (41) and Rubiaceae (21).

Thirty-four families are represented by only a single genus, while 29 families are represented by only a single species. The larger families of 10 and more genera are: Asteraceae (25), Euphorbiaceae (10), Fabaceae (17), Poaceae (25), and Rubiaceae (16). The number of families with 5 or less species is high and amounts to 68, i.e. 75% of the total number of families.

Of the 90 angiosperm families, 52 have a predominantly tropical distribution and 3 a temperate one. Thirty-one families are considered to be cosmopolitan; of these 15 have their greater distribution in the tropics and 2 have a predominantly temperate distribution. Four families have a subtropical or temperate to tropical distribution. Families with

predominant affinities to the southern hemisphere are: Myrtaceae, Oxalidaceae and Rutaceae. Predominantly northern-hemisphere affinities: Apiaceae, Brassicaceae, Papaveraceae, Polygonaceae, Rosaceae, and Ulmaceae. Families whose distribution is mainly in America: Bromeliaceae, Cactaceae, Erythroxylaceae, Malpighiaceae, Malvaceae, Marcgraviaceae, Melastomataceae, Nyctaginaceae, Ochnaceae, Passifloraceae, Phytolaccaceae, Portulacaceae, Theophrastaceae, Turneraceae and Verbenaceae.

C. St. Eustatius

The flora comprises 453 species and varieties, divided up as follows: ferns 26; angiosperms 427, made up of 71 monocotyledons and 356 dicotyledons. The ferns are represented by 13 genera in 2 families.

The monocotyledons number 10 families, with 49 genera and 71 species. The grasses and sedges account for 37 species. The dicotyledons comprise 77 families, with 255 genera, 354 species and 2 varieties. The family of the Fabaceae is the largest with 33 species, followed by the Poaceae. Families with 20 or more species are: Asteraceae (21), Euphorbiaceae (21), Fabaceae (33), Poaceae (31), and Rubiaceae (20).

Twenty-nine families are represented by only a single genus, while 25 families are represented by only a single species. The larger families of 10 and more genera are: Asteraceae (20), Euphorbiaceae (14), Fabaceae (22), Poaceae (23), and Rubiaceae (16). The number of families with 5 or less species is high and amounts to 66, i.e. over 75% of the total number of families.

Of the 87 angiosperm families, 52 have a predominantly tropical distribution and 2 a temperate one. Thirty-one families are considered to be cosmopolitan; of these 15 have their main distribution in the tropics and 2 families have a predominantly temperate distribution. Two families have a subtropical or temperate to tropical distribution.

Families with their distribution predominantly in the southern hemisphere are: Myrtaceae, Oxalidaceae and Rutaceae. Northern-hemisphere affinities: Brassicaceae, Papaveraceae, Polygonaceae, Rosaceae, and Ulmaceae. Mainly American distribution: Agavaceae, Bromeliaceae, Cactaceae, Erythroxylaceae, Malvaceae, Malpighiaceae, Melastomataceae, Nyctaginaceae, Passifloraceae, Phytolaccaceae, Portulacaceae, Theophrastaceae, Turneraceae and Verbenaceae.

PLANT GEOGRAPHY

The five main groups into which the flora may be divided are:
1. The introduced element, 2. the "cosmopolitan" element, 3. the West Indian element, 4. the endemic element, 5. the continental element.

The introduced element contains species cultivated formerly and running wild nowadays, as well as introduced species which were subsequently naturalized.

The "cosmopolitan" element comprises widely distributed species, mainly pan-Tropic and pan-American or Caribbean plants.

The West Indian element comprises species occurring in the West Indies only.

The continental element comprises a number of sub-groups. These sub-groups include species occurring in:
a. The southern United States, b. the southern United States and Central America, c. Central America, d. Central America and South America, e. South America, f. Florida — West Indies — northern South America.

A. St. Maarten

The introduced element comprises 32 species.

The "cosmopolitan" element comprises 244 species.

The West Indian element, 72 species: *Adelia ricinella, Alternanthera crucis, Annona muricata, A. squamosa, Anthurium cordatum, Argithamnia candicans, Aristida suringari, Beloperone eustachiana, Bourreria succulenta, Bumelia obovata, Byrsonima lucida, Cassia polyadena, Croton astroites, C. betulinus, Cissus obovata, Coccoloba krugii, C. venosa, Comocladia ilicifolia, Cyperus swartzii* var. *granularis, Daphnopsis caribaea, Ditaxis fasciculata, Epidendrum papilionaceum, Erythroxylon brevipes, E. havanense, Eugenia cordata, E. monticola, Euphorbia articulata, E. petiolaris, Fagara martinicensis, F. trifoliata, Ficus urbaniana, Forestiera eggersiana, Galactia dubia, G. rubra, Heliotropium microphyllum, Ipomoea arenaria, Jacquinia barbasco, J. berteri, Lithophila muscoides, Lycium americanum, Malpighia angustifolia, Maytenus elliptica, Metastelma parviflorum, Myrcia citrifolia, M. splendens, Opuntia catacantha, O. triacantha, Paspalum diffusum, P. laxum, Pectis humifusa, Phyllanthus epiphyllanthus, Picrasma antillana, Pisonia fragrans, P. subcordata, Plumiera alba, Polanisia viscosa, Portulaca poliosperma, Rochefortia acanthophora, Samyda dodecandra, Sesbania sericea, Sida cordifolia* var. *althaeifolia, S. humilis, Smilax ilicifolia, Solanum lanceaefolium, S. racemosum, S. racemosum* var. *igneum, Stenandrium tuberosum, Stigmatophyllon periplocifolium, S. sericeum, Ternstroemia pedunculatis, Tournefortia filiflora,* and *Wittmackia lingulata.*

The endemic element comprises only 2 species: *Calyptranthes boldinghii* and *Galactia nummularia.*

The continental element comprises 99 species:

Southern United States: Ferns: *Polypodium heterophyllum;* Angiosperms: *Acalypha chamaedrifolia, Amyris elemifera, Canella alba, Cymodocea manatorum, Cyperus planifolius* var. *ottonis, Eugenia axillaris, E. fragrans, E. rhombea, Ficus populnea, Hypelate trifoliata, Krugiodendron ferreum, Oncidium variegatum, Panicum adspersum, Picramnia pentandra* and *Urechites lutea.*

Southern United States and Central America: *Ambrosia hispida, Borrichia arborescens, Celosia nitida, Chiococca alba, Erithalis fruticosa, Ernodea littoralis, Exostemma caribaeum, Gouania lupuloides, Guettarda scabra, Gyminda latifolia, Piscidia piscipula, Salvia serotina, Strumpfia maritima,* and *Tournefortia gnaphalodes.*

Central America: Ferns: *Polypodium piloselloides;* Angiosperms: *Acanthospermum humile, Caesalpinia ciliata, Catopsis nutans, Croton flavens, Cyperus planifolius* var. *brunneus, Dorstenia contrajerva, Helicteris jamaicensis, Inga laurina, Nectandra coriacea, Phoradendron trinervium, Tabernaemontana citrifolia,* and *Vernonia longifolia.*

Central America and South America: Ferns: *Polypodium polypodioides* var. *polypodioides;* Angiosperms: *Bidens cynapiifolius, Boerhavia paniculata, Brassavola cucculata, Bromelia pinguin, Byrsonima crassifolia, Capparis baducca, C. indica, Cracca caribaea, Cuscuta americana, Desmodium procumbens, Epidendrum ciliare, Erythrina corallodendron, Melochia nodiflora, Paspalum fimbriatum, Peperomia glabella, Phyl-*

lanthus nobilis, Portulaca halimoides, Tabebuia pallida, and *Turnera ulmifolia.*
South America: *Amomis caryophyllata, Bernardia corensis, Bunchosia glandulosa, Caesalpinia coriaria, Cakile lanceolata, Casearia decandra, Cassia glandulosa, Cyperus confertus, Eugenia floribunda, E. ligustrina, Evolvulus argyreus, Fagara spinifex, Guettarda parvifolia, Ibatia maritima, Lasiacis harrisii, Linociera caribaea, Malpighia punicifolia, Mammea americana, Mapourea microdon, M. undata, Morisonia americana, Peperomia acuminata, P. blanda* var. *langsdorffii, Rauwolfia lamarckii, Rhynchosia reticulata, Setaria rariflora, S. setosa, Sida acuminata, Siphonoglossa sessilis, Spiranthes elata,* and *Thalassia testudinum.*
Florida — West Indies — South America: *Datura fastuosa, Evolvulus glaber, Guaiacum officinale, Rhacoma crossopetalum,* and *Ruellia tuberosa.*

B. SABA

The introduced element comprises 40 species.
The "cosmopolitan" element comprises 244 species.
The West Indian element, 87 species: Ferns: *Blechnum striatum, Cyathea antillana, Dryopteris meridionalis, D. scalpturoides, D. subtetragona* var. *guadelupensis, Elaphoglossum martinicense, Hymenophyllum hirtellum, Trichomanes alatum;* Angiosperms: *Annona muricata, A. reticulata, A. squamosa, Anthurium cordatum, Ardisia coriacea, Aristida cognata, Begonia retusa, Beloperone eustachiana, Besleria lutea, Boehmeria ramiflora, Bourreria succulenta, Bumelia obovata, Cestrum laurifolium, Charianthus crinitus, Chrysophyllum argenteum, Cladium restoides, Clibadium erosum, Clusia alba, Coccoloba diversifolia, C. venosa, Comocladia ilicifolia, Cordia salvifolia, C. sulcata, C. tremula, Cyperus swartzii* var. *granularis, Daphnopsis caribaea, Epidendrum papilionaceum, Erythroxylon havanense, Eupatorium macranthum, Euphorbia articulata, Euterpe globosa, Fagara martinicensis, Ficus krugiana, F. omphallophora, F. urbaniana, Freziera undulata, Galactia rubra, Gesneria ventricosa, Gundlachia corymbosa, Isachne disperma, I. rigidifolia, Lithophila muscoides, Marila racemosa, Microstylis spicata, Mitracarpus polycladus, Myrcia citrifolia, M. splendens, Nectandra krugii, Opuntia triacantha, Palicourea domingensis, Paspalum laxum, Pectis humifusa, Philodendron dispar, P. giganteum, Physurus plantagineus, Picrasma antillana, Pilea obtusata, P. parietaria, P. semidentata, Pisonia fragrans, P. subcordata, Pitcairnia latifolia, Plumiera alba, Polanisia viscosa, Pouteria multiflora, Psychotria pendula, Rousselia humilis, Sida cordifolia* var. *althaeifolia, S. humilis, Solanum lanceaefolium, S. racemosum, S. racemosum* var. *igneum, Symplocos martinicensis, Tillandsia excelsa, Trema lima, Tournefortia caribaea, T. filiflora, Vriesea guadelupensis,* and *Wittmackia lingulata.*
The endemic element comprises only 2 species: *Coccothrinax sabana* and *Peperomia boldinghii.*
The continental element comprises 111 species:
Southern United States: Ferns: *Dryopteris reticulata, Polypodium heterophyllum;* Angiosperms: *Acalypha chamaedrifolia, Colubrina ferruginosa, Cyperus planifolius* var. *ottonis, Eugenia axillaris, E. fragrans, E. rhombea, Ficus populnea, Mastichodendron foetidissimum, Panicum adspersum,* and *Urechites lutea.*
Southern United States and Central America: *Ambrosia hispida, Borrichia arborescens, Chiococca alba, Cuscuta umbellata, Ernodea littoralis, Gouania lupuloides, Guettarda scabra, Jacquemontia pentantha, Salvia serotina,* and *Zebrina pendula.*
Central America: Ferns: *Polypodium piloselloides;* Angiosperms: *Baccharis cotinifolia, Caesalpinia ciliata, Catopsis nutans, Croton flavens, Dichromena radicans, Epidendrum ramosum, Erechthites hieracifolia, Inga laurina, Nectandra coriacea, Phoradendron trinervium, Tabernaemontana citrifolia,* and *Vernonia longifolia.*
Central America and South America: Ferns: *Cyathea arborea, Diplazium striatum, Dryopteris decussata, Lycopodium taxifolium, Polypodium polypodioides* var. *polypodioides;* Angiosperms: *Bidens cynapiifolius, Boerhavia paniculata, Brassavola cucculata, Bromelia pinguin, Byrsonima spicata, Capparis baducca, C. indica, Cuscuta americana, Desmodium axillare, D. procumbens, D. scorpiurus, Epidendrum ciliare,*

E. globosum, Erechthites valerianaefolia, Erythrina corallodendron, Eupatorium iresinoides, Hamamelia axillaris, Hirtella triandra, Melothria guadelupensis, Neurolaena lobata, Paspalum fimbriatum, Peperomia emarginella, P. glabella, Phyllanthus nobilis, Phytolacca rivinoides, Piper reticulatum, Rhynchospora polyphylla, Tabebuia pallida, Tephrosia cathartica, and *Turnera ulmifolia.*
South America: Ferns: *Polypodium taenifolium, Selaginella flabellata, S. substipitata;* Angiosperms: *Amomis caryophyllata, Annona montana, Bernardia corensis, Caesalpinia coriaria, Cakile lanceolata, Casearia decandra, Cassia glandulosa, Cecropia peltata, Eugenia uniflora, Faramea occidentalis, Gonzalagunia spicata, Guettarda parvifolia, Hillia parasitica, Hyperbaena domingensis, Lasiacis harrisii, Linociera caribaea, Malpighia punicifolia, Mammea americana, Mapourea microdon, M. undata, Morisonia americana, Pectis febrifuga, Peperomia acuminata, P. petiolaris, P. urocarpa, Philodendron oxycardium, Rauwolfia lamarckii, Rhynchosia reticulata, Setaria rariflora, S. setosa, Siphonoglossa sessilis, Smilax guianensis, Tetrazygia discolor,* and *Tibouchina strigosa.*
Florida — West Indies — South America: *Datura fastuosa, Epidendrum strobuliferum, Rhacoma crossopetalum,* and *Ruellia tuberosa.*

C. St. Eustatius

The introduced element comprises 33 species.

The "cosmopolitan" element comprises 232 species.

The West Indian element comprises 79 species: Ferns: *Dryopteris meridionalis, Elaphoglossum martinicense, E. petiolatum, Lomariopsis sorbifolia;* Angiosperms: *Annona muricata, A. reticulata, A. squamosa, Anthurium cordatum, Ardisia coriacea, Aristida suringari, Begonia retusa, Beloperone eustachiana, Besleria lutea, Boehmeria ramiflora, Borreria podocephala, Bourreria succulenta, Bouteloua heterostega, Bumelia obovata, Cestrum laurifolium, Clusia alba, Coccoloba diversifolia, C. venosa, Comocladia ilicifolia, Cordia salvifolia, C. sulcata, Croton astroites, Daphnopsis caribaea, Epidendrum papilionaceum, Erythroxylon havanense, Eugenia cordata, Euphorbia articulata, Fagara martinicensis, Fagara trifoliata, Ficus krugiana, F. urbaniana, Galactia dubia, G. longifolia, G. rubra, Gesneria ventricosa, Jacquinia barbasco, Lithophila muscoides, Maytenus elliptica, Myrcia citrifolia, M. splendens, Nectandra krugii, Oncidium velutinum, Opuntia catacantha, O. triacantha, Palicourea domingensis, Paspalum laxum, Pectis humifusa, Philodendron dispar, P. giganteum, Phoebe elongata, Physurus hirtellus, P. plantagineus, Picrasma antillana, Pilea semidentata, Pisonia fragrans, P. subcordata, Pitcairnia latifolia, Plumiera alba, Polanisia viscosa, Pouteria multiflora, Rochefortia acanthophora, Samyda dodecandra, Sida cordifolia* var. *althaeifolia, Smilax coriacea, Solanum lanceaefolium, S. racemosum, S. racemosum* var. *igneum, Stigmatophyllon periplocifolium, Symplocos martinicensis, Ternstroemia peduncularis, Tetramicra elegans, Tournefortia filiflora, Trema lima, Vriesea guadelupensis,* and *Xylosma buxifolia.*

The endemic element comprises only 2 species: *Ipomoea sphenophylla* and *Mapourea eustatiana.*

The continental element comprises 106 species:
Southern United States: Ferns: *Polypodium heterophyllum;* Angiosperms: *Acalypha chamaedrifolia, Cyperus planifolius* var. *ottonis, Eugenia axillaris, E. rhombea, Exothea paniculata, Ficus populnea, Gymnanthus lucida, Krugiodendron ferreum, Oncidium variegatum, Panicum adspersum,* and *Urechites lutea.*
Southern United States and Central America: *Ambrosia hispida, Chiococca alba, Dipholis salicifolia, Erithalis fruticosa, Ernodea littoralis, Gouania lupuloides, Guettarda scabra, Gyminda latifolia, Jacquemontia pentantha, Piscidia piscipula, Prunus myrtifolius, Salvia serotina, Strumpfia maritima,* and *Tournefortia gnaphalodes.*
Central America: *Caesalpinia ciliata, Catopsis nutans, Croton flavens, Erechthites hieracifolia, Inga laurina, Nectandra coriacea, Phoradendron trinervium, Tabernaemontana citrifolia,* and *Vernonia longifolia.*

Central America and South America: Ferns: *Bolbitis cladorrhizaus, Lycopodium taxifolium, Polypodium polypodioides* var. *polypodioides;* Angiosperms: *Aegiphila martinicensis, Boerhavia paniculata, Brassavola cucculata, Bromelia pinguin, Byrsonima spicata, Capparis baducca, C. indica, Cracca caribaea, Cuscuta americana, Epidendrum ciliare, E. globosum, Hamamelia axillaris, Hibiscus brasiliensis, Melothria guadelupensis, Neurolaena lobata, Paspalum fimbriatum, Peperomia glabella, P. serpens, Piper medium, P. reticulatum, Portulaca halimoides, Prescottia stachyoides, Sida glomerata, Stenorrhynchus orchioides, Tabebuia pallida, Tephrosia cathartica,* and *Turnera ulmifolia.*
South America: *Amomis caryophyllata, Annona montana, Bernardia corensis, Caesalpinia coriaria, Cakile lanceolata, Casearia decandra, Cassia glandulosa, Cecropia peltata, Diodia rigida, Eugenia floribunda, E. ligustrina, E. uniflora, Faramea occidentalis, Guettarda parvifolia, Heteropteryx purpurea, Hillia parasitica, Hyperbaena domingensis, Ibatia maritima, Krameria ixina, Lasiacis harrisii, Linociera caribaea, Lonchocarpus violaceus, Malpighia punicifolia, Mammea americana, Mapourea microdon, M. undata, Morisonia americana, Peperomia acuminata, P. blanda* var. *langsdorffii, P. petiolaris, Philodendron oxycardium, Rauwolfia lamarckii, Rhynchosia reticulata, Setaria rariflora, S. setosa, S. utowanaeum, Siphonoglossa sessilis, Smilax guianensis,* and *Tetrazygia discolor.*
Florida — West Indies — South America: *Rhacoma crossopetalum* and *Ruellia tuberosa.*

ECOLOGICAL SPECIALIZATION

Reference should be made to the discussion of ecological specialization in Part I. The following additions can be given:

Root specialization. — Plank-buttresses are to be seen in *Ceiba pentandra;* stilt roots in *Rhizophora mangle, Clusia alba,* and *Cecropia peltata;* pneumatophores in *Avicennia nitida.*

Leaf specialization. — Deciduous species are, for instance, *Bursera simaruba, Ceiba pentandra, Piscidia piscipula, Spondias mombin,* whilst *Cecropia peltata* is semi-deciduous.

Special life-forms. — Palms: *Euterpe globosa;* Tree-ferns: *Cyathea antillana* and *C. arborea;* embossed prickles: *Hura crepitans;* hooked prickles: *Smilax ilicifolia.*

CHAPTER VII

DESCRIPTION OF THE REGIONS INVESTIGATED

ST. MAARTEN

It is hardly possible to speak of a vegetation existing around the Great Salt-pond [1]. Only a few scattered patches of halophytic plants are found there, viz. *Heliotropium curassavicum, Batis maritima, Sesuvium portulacastrum, Sporobolus virginicus, Eleocharis caribaea* and, along the western side, a very small, often interrupted fringe of *Laguncularia racemosa,* besides a few shrubs of *Conocarpus erecta.* The vegetation has been classified as vegetation of salt flats and salinas [XXVII].

Fort Hill [2], west of Philipsburg, rises to a height of about 250 m. To reach the foot of the hill from Philipsburg, it is necessary to pass through a destroyed vegetation consisting of scattered small trees of *Acacia farnesiana, Capparis indica, Tamarindus indica, Acacia tortuosa* and small shrubs: *Croton flavens, Jatropha gossypifolia, Melochia tomentosa,* many *Opuntia,* etc. On the slope of the hill, the vegetation becomes denser and is formed by shrubs 1—1½ m in height and strongly varying in ratio from place to place. Large trees are absent but small trees occur. The wonderful *Plumiera alba* is present in great numbers, and *Piscidia piscipula* is frequent. The shrub layer contains a large number of *Opuntia, Euphorbia petiolaris, Croton flavens* and *Melochia tomentosa.* The following species were noted, given here more or less in order of abundance:
Small trees: *Plumiera alba, Acacia farnesiana, A. tortuosa, Piscidia piscipula, Capparis cynophallophora, C. indica* and *Pisonia subcordata.*
Shrubs: *Euphorbia petiolaris, Opuntia, Croton flavens, Jatropha gossypifolia, Solanum racemosum, Melochia tomentosa, Amyris elemifera, Eugenia axillaris, Randia aculeata, Casearia decandra, Indigofera suffruticosa, Comocladia ilicifolia.*
Small shrubs and herbs: *Vinca rosea, Siphonoglossa sessilis, Oncidium variegatum, Euphorbia thymifolia, Melocactus, Rivina humilis, Malvastrum spicatum, Sida cordifolia, Eragrostis ciliaris, Dactyloctenium aegyptium, Chloris inflata, Tragus berteronianus, Cenchrus echinatus, Desmodium canum, Heliotropium indicum* and *Sida rhombifolia.*
Climbers: *Abrus precatorius, Centrosema virginiana, Rhynchosia reticulata* and *Alysicarpus vaginalis.*
Epiphyte: *Tillandsia recurvata.*

On the top of the hill [2a], some tall specimens of *Agave sisalana* are seen. Vegetation is much denser here and nearly impenetrable. The ruins of the old fort are overgrown in several places with high shrubs, reaching a height of 2½ metres. The trees are still rather small and do not exceed 4—5 m in height. Here the following species were noted:
Trees: *Pisonia subcordata, Piscidia piscipula, Acacia tortuosa* and *Capparis cynophallophora.*
Shrubs: many *Eugenia axillaris* and *E. ligustrina, Comocladia ilicifolia, Croton flavens, Rochefortia acanthophora, Acacia tortuosa, Capparis cynophallophora, Opuntia, Pithecellobium unguis-cati, Capparis baducca* and *Celtis iguanaea.*
Small shrubs and herbs: *Melochia tomentosa, M. nodiflora, Jatropha gossypifolia, Vinca rosea, Ruellia tuberosa, Solanum torvum, S. racemosum, Physalis angulata, Pectis linifolia, Synedrella nodiflora, Coleus amboinicus, Siphonoglossa sessilis, Pilea microphylla, Anthephora hermaphroditica, Chloris ciliata, C. inflata, Paspalum laxum, Oncidium variegatum* and *Eupatorium odoratum.*
Climbers: *Abrus precatorius, Rhynchosia reticulata* and *Tragia volubilis.*
Epiphytes: *Tillandsia recurvata* and *T. utriculata.*

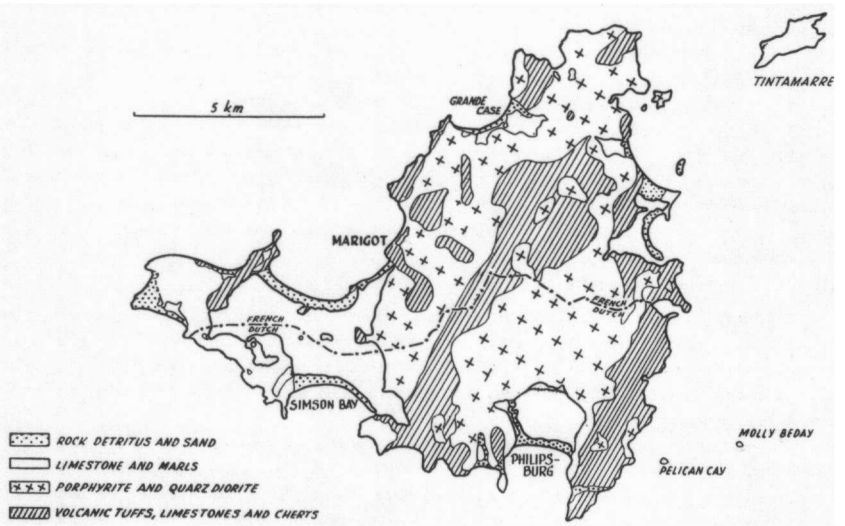

Fig. 8. Sketch map of St. Martin, with localities.
Fig. 9. Geological sketch map of St. Martin.

Kay Bay Hill [3]. In co-operation with Professor J. Lanjouw a small strip was enumerated. The strip, 20 × 5 m in size, was marked out at an altitude of 40 m above sea-level. Only a few trees emerge above the layer of high shrubs and shrubby trees. One of these trees appears to be deciduous. Undergrowth of herbs is absent except for some common weeds. The slope of the hill is strewn with stones and the gradient amounts to 15 degrees. The shrubs and shrubby trees reach a height of 3—4 metres, while the larger trees rise to 7 m (*Bursera simaruba, Bumelia obovata*).

Trees:

Bursera simaruba	4 (11.4%)	*Bumelia obovata*	4 (11.4%)

High shrubs and small trees:

Capparis flexuosa	10 (28.6%)	*Rhacoma crossopetalum*	2 (5.7%)
Capparis indica	4 (11.4%)	*Pisonia fragrans*	1 (2.9%)
Euphorbia petiolaris	3 (8.6%)	*Plumiera alba*	1 (2.9%)
Comocladia ilicifolia	3 (8.6%)	*Capparis baducca*	1 (2.9%)
Capparis cynophallophora	2 (5.7%)		

Lower shrubs: *Randia aculeata* (fr), *Euphorbia petiolaris* (fr), *Cephalocereus* (fr), *Opuntia triacantha* (v. fr), *Eugenia axillaris* (fr), *Croton flavens* (r), *Melochia nodiflora* (r), *Lantana involucrata* (r), *Solanum racemosum* (r), *Pedilanthes tithymaloides* (v. r). Climbers: *Acacia riparia, Abrus precatorius,* and *Stigmatophyllon periplocifolium.* Epiphytes: *Tillandsia utriculata* (fr), *T. recurvata* (a).

Outside this strip a few specimens of *Morisonia americana, Opuntia tuna* and *Oncidium variegatum* were observed. On more open spots many specimens of *Melocactus.* On the slope nearer to the sea many *Plumiera alba,* and an increasing number of *Pisonia subcordata.* Besides these species *Piscidia piscipula, Abrus precatorius* and *Bryophyllum pinnatum* were also seen.

Four other strips, each measuring 25 × 5 m were enumerated in this vicinity, at an altitude of 150 m above sea-level, with the following results:

Trees and high shrubs:

Cephalocereus	11 (23.9%)	13 (25.5%)	2 (5.7%)	18 (30.0%)
Randia aculeata	8 (17.4%)	5 (10.2%)	1 (2.9%)	18 (30.0%)
Capparis indica	5 (10.9%)	4 (8.2%)	4 (11.4%)	5 (8.3%)
Acacia macracantha	4 (8.7%)	1 (2.0%)	— —	1 (1.7%)
Capparis flexuosa	3 (6.5%)	7 (14.3%)	6 (17.1%)	1 (1.7%)
Capparis cynophallophora	3 (6.5%)	— —	— —	1 (1.7%)
Pisonia subcordata	3 (6.5%)	— —	1 (2.9%)	— —
Schaefferia frutescens	2 (4.4%)	1 (2.0%)	— —	4 (6.7%)
Erythroxylon brevipes	2 (4.4%)	4 (8.2%)	3 (8.6%)	1 (1.7%)
Morisonia americana	2 (4.4%)	4 (8.2%)	4 (11.4%)	3 (5.0%)
Piscidia piscipula	1 (2.2%)	1 (2.0%)	2 (5.7%)	1 (1.7%)
Citharexylum spinosum	1 (2.2%)	— —	— —	— —
Pithecellobium unguis-cati	1 (2.2%)	6 (12.2%)	— —	1 (1.7%)
Comocladia ilicifolia	— —	2 (4.1%)	— —	— —
Capparis baducca	— —	1 (2.0%)	10 (28.6%)	5 (8.3%)
Samyda dodecandra	— —	— —	1 (2.9%)	— —
Tabernaemontana citrifolia	— —	— —	1 (2.9%)	— —
Bursera simaruba	— —	— —	— —	1 (1.7%)

Lower shrubs, less than 1 m high:

Opuntia triacantha	a	fr	a	a
Euphorbia petiolaris	a	—	r	r
Eugenia ligustrina	fr	—	r	fr

Pedilanthes tithymaloides	fr	fr	—	r
Cephalocereus	fr	—	r	r
Croton flavens	r	—	r	fr
Lantana involucrata	r	—	—	—
Opuntia tuna	r	—	r	r
Melocactus	r	—	r	—
Euphorbia articulata	r	r	—	r
Randia aculeata	—	r	—	fr
Sida rhombifolia	—	r	—	—
Tabernaemontana citrifolia	—	r	r	—

Climbers: *Tournefortia volubilis, Alysicarpus vaginalis, Rhynchosia reticulata* and *Abrus precatorius.*
Herbs: *Commelina virginica* and *Ruellia tuberosa.*
Epiphytes: *Tillandsia recurvata* and *T. utriculata.*

Outside these plots the following species were noted: *Oncidium variegatum, Tragia volubilis, Solanum racemosum, Bryophyllum pinnatum, Croton astroites, Plumiera alba* and *Acacia tortuosa. Opuntia triacantha* is abundant, especially in the more open places.

At a lower altitude, near the sea, a shrub vegetation about 2 m in height is to be found, containing many *Croton astroites,* many *Randia aculeata, Croton flavens, Rauwolfia lamarckii, Tabernaemontana citrifolia, Eugenia axillaris, E. ligustrina, Pisonia aculeata, Acacia tortuosa, Euphorbia petiolaris* and *Clerodendron aculeatum.* A few trees rise above these shrubs: *Tamarindus indica, Leucaena glauca, Pisonia subcordata, Piscidia piscipula,* many *Plumiera alba,* and *Capparis indica.* Epiphytes: many *Tillandsia utriculata* and *T. recurvata. Opuntia, Cephalocereus,* and *Melocactus* are frequent. This vegetation represents a secondary woodland derived from dry evergreen forest [XVII].

Cole Bay Hill [4] is subject to repeated clearances, and the result has been a dense, impenetrable growth of shrubs 1—1½ m high, between which are found scattered trees, rising above this shrub layer to heights of 5 m. Among these trees the following species were noted: *Acacia macracantha, Bourreria succulenta, Bumelia obovata, Bursera simaruba, Capparis cynophallophora, Erythroxylon brevipes, Jacquinia barbasco, Morisonia americana, Pisonia fragrans, P. subcordata* and *Plumiera alba.*
Among the shrubs: *Adelia ricinella, Argithamnia candicans, Bromelia pinguin, Capparis baducca, Cephalocereus, Comocladia ilicifolia, Croton astroites, C. flavens, Eugenia rhombea, E. floribunda, Fagara trifoliata, Guettarda parviflora, Lycium americanum, Melochia tomentosa, Opuntia, Pisonia aculeata, Pithecellobium unguis-cati, Samyda dodecandra, Schaefferia frutescens* and *Wedelia jacquinii.*
Herbs: *Alternanthera repens, Boerhavia, Commicarpus scandens, Iresine elatior, Ocimum micranthum, Peperomia blanda* var. *langsdorffii, Stylosanthes hamata* and *Siphonoglossa sessilis.*
Several grasses occur.
Climbers and small vines: *Abrus precatorius, Cardiospermum halicacabum* var. *microcarpum, Dalechampia scandens, Ibatia maritima, Ipomoea nil* and *Rhynchosia reticulata.*
Epiphytes: *Catopsis nutans, Tillandsia recurvata* and *T. utriculata.*

The lower parts of the region, between the settlement of Cole Bay and the French frontier, are either still used for pasture and grazing land or are overgrown with Acacia thickets, in which some other common species are to be found: *Capparis indica, Opuntia, Tamarindus indica, Delonix regia, Croton flavens, C. astroites, Euphorbia* and other ruderals and weeds.

North-west of Great Saltpond [5] a very dense, entirely secondary vegetation is encountered, composed mainly of *Acacia farnesiana, Randia aculeata* and *Malpighia punicifolia.* There is a rather low number of small shrubs, and the general impression is of a very dry vegetation. Only a few scattered, taller trees rise above

this 3½—4 m-high shrub layer. In a strip 100 × 5 m, the following species were recorded:

Randia aculeata	42 (33.3%)	*Bursera simaruba*	3 (2.4%)
Malpighia punicifolia	26 (20.6%)	*Acacia macracantha*	2 (1.6%)
Acacia farnesiana	25 (19.8%)	*Plumiera alba*	2 (1.6%)
Capparis flexuosa	13 (10.3%)	*Tabebuia pallida*	1 (0.8%)
Capparis indica	6 (4.8%)	*Cephalocereus*	1 (0.8%)
Pisonia subcordata	5 (4.0%)		

Shrubs and herbs: *Bastardia viscosa, Croton astroites, Croton flavens, Melochia nodiflora, Opuntia dillenii, O. tuna, O. triacantha, Pedilanthes tithymaloides, Ruellia tuberosa, Sida carpinifolia.*
Climbers and small vines: *Abrus precatorius, Rhynchosia reticulata* and *Stigmatophyllon periplocifolium.*
Epiphytes: *Tillandsia recurvata,* (a) and *T. utriculata,* (fr).

A similar, but more open vegetation is found east of the Great Saltpond [6]. The lower shrubs are more prominent and some *Aloe vera* was seen. In the lowest layer *Opuntia triacantha* is very conspicuous, often only the one species, densely covering the ground.

The lower part of the western slope of Vineyard Hill [7] is sparsely covered by an open, low shrub vegetation with many *Opuntia triacantha, Croton flavens* and *Euphorbia petiolaris,* whilst *Melocactus* frequently occurs. There are some scattered trees, such as *Tamarindus indica, Acacia farnesiana, Capparis indica, Randia aculeata* and *Plumiera alba.* This is one of the most impoverished vegetations of St. Maarten.

The higher parts [8] are comparable to the vegetation of the southern slope of this hill, which is also secondary. Here, 4 plots 20 × 10 m were enumerated:

Capparis indica	6 (21.4%)	3 (10.3%)	7 (31.8%)	3 (10.3%)
Randia aculeata	6 (21.4%)	4 (13.8%)	1 (4.5%)	— —
Cephalocereus	4 (14.3%)	3 (10.3%)	3 (13.6%)	— —
Capparis flexuosa	3 (10.7%)	— —	1 (4.5%)	— —
Zizyphus jujuba	2 (7.1%)	10 (34.5%)	3 (13.6%)	7 (24.1%)
Capparis baducca	3 (10.7%)	— —	— —	1 (3.4%)
Acacia farnesiana	2 (7.1%)	— —	— —	3 (10.3%)
Bursera simaruba	1 (3.6%)	4 (13.8%)	— —	2 (6.9%)
Rauwolfia lamarckii	1 (3.6%)	3 (10.3%)	3 (13.6%)	1 (3.4%)
Piscidia piscipula	— —	2 (6.9%)	— —	4 (13.8%)
Pisonia subcordata	— —	— —	3 (13.6%)	7 (24.1%)
Malpighia punicifolia	— —	— —	1 (4.5%)	— —
Comocladia ilicifolia	— —	— —	— —	1 (3.4%)

Shrubs:

Opuntia triacantha	v.a	v.a	a	a
Melocactus	v.a	v.a	a	fr
Croton flavens	a	a	v.a	r
Melochia tomentosa	fr	fr	—	r
Opuntia tuna and *O. dillenii*	fr	fr	r	r
Lantana camara	r	fr	r	r
Randia aculeata	—	a	fr	—
Comocladia ilicifolia	—	r	—	—

Small shrubs and herbs: *Amaranthus spinosus, Boerhavia, Portulaca pilosa, Ruellia tuberosa, Sida cordifolia* and some grasses.
Epiphytes: *Tillandsia recurvata* and *T. utriculata.*
Climbers and vines: *Abrus precatorius, Rhynchosia reticulata* and *Stigmatophyllon periplocifolium.*

Outside this strip, the following species were noted: *Annona muricata, Bourreria succulenta, Euphorbia petiolaris, Pisonia aculeata, Pithecellobium unguis-cati, Plumiera alba* (especially in the higher parts), *Solanum racemosum* and *Tabebuia pallida.* The vegetation represents a woodland derived from dry evergreen woodland [XVII].

From Experiment to Guana Bay [9]. First comes a dry shrub bushland on the western slope of the hill. This part was once under cultivation, for such plants as *Agave sisalana, Zizyphus jujuba, Anacardium occidentale, Tamarindus indica, Psidium guajava,* etc. occur.

The trees and high shrubs include: *Acacia macracantha, Agave sisalana, Anacardium occidentale, Annona muricata, Capparis baducca, C. cynophallophora, C. indica, Casearia sylvestris, Celtis iguanaea, Comocladia ilicifolia, Fagara trifoliata, Jacquinia barbasco, Malpighia punicifolia, Picramnia pentandra, Pithecellobium unguis-cati, Plumiera alba, Samyda serrulata, Tamarindus indica* and *Zizyphus jujuba.*
Shrubs: *Cephalocereus, Chiococca racemosa, Croton astroites, C. flavens, Euphorbia petiolaris, Lantana camara, Melochia tomentosa, Opuntia dillenii, O. tuna* and *Vernonia longifolia.*
Undershrubs and herbs: *Anthephora hermaphroditica, Bidens, Bryophyllum pinnatum, Cenchrus echinatus, Chloris inflata, Cyperus rotundus, Dactyloctenium aegyptium, Eragrostis ciliaris, Evolvulus glaber, Hyptis pectinata, Opuntia triacantha, Portulaca oleracea, Sida cordifolia, Siphonoglossa sessilis* and *Talinum triangulare.*
Climbers and vines: *Alysicarpus vaginalis, Cardiospermum halicacabum* var. *microcarpum, Cissus sicyoides, Commicarpus scandens, Rhynchosia reticulata* and *Tournefortia volubilis.*

On the summit shrub vegetation about 1.25 m high is found, consisting mainly of shrubs and Cactaceae, overtopped by some higher shrubs and small trees. In the lower shrub layer *Croton flavens, C. astroites, Lantana involucrata* and *Pithecellobium unguis-cati* are the most prominent species. Among the higher shrubs and small trees *Capparis indica* and *Malpighia punicifolia* mainly appear. *Opuntia* and *Melocactus* frequently occur. The eastern slope, i.e. the slope facing the sea, is densely overgrown with high shrubs, in which *Malpighia punicifolia, Capparis indica, Pithecellobium unguis-cati* are the dominant species. The other high shrubs and small trees include: *Leucaena glauca, Plumiera alba, Capparis flexuosa, Comocladia ilicifolia, Cephalocereus, Randia aculeata, Pisonia fragrans, Rhacoma crossopetalum, Acacia tortuosa, A. farnesiana,* and only a very few specimens of *Guaiacum officinale, Jacquinia barbasco* and *Bursera simaruba.* Smaller shrubs: *Melochia tomentosa, Euphorbia petiolaris* (a), *Opuntia* (a), *Croton flavens, Lantana involucrata, Pedilanthes tithymaloides,* and *Melocactus.* Epiphytes: *Tillandsia recurvata* and *T. utriculata.* Climbers and vines: *Stigmatophyllon periplocifolium, Rhynchosia reticulata, Abrus precatorius.* A few specimens of *Oncidium variegatum* were seen. The vegetation exhibits very variable growth from point to point, and represents a secondary woodland derived from dry evergreen forest [XVII].

Pointe Blanche [10]. At the southern end of Pointe Blanche there is a small, rather flat area. It is covered by a low shrub thicket, about 90 cm high, in which *Croton flavens* and *Lantana involucrata* are dominant, respectively forming about 30 and 20% of it. Some scattered small trees and high shrubs occur, mainly *Capparis indica,* whilst *Pisonia subcordata* and *Plumiera alba* are present only in small numbers. *Cephalocereus* occurs frequently. In the shrub layer *Pedilanthes tithymaloides* is generally distributed, and *Opuntia dillenii* and *O. tuna* are frequent. In more open places *Opuntia triacantha* covers the ground in dense masses. The following shrubs are rare: *Fagara trifoliata, Melochia tomentosa, Euphorbia articulata, Lantana camara, Randia aculeata, Comocladia ilicifolia* and *Euphorbia petiolaris.* Forty specimens of *Melocactus* were counted per 100 sq.m. *Tillandsia utriculata* is abundant, and one climber, *Stigmatophyllon periplocifolium,* was frequently seen. Only a few herbs were collected: *Boerhavia erecta, Commelina virginica, Paspalum laxum* and *Eragrostis ciliaris:* Croton thicket [XX].

In more sheltered places the vegetation increases in height, and *Pisonia subcordata* becomes the dominant tree species in dense bush 2½—3 m high. The most conspicuous species is the white-flowered *Plumiera alba*. In a plot 20 × 10 m, the following species were recorded:

Pisonia subcordata	23	*Eugenia* sp.	6
Euphorbia petiolaris	9	*Capparis flexuosa*	5
Cephalocereus	8	*Fagara martinicensis*	3
Fagara trifoliata	7	*Randia aculeata*	2
Comocladia ilicifolia	7	*Citharexylum spinosum*	2
Capparis indica	6		

In the lower shrubs, up to 2 m in height, *Comocladia ilicifolia* is very abundant, whilst *Fagara trifoliata, Pithecellobium unguis-cati* and *Euphorbia articulata* are frequent. The epiphyte *Tillandsia utriculata* is frequent, and the semi-parasite *Phoradendron trinervium* is also present.

Some areas of the Low Lands [11] are planted with subsistence crops, especially the "Sion loam area" (Veenenbos 1955), while the rest of the Low Lands is used, at any rate for the most part, for charcoal-burning and goat-keeping. Consequently, this region has been strongly affected by man. The vegetation resembles Beard's "dry evergreen bushland" [XVIII]. In a plot 50 × 10 m, the following species were counted:

Trees over 5 m high:

Pisonia subcordata	14	*Comocladia ilicifolia*	4
Canella alba	7	*Bourreria succulenta*	2
Plumiera alba	7	*Bursera simaruba*	1
Coccoloba venosa	5		

Shrubs, 2—3 m high:

Eugenia axillaris	18	*Byrsonima crassifolia*	5
Rhacoma crossopetalum	13	*Plumiera alba*	3
Samyda dodecandra	8	*Bourreria succulenta*	2
Pithecellobium unguis-cati	7	*Jacquinia berteri*	2
Jacquinia barbasco	6	*Comocladia ilicifolia*	2
Coccoloba krugii	6		

Shrubs, less than 2 m high: *Croton betulinus* (a), *Wedelia jacquinii* (fr), *Phyllanthus epiphyllanthus* (fr), *Comocladia ilicifolia* and *Coccoloba krugii.*
Herbs: *Cyperus planifolius* var. *brunneus, C. rotundus, Ruellia tuberosa, Portulaca polyosperma, Epidendrum papilionaceum* and *Crotalaria incana.*
Climber: *Stigmatophyllon sericeum* (a).

Another plot 100 × 5 m was enumerated:

Trees over 5 m high:

Bourreria succulenta	14	*Tabebuia pallida*	1
Ternstroemia peduncularis	9	*Bursera simaruba*	3
Pisonia subcordata	5		

Shrubs and shrubby trees 2—4 m high:

Ernodea littoralis	7	*Canella alba*	2
Coccoloba krugii	4	*Jacquinia berteri*	2
Eugenia ligustrina	3	*Pisonia subcordata*	2

Pithecellobium unguis-cati is very abundant.
Shrubs 1—1¾ m high: *Lantana involucrata* (v.a), *Croton betulinus* (a), *Wedelia jacquinii* (a), *Croton flavens* (fr), *Eugenia axillaris* (fr), *Jacquinia barbasco, Pluchea odorata, Plumiera alba, Solanum racemosum,* and *Melochia tomentosa* (r). *Phyllanthus epiphyllanthus* is regularly distributed.

Herbs and undershrubs: *Cyperus planifolius* var. *ottonis, Crotalaria retusa, Corchorus hirsutus, Cassia glandulosa, Euphorbia thymifolia, Turnera ulmifolia,* and *Vernonia cinerea.*
Climbers and small vines: *Stigmatophyllon sericeum, Smilax ilicifolia, Rhynchosia reticulata.*
Epiphyte: *Tillandsia utriculata.*
This vegetation greatly varies in growth from place to place, and resembles the dry evergreen bushland according to Beard's classification.

A mangrove vegetation is to be found near Oysterpond [12] and along Simson Bay Lagoon [13]. The best intact example is near Simson Bay Lagoon, where a small fringe of *Rhizophora mangle* occurs, bordering the lagoon side of the bay, followed by a strip of *Avicennia nitida* and *Laguncularia racemosa.* In the latter strip there is a ground cover consisting of dense patches of *Batis maritima* and *Fimbristylis spathacea,* whilst some shrubs of *Tournefortia gnaphalodes* and *Borrichia arborescens* are also to be found. On the higher ground some *Conocarpus erecta* occurs. This mangrove becomes denser near Mullet Pond, where *Avicennia* is more conspicuous and *Sporobolus virginicus* frequently occurs. The mangrove has been badly disturbed by human interference. Near Oysterpond, the mangrove is often interrupted and intermingled with *Coccoloba uvifera. Rhizophora* is present, but only in small quantities. *Laguncularia racemosa* and *Conocarpus erecta* are the prominent species here.

The beaches of St. Martin are well developed along Simson Bay [14], Mullet Pond Bay [15], Great Bay [16], Guana Bay [17] and south of Oysterpond [18]. They all present the same aspect, except the beach of Great Bay, where there is a sand bar about 300 m wide, on which the town of Philipsburg has been built. Along the high-tide line remnants of *Cymodocea manatorum* and *Thalassia testudinum* are usually found. In the herbaceous strand community [XXV], *Ipomoea pes-caprae, Canavalia maritima, Sporobolus virginicus, Fimbristylis spathacea* and *Heliotropium curassavicum* are found, whilst two species of the Brassicaceae occur frequently: *Cakile lanceolata* and *Lepidium virginicum.* Some shrubs of the strand scrub community [XXVI] follow this zone: *Tournefortia gnaphalodes, Suriana maritima, Euphorbia buxifolia* and *Scaevola plumieri,* merging into a very dense littoral woodland [XXI], up to 2½ m high, in which *Coccoloba uvifera* is dominant, whilst many *Conocarpus erecta, Rhacoma crossopetalum, Erithalis fruticosa, Lantana involucrata, Suriana maritima, Tournefortia gnaphalodes* and *Thespesia populnea* are present. In the ground layer, *Cenchrus echinatus, Cyperus planifolius* var. *ottonis,* and *Capraria biflora,* are to be found.

Along the coast a woodland of *Hippomane mancinella* [XVIII] occurs in several places: at the pond between Old Battery Hill and Pointe Blanche [19], near Old Battery [20], and along the southern part of the pond of Little Bay [21]. The species occurs at several other places in the island, e.g. near Lay Bay [22], beside the Great Saltpond [23], Low Lands [24] and Cul de Sac [25], but nowhere does it form such woodlands as in the first three of these places. Pure growths are, however, unknown, and one or more of the following species is usually present: *Conocarpus erecta, Croton flavens, Euphorbia petiolaris* and, in the ground layer, *Sporobolus virginicus, Fimbristylis spathacea, Batis maritima* and *Sesuvium portulacastrum.*

The vegetation of two other spots is worthy of mention.

The spit of land south of Oysterpond [26] consists of limestone. Soil is practically absent, except where deposited in the crevices. The vegetation is formed by a shrub growth up to 1 m high, in which *Croton astroites, C. flavens, Lantana camara* and *Wedelia jacquinii* are dominant. *Melocactus* occurs frequently and many small shrubs of *Strumpfia maritima* are to be found, especially near the sea. *Erithalis fruticosa* and *Ernodea littoralis* frequently occur, and a few somewhat higher shrubs

and small trees are present: *Bumelia obovata, Rhacoma crossopetalum* and *Jacquinia barbasco.* Only a few grasses and sedges were seen: *Eragrostis ciliaris, Fimbristylis ferruginea* and *Cyperus swartzii* var. *granularis.* Vegetation of the rock pavement [XXII].

The shore of Pointe Blanche Bay [27] is strewn with small boulders, between which *Eleocharis caribaea, Fimbristylis spathacea,* and *Sporobolus virginicus* occur. Only a few specimens of *Ipomoea pes-caprae* and *Tournefortia gnaphalodes* were seen. The great number of *Melocactus,* between *Croton flavens* and *Lantana camara,* is striking. There are a few shrubs of *Coccoloba uvifera.* This vegetation gradually merges into that of the slope of Old Battery Hill, where *Capparis indica* and *C. flexuosa, Croton flavens* and *Euphorbia petiolaris* are the most important species.

It can be said that the following types of vegetation occur in St. Maarten:

CLIMATIC COMMUNITIES

Seasonal formations

Semi-evergreen seasonal forest [XI]
Secondary woodland derived from seasonal formations
Thorny woodland [XIII]
Leucaena thicket [XIV]
Croton thickets [XV]

Dry evergreen formations

Woodland derived from dry evergreen forest [XVII]
Evergreen bushland [XVIII]
Thorny woodland [XIX]
Croton thickets [XX]
Littoral woodland [XXI]
Vegetation of the rock pavement [XXII]
Vegetation of rocky slopes [XXIII]

EDAPHIC COMMUNITIES

Mangrove woodland [XXIV]
Herbaceous strand community [XXV]
Strand scrub community [XXVI]
Vegetation of the salt flats [XXVII]
Hippomane woodland [XXVIII]

SABA

On top of The Mountain [1] a cloud forest or elfin woodland [IX] is found. The small trees are confined to a few species, which form a low, gnarled and often impenetrable growth up to 6 m in height. The branches of the trees are laden with mosses and epiphytes, mainly ferns, but orchids are also present.

In some places the stratum is more open, and here *Anthurium cordatum* covers the ground in dense masses. *Euterpe globosa* and tree ferns occur, but in small numbers. Climbers are abundant, and the epiphytes also occur terrestrially. Many of the trees tend to become shrubby. Of the trees, *Freziera undulata* and *Rapanea ferruginea* are the most abundant. *Euterpe globosa* and *Cyathea antillana* are found in the more open spots. Of the shrubs, *Marila racemosa, Charianthus crinitus* and *Hillia longiflora* frequently occur. *Phytolacca rivinoides* and *Psychotria pendula* are present in small numbers. In the ground layer many ferns, *Begonia retusa* and (locally) *Anthurium cordatum,* are found. One saprophyte is present: *Leiphaimos aphylla.* The greatest number of species is to be found among the climbers and epiphytes: *Blechnum striatum, Nephrolepis rivularis, Polypodium loriceum, Dryopteris reticulata, Polypodium piloselloides, P. taenifolium, P. duale, Dryopteris opposita, Hymenophyllum hirtellum, Selaginella flabellata,* S. *substipitata, Ophioglossum reticu-*

latum, Gleichenia bifida, Trichomanus alata, Lonchitus hirsuta, Polybotria cervina. Phanerogams: *Philodendron giganteum, P. oxycardium, Tillandsia excelsa, Physurus plantagineus, Epidendrum anceps, Ornithidium coccineum, Potomorphe peltata, Peperomia emarginella, P. hernandiaefolia, Pilea obtusata, P. parietaria, Microstylis spicata, Boehmeria ramiflora, Sauvagesia erecta, Baccharis cotinifolia, Neurolaena lobata, Utricularia alpina.* One small tree of *Cecropia peltata* was seen, whilst *Gonzalagunia spicata* is represented by only a few specimens. Two sedges were collected: *Cladium restioides* and *Rhynchospora polyphylla.*

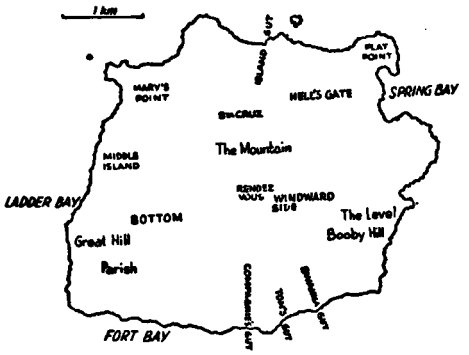

Fig. 10. Sketch map of S a b a, with localities.

Slightly b e l o w the top of T h e M o u n t a i n, between approximately 775 and 825 metres [2], the slopes are covered by palm brake [VIII]. *Euterpe globosa* is the dominant species, contributing 50—75% of the total crop. As the area is nearly inaccessible, it proved impossible to enumerate a strip of this community. In several places the slope is very steep and the gradient amounts to 60—80 degrees. The shrub layer is absent, only an occasional small shrub being found, whilst the ground layer is very luxuriant, and consists mainly of ferns. Tree ferns occur rather frequently. Some species common to the pioneer forest are present: *Cecropia peltata, Cordia sulcata, Acnistus arborescens* and *Heliconia bihai.* These species occur in the rain forest, under natural conditions, as the pioneers of forest gaps. The palms reach a height of 6—8 m, but the average height is very variable, and a regular canopy is absent. Only a small number of other tree species was counted, all small trees: *Marila racemosa, Hirtella triandra, Citharexylum spinosum, Freziera undulata, Tournefortia foetidissima, Cyathea arborea,* and *Cecropia peltata.* The scattered shrubs include: *Rapanea arborea, Miconia laevigata, Charianthus crinitus, Hillia longiflora, Gonzalagunia spicata, Phytolacca rivinoides, Mapourea undata,* and *Gesneria ventricosa.* The greatest number of different species is found in the ground layer, which is again dominated by ferns. These ferns are usually of small herbaceous species, but tree-ferns also occur, as mentioned above. Ferns: *Selaginella flabellata, S. substipitata, Gleichenia bifida, Dryopteris subtetragona, Elaphoglossum martinicense, Nephrolepis rivularis, Polypodium heterophyllum, P. piloselloides, Tectaria incisa.* Phanerogams: *Cyperus rotundus, Hypoxis decumbens, Potomorphe peltata, Peperomia emarginella, Boehmeria ramiflora, Sauvagesia erecta, Begonia retusa, Leiphaimos aphylla,* and *Lagenaria vulgaris.* Several orchids are also present: *Physurus plantagineus, Microstylis spicata, Epidendrum anceps, E. globosum,* and *Ornithidium coccineum.*

Below this palm brake there is a belt of tree-ferns [3], *Cyathea arborea* and *C. antillana* being the component species: tree-fern brake [III]. This belt occurs near Rendez Vous at an altitude of about 575 m, near Santa Cruz at about 600 m, and above Middle Island at 600—650 m. Only these two species of tree-ferns are present, forming a dense grove 4 m high. Many clearings planted with yams and bananas are to be found.

In one of these abandoned clearings "Under the Cliff", 680 m above sea-level at the Rendez Vous side, the following species were collected: *Rapanea ferruginea, Dichromena radicans, Paspalum conjugatum, Drymaria cordata, Pilea nummularifolia, Erechthites valerianaefolia, Rhynchospora polyphylla, Sida acuta, Stachytarpheta jamaicensis, Peperomia acuminata, Nephrolepis rivularis, Dryopteris patens, Priva lappulacea, Gonzalagunia spicata, Thunbergia alata, T. fragrans, Borreria laevis, Oxalis martiana, Emilia sonchifolia, Bidens pilosa, Erigeron bonairensis, Synedrella nodiflora, Blechnum occidentale, Dryopteris dentata, Ophioglossum reticulatum, Begonia retusa, Miconia laevigata, Kyllinga brevifolia, Plantago major, Pothomorphe peltata, Leonurus sibiricus,* and *Citharexylum spinosum.* Some bananas are also present.

Mountain above Windwardside [4]. The small village of Windwardside is situated at an altitude of 500 m above sea-level, on the windward slope of the island. Above this village a belt 75—100 m in breadth has been cleared for agricultural purposes. But even in the higher parts of The Mountain clearings are frequently encountered, which are planted either with bananas and subsistence crops or with guinea grass, *Panicum maximum.* The rest of the slope of The Mountain is well wooded, but the vegetation is clearly secondary, as remnants of former cultivation are also to be found: *Theobroma cacao, Coffea arabica, Citrus, Murraya exotica, Mammea americana, Persea americana,* and *Psidium guajava.* Miconia thickets, indicating plots abandoned after cultivation, are frequently met with. Most of the guts are still used for banana-planting, at any rate up to a certain altitude.

The secondary rain forest [II] does not usually exceed 5 m in height; these trees are scarcely ever straight, but are more or less crooked, probably owing to wind influences. Some trees have developed aerial roots. Undergrowth is practically absent, except for patches of *Anthurium cordatum.* As far as can be seen, climbing Araceae are absent. The constrictor *Clusia alba* occurs frequently, while *Ficus krugiana* is also seen, but only rarely. Several rain forest species occur: *Nectandra krugii, Hirtella triandra, Symplocos martinicensis,* and *Cordia sulcata.* A definite stratum is absent. The following species are very frequent to abundant: *Cordia sulcata, Nectandra krugii, N. coriacea, Linociera caribaea, Citharexylum spinosum, Symplocos martinicensis,* and *Clusia alba.* Shrubs: *Myrcia splendens, Mapourea undata, Miconia laevigata.* There are several walls of big stones about 1 m high, and these are usually overgrown with lichens, *Peperomia acuminata, Polypodium polypodioides, P. lycopodioides, Peperomia petiolaris, Pilea microphylla,* and *P. semidentata.*

Between Hellsgate and Santa Cruz, the side of The Mountain has very largely been cleared for agricultural purposes. Above this cleared area the slope becomes very steep and inaccessible.

In one of the ravines near Island Gut [5] a type of rain forest [I] was found, at an altitude of about 600 m. The slope faces east-north-east. The forest is two-storied. There is no definite shrub layer, but ground cover is very luxuriant. *Myrcia citrifolia* is the most abundant species, reaching a height of 10 metres. In the lower story, 5—7 m high, *Psychotria berteriana* is abundant, while *Sloanea truncata* and a not yet identified species of *Drypetes* are frequent. *Euterpe globosa* is present, but only in very small numbers. Tree-ferns are abundant. Among the shrubs *Psychotria berteriana, Myrcia citrifolia, Piper reticulatum* and *Charianthus crinitus* are found. Climbers and lianas are abundant; among them *Philodendron dispar* and *P. oxycardium,* and *Marcgravia umbellata,* are especially noticeable. *Clusia alba* occurs frequently, in addition to an occasional *Cecropia peltata.* The latter is more common on the

higher parts of the slopes around this ravine. The ground layer is closed, and consists mainly of ferns, among them *Blechnum occidentale, Nephrolepis rivularis, Polybotrya cervina, Tectaria trifoliata* and *Lonchitis hirsuta,* whilst *Selaginella flabellata* is very abundant. Some scattered groups of *Heliconia bihai* are to be found. Only one epiphyte was observed: *Tillandsia utriculata.* Leaves are covered with epiphyllous hepatics, which also occur on stems.

A small plot was marked out in the clearly secondary woodland on the northern slope between The Level and Curve Gut, near Windwardside [6]. This area is stony and very steep, and is used as grazing land. In the plot, which measured 40 × 10 m, the following species were counted.

Trees and shrubs over 4 m high:

Miconia laevigata	21	*Cordia sulcata*	5
Daphnopsis caribaea	19	*Citharexylum spinosum*	4
Nectandra coriacea	17	*Pisonia subcordata*	3
Inga laurina	14	*Tabebuia pallida*	3
Nectandra krugii	11	*Cestrum laurifolium*	2
Coccoloba venosa	8	*Myrcia citrifolia*	2
Linociera caribaea	6	*Allophylus occidentalis*	3

Lower shrubs: *Miconia laevigata* (v.a), *Psidium guajava* (a), *Chrysobalanus icaco* (fr), *Tetrazygia discolor* (a), *Piper reticulatum* (a), *Mapourea undata* (fr), *Casearia decandra* (fr), *Piper dilatatum* (r), *Chiococca alba* (r), *Gonzalagunia spicata* (r).
Small shrubs and herbs: *Bidens cynapiifolia, Borreria laevis, Bryophyllum pinnatum, Eleusine indica, Emilia sonchifolia, Eryngium foetidum, Paspalum fimbriatum, P. laxum, Physalis angulata, Pilea microphylla, P. semidentata, Rivina humilis, Sida acuta.*
Climbers and vines: *Cissus sicyoides, Clusia rosea, Rhynchosia reticulata.*
Ferns: *Blechnum occidentale, Polypodium aureum, P. lycopodioides.*

No real canopy is formed; in several places this vegetation is rather open, in other places it is very dense and clearly secondary and of seasonal origin. Stones are numerous and usually overgrown with mosses, ferns and herbs.

Fort Bay Gut [7] is situated in one of the driest parts of the island. Ground cover does not exceed 75% and the vegetation consists of nearly pure Croton flavens thicket, intermixed with small numbers of other species: *Lantana involucrata, Jatropha gossypifolia, Urechites lutea, Plumbago scandens, Opuntia dillenii, O. tuna, O. triacantha, Rauwolfia lamarckii,* and *Randia aculeata.* In the higher parts a few trees occur: *Pisonia subcordata, Bursera simaruba, Capparis indica* and *Cephalocereus.* On the very steep slopes *Bromelia pinguin* occurs, often in great abundance. On the large rocks west of the road from Fort Bay to The Bottom, a few specimens of *Pithyrogramme calomelanos, Urechites lutea, Oncidium variegatum, Melocactus, Spermacoce confusa,* and *Tillandsia recurvata* were collected. In some places, especially in the deeper guts, a mixture of several species occurs, forming a dense bush of no particular structure. Here the following species were collected: *Abrus precatorius, Achyranthes aspera, Aloe vera, Annona muricata, Antigonon leptopus, Boerhavia coccinea, Bourreria succulenta, Bryophyllum pinnatum, Bursera simaruba, Caesalpinia bonduc, Calotropis procera, Capparis baducca, C. flexuosa, Casearia decandra, Cassia bicapsularis, Cissus sicyoides, Citharexylum spinosum, Clerodendron aculeatum, Croton flavens, C. lobatus, Cyperus planifolius, Cuscuta americana, Indigofera suffruticosa, Jatropha gossypifolia, Lantana involucrata, Leonotis nepetaefolia, Leucaena glauca, Melicocca bijuga, Melocactus, Morisonia americana, Opuntia dillenii, O. triacantha, Pectis febrifuga, Ricinus communis, Solanum argillicolum, S. racemosum, Spermacoce confusa, Plumbago scandens, Rauwolfia lamarckii, Tabebuia pallida, Tamarindus indica, Tecoma stans, Thespesia populnea, Urechites lutea* and *Vinca rosea.*

This dry vegetation presents the same aspect near Spring Bay Flat [8]. Ground cover is less than 70%, and consists mainly of *Croton flavens* and *Lantana*

involucrata. There are some high trees of *Tabebuia* and *Pisonia subcordata*. Scattered individuals of *Melocactus, Urechites lutea, Opuntia dillenii* and *O. tuna* are to be found. At a higher altitude, between 350 and 450 m, a much denser vegetation occurs, comparable to the dry evergreen woodland [XVII]; it has been badly damaged by human interference. *Tabebuia pallida, Pisonia subcordata, Comocladia ilicifolia, Randia aculeata, Jacquinia barbasco*, and *Citharexylum spinosum* are prominent species, whilst in the shrub layer *Croton flavens, Lantana involucrata, L. camara, Jatropha gossypifolia* and Cactaceae predominate. *Acacia macracantha, Pithecellobium unguis-cati, Malpighia punicifolia*, and *Leucaena glauca* occur frequently. Other species are: *Piper reticulatum, Peperomia glabella, Celtis iguanaea, Ficus urbaniana, Schoepfia schreberi, Coccoloba venosa, Pisonia aculeata, Capparis cynophallophora, C. indica, C. baducca, Erythroxylon havanense, Bryophyllum pinnatum, Bursera simaruba, Daphnopsis caribaea, Eugenia axillaris, Guettarda parvifolia, Chiococca racemosa, Hyptis pectinata, Solanum lanceaefolium, Salvia serotina*, and *Solanum racemosum*.

In Compagnie's Gut, Tom's Gut and Swanna Gut [9], the vegetation consists of a shrub layer about 1 m high, *Lantana camara, L. involucrata, Croton flavens, Wedelia jacquinii* and *Mitracarpus polycladus* being the predominant species, and varying in abundance from point to point: Croton thickets [XX]. The total cover ranges from 75 to 100%. *Annona montana, Calotropis procera, Casearia decandra* and *Rauwolfia lamarckii* rise above this shrub layer. Other species in the shrub layer are *Sida cordifolia, Solanum racemosum, Indigofera suffruticosa, Sida cordifolia* var. *althaeifolia, Vinca rosea, Jatropha gossypifolia*, and *Eupatorium odoratum*. Some vines are present: *Plumbago scandens, Abrus precatorius*, and *Centrosema virginianum*. Herbs: *Siphonoglossa sessilis, Capraria biflora*, and *Cenchrus echinatus*. The fern *Pithyrogramme calomelanos* is found there, but is rare. Only on the higher ground and on The Flat, between Tom's Gut and Compagnie's Gut, do several scattered trees occur, *Pisonia subcordata* being the most frequent one, accompanied by *Tabebuia pallida, Citharexylum spinosum* and *Comocladia ilicifolia*.

The same scanty vegetation is to be found on the steep slopes of Parish Hill and Great Hill [10], except on a small part of the northern slope of the latter, where a dense cover of *Anthurium cordatum* is found. South-west of the depression between Great Hill and Parish Hill a dry evergreen woodland [XVII] occurs, at an altitude of between 300 and 400 m. In this woodland, varying from dense to very open, some scattered larger trees are found: *Bursera simaruba, Tabebuia pallida*, and *Swietenia mahagoni*. The shrubs and shrubby trees are: *Coccoloba diversifolia, C. venosa, Celtis iguanaea, Acacia farnesiana, Rhacoma crossopetalum, Citharexylum spinosum, Cestrum laurifolium, Comocladia ilicifolia, Chiococca racemosa, Pisonia subcordata, P. fragrans* and *P. aculeata, Casearia parvifolia, Myrcia citrifolia, Daphnopsis caribaea, Capparis cynophallophora, Amomis caryophyllata, Guettarda scabra, Croton flavens*, and *Lantana involucrata*. Herbs: *Peperomia acuminata, Chenopodium ambrosioides, Desmanthus virgatus, Opuntia triacantha, Asclepias curassavica, Siphonoglossa sessilis, Beloperone eustachiana, Pilea microphylla*, some grasses, and *Cyperus planifolius* var. *ottonis*. Epiphytes are abundant: *Tillandsia utriculata, T. fasciculata* and *T. recurvata, Epidendrum ciliare, Oncidium sylvestre, Brassavola cucculata, Wittmackia lingulata*, and *Pitcairnia latifolia*. Ferns: *Pithyrogramme calomelanos, Adianthum tenerum, Polypodium lycopodioides* and *P. triseriale*. Semi-parasite: *Phoradendron trinervium*.

Between The Bottom and Saddle [11], comes a belt of semi-cultivated land, *Mangifera indica, Anacardium occidentale, Annona muricata* and *A. squamosa* being the prominent fruit-trees on it. Some other tree species occur: *Trema lima, Daphnopsis caribaea, Bursera simaruba* and *Citharexylum spinosum*. In the shrub layer *Piper dilatatum* and *Miconia laevigata* are especially dominant species. Ferns and herbs are abundant; *Bryophyllum pinnatum* is even very abundant. *Theobroma cacao* is to be found in the higher parts of this steep gut. In the highest part of it bananas are grown, and, besides the common weeds, *Potomorphe peltata* and many

other Piperaceae occur. From this gut a small path leads to Little Rendez Vous [11a]. *Mangifera indica* and *Mammea americana* are remnants of former cultivation. *Miconia laevigata* is the only tall shrub there, reaching a height of as much as 5 metres: Miconia thicket [IV]. One specimen of *Cyathea arborea* was seen, and only two other species occur sporadically in the shrub layer: *Chrysobalanus icaco* and *Inga laurina*. *Anthurium cordatum* covers the soil at several points, but the greater part of the layer is occupied by *Polypodium phyllitidis* and *Blechnum occidentale*. *Epidendrum anceps, Scleria pterota, Polypodium aureum* and *Pilea semidentata* are present in very small numbers, whilst *Dioscorea alata* runs wild.

East of this rather small plot, the secondary vegetation consists of *Chrysobalanus icaco* to the extent of more than 60%, intermixed with *Mammea americana, Annona squamosa, Miconia*, etc.

Between Windwardside and Great Rendez Vous [12], most of the original vegetation has been cleared for agricultural purposes. However, some very dense groups, clearly secondary, remain. They generally cover the very steep parts, and are very dense.

In a small plot 30 × 5 m in area at an altitude of 450 m, the following species were counted:

Miconia laevigata and *M. impetiolaris*	12	*Clusia alba*	4
		Coccoloba venosa	3
Cordia sulcata	6	*Inga laurina*	3

The shrub layer contains: *Piper reticulatum* (v.a), *Inga laurina* (a), *Chrysobalanus icaco* (a), *Eugenia* (a), *Mapourea undata* (fr).

Among the herbs, the following species were noted: *Pilea semidentata, Bryophyllum pinnatum, Abutilon hirtum, Solanum seaforthianum, Desmodium scorpiurus* and *Commelina virginica*.

The western part of Saba, north of The Bottom [13], is intersected by deep ravines. The lower areas in particular, show traces of former human activity, and the vegetation consists of a degraded bushland, probably of dry evergreen origin. North-east of Middle Island a young mahogany woodland, about 4 m high, exists. As far as can be seen, only a few specimens have rather tall and erect stems; most of the trees exhibit a shrubby growth, branching immediately above or at a small distance from the ground. It proved impossible to estimate the area covered by this mahogany woodland. In the higher parts several small plots have been cleared and planted with subsistence crops, while the guts are usually planted with bananas.

In going down Ladder Bay from The Bottom [14], an area planted with fruit-trees is passed at an altitude of between 200 and 150 m: *Mangifera indica, Annona reticulata, A. squamosa, Anacardium occidentale, Melicocca bijuga, Persea americana*, between which a few trees of *Tabebuia pallida* and *Bursera simaruba* occur, while *Tamarindus indica* is also present. In the shrub layer *Phyllanthus nobilis, Casearia decandra, Croton flavens, Lantana involucrata* and *Agave sisalana* are the prominent species. Many common weeds occur.

Between 150 and 100 m, a young mahogany plantation is seen on the southern side of the path. The trees are about 3 m high, and their stems vary between 3 and 7 cm in diameter. In a strip 20 × 5 m, 87 specimens were counted. Undergrowth is absent, except for a few common weeds. An attempt to enumerate a plot in the gut failed and only the following species could be noted: *Tabebuia pallida, Tamarindus indica, Coccoloba uvifera, Acacia farnesiana, Citharexylum spinosum, Capparis cynophallophora, Phyllanthus nobilis, Casearia decandra, Linociera caribaea, Amomis caryophyllata, Swietenia mahagoni, Croton flavens, Rauwolfia lamarckii, Lantana involucrata, Jatropha gossypifolia, Capraria biflora*, and *Indigofera suffruticosa*.

The lowest part is too steep to carry much vegetation, and only some small patches were seen, grown with *Cyperus planifolius* var. *ottonis, Opuntia dillenii, Paspalum laxum, Pithyrogramme calomelanos*, and *Wedelia jacquinii*.

Between Middle Island and Mary's Point [15], as well as between The Bottom and Middle Island, an open, rather scanty vegetation occurs in the lower parts, especially on the steep slopes of the ravines. It consists of *Croton, Lantana* and some *Eugenia,* with scattered trees: Croton thickets [XX]. In the more gently sloping places a degraded bushland is to be found [XVII]. A dense shrub layer of *Eugenia axillaris, Myrcia splendens, Pithecellobium unguis-cati, Celtis iguanaea, Malpighia punicifolia, Citharexylum spinosum, Randia aculeata, Guettarda parvifolia, G. scabra, Chiococca racemosa, Croton flavens,* and *Lantana* is overtopped by such higher trees as *Morisonia americana, Tamarindus indica, Picrasma antillana, Bumelia obovata, Tabebuia pallida, Pisonia subcordata,* and *Trema lima.*

It can be said that the following types of vegetation occur in the island of Saba:

CLIMATIC CLIMAX COMMUNITIES

Optimal formation

Rain forest [I]
Secondary rain forest [II]
Tree-fern brake [III]
Miconia thickets [IV]
Piper dilatatum thicket [V]
Pioneer forest [VI]

Montane formations

Palm brake [VIII]
Elfin woodland [IX]

Seasonal formations

Woodland derived from seasonal forest
Leucaena thicket [XIV]
Croton thickets [XV]

Dry evergreen formations

Woodland derived from dry evergreen forest [XVII]
Croton thickets [XX]

ST. EUSTATIUS

On the sandy beach of Concordia Bay [1], species of the herbaceous strand community are absent. A very dense littoral woodland [XXI] is present, about 8 m high. This belt varies greatly in width. *Coccoloba uvifera* dominates, and besides this species some specimens of *Hibiscus tiliaceus* and *Thespesia populnea* occur. *Jacquinia barbasco, Solanum racemosum, Pedilanthus tithymaloides, Euphorbia buxifolia,* and *Sesuvium portulacastrum* are present, although in very small quantities.

Along Venus Bay [2], a belt of *Conocarpus erecta* is found. Owing to the strong winds the shrubs do not exceed 50 cm in height, and they vary greatly in density.

Strand near Big Gut [3] (near Fort de Windt). The beach is very stony and a large number of boulders are to be found. A few specimens of *Ipomoea pes-caprae* and *Canavalia maritima* are present, intermixed with shrubs of *Tournefortia gnaphalodes, Euphorbia buxifolia* and *Tephrosia cinerea.* Only a small number of grasses occur: *Sporobolus virginicus* and *Dactyloctenium aegyptium.* Behind this zone is an open and often interrupted strip of *Coccoloba uvifera,* intermixed with many species such as *Cassia obovata, Croton flavens, Acacia macracantha, Jacquinia barbasco, Tabebuia pallida, Leucaena glauca, Piscidia piscipula* and *Lantana involucrata.*

On Sugar Loaf [4] many small shrubs of *Strumpfia maritima* occur, as well as a few shrubs of *Coccoloba uvifera, Urechites lutea* and one specimen of *Jacquinia barbasco:* vegetation of the rock pavement [XXII].

South of Oranjestad [5]. Along the shore between Oranjestad and Gallows Bay some scattered patches of *Heliotropium curassavicum, Sporobolus virginicus,* the creeping *Ipomoea pes-caprae,* and *Canavalia maritima* are found. *Hippomane mancinella* frequently occurs, reaching a height of not more than 7 m; the stands are usually intermixed with several other species: *Opuntia, Malpighia punicifolia, Randia aculeata, Acacia farnesiana, Croton flavens, C. astroites, Lantana involucrata* and the more or less climbing species *Plumbago scandens.* Near Gallows Bay *Hippomane* reaches a height of as much as 10 m. In the undergrowth here only a few scattered *Solanum racemosum, Acacia farnesiana, Opuntia* and *Plumbago scandens* are encountered. The parasite *Cuscuta americana* is found on *Acacia farnesiana.*

This type of Hippomane woodland also occurs along the southern part of Tumble Down Dick Bay [6]. Here *Thespesia populnea* is present, but only in the shape of a few specimens. A few herbs were found: *Paspalum laxum, Achyranthes aspera* and *Cenchrus echinatus.*

On the beach at Oranjestad [7], vegetation is very scanty owing to human interference. The only plant life found consists of scattered shrubs of *Acacia, Ricinus communis, Opuntia, Croton* and *Ipomoea pes-caprae.*

In former days the northern hills were under cultivation — at any rate to a very large extent. Nowadays agricultural activity is confined to a small plateau in the centre of the area: Little Mountains and Mary Glory. But the greater part is grazing land for half-wild goats and, especially in the south, for cattle. There are great differences in the plant cover from point to point; it varies from a low open shrub layer consisting mainly of *Croton,* to a very dense and impenetrable growth of gnarled, small trees, so typical of secondary communities. Traces of charcoal-burning are often found.

Several plots and strips were examined in this area, data being obtained either by enumerating the trees and high shrubs or by visual estimation of the percentages.

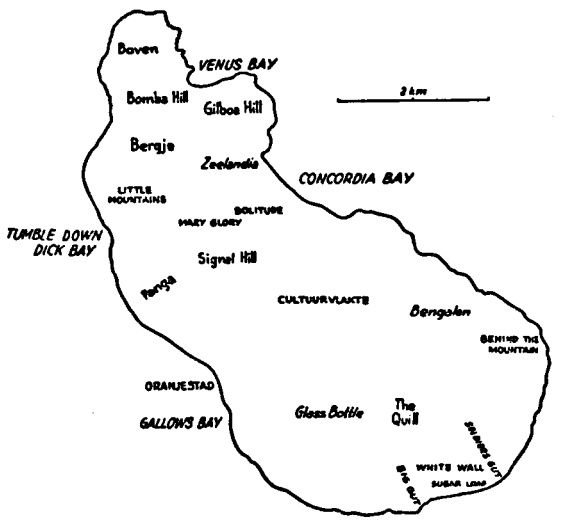

Fig. 11. Sketch map of St. Eustatius, with localities.

Solitude [8]. Altitude: about 80 m above sea-level. Slope: easterly, gradient: about 20 degrees. Soil: rocky, strewn with stones. — A rather open vegetation with a ground cover of 75%. Above the shrub layer, which is about 1 m high, scattered trees are found, sometimes occurring in groups. The shrub layer contains the dominant species *Croton flavens* and *C. astroites*, which make up 45—50% of the total. *Coccoloba uvifera* forms nearly 25%, whilst *Krameria ixina* and *Acacia tortuosa* are regularly distributed. *Randia aculeata, Rauwolfia lamarckii* and *Lantana involucrata* are rare. Among the trees *Tabebuia pallida* and *Acacia tortuosa* are frequent, whereas *Bumelia obovata, Rhacoma crossopetalum, Pisonia fragrans* and *P. subcordata* occur only in the shape of a few specimens. *Melocactus* is frequent, but *Opuntia dillenii* and *O. triacantha* are rare. *Rhynchosia reticulata* is present and the parasitic vine *Cuscuta americana* has been noted.

At an altitude of about 120 m above sea-level, 4 plots were marked out, each 20 × 10 m.

Trees and shrubs over 5 m high:

Pisonia subcordata	14 (40.0%)	14 (37.8%)	1 (4.8%)	3 (17.6%)
Bursera simaruba	8 (22.9%)	5 (13.5%)	3 (14.3%)	4 (23.5%)
Pisonia fragrans	4 (11.4%)	3 (8.1%)	3 (14.3%)	3 (17.6%)
Capparis indica	3 (8.6%)	3 (8.1%)	2 (9.5%)	2 (11.8%)
Tabebuia pallida	3 (8.6%)	8 (21.6%)	2 (9.5%)	1 (5.9%)
Malpighia punicifolia	2 (5.7%)	— —	2 (9.5%)	1 (5.9%)
Melicocca bijuga	1 (2.8%)	— —	— —	— —
Leucaena glauca	— —	4 (10.8%)	2 (9.5%)	1 (5.9%)
Acacia tortuosa	— —	— —	3 (14.3%)	— —
Annona muricata	— —	— —	1 (4.8%)	— —
Ficus lentiginosa	— —	— —	1 (4.8%)	— —
Achras sapota	— —	— —	1 (4.8%)	— —
Tamarindus indica	— —	— —	— —	1 (5.9%)
Coccoloba venosa	— —	— —	— —	1 (5.9%)

Small trees and shrubs, up to 4 m high:

Croton astroites	a	v.a	fr	o
Randia aculeata	fr	fr	a	a
Pedilanthus tithymaloides	fr	a	r	a
Pithecellobium unguis-cati	fr	fr	—	fr
Rauwolfia lamarckii	r	r	—	—
Wedelia jacquinii	r	—	r	—
Indigofera suffruticosa	r	—	—	—
Solanum torvum	r	—	—	—
Lantana camara	r	—	—	—
Triphasia trifoliata	r	r	r	r
Comocladia ilicifolia	r	r	r	r
Melochia tomentosa	o	—	—	—
Eugenia spp.	o	r	r	—
Malpighia punicifolia	—	r	fr	fr
Capparis indica	—	—	fr	o
Capparis baducca	—	—	r	r
Pisonia fragrans	—	—	r	—
Croton flavens	—	—	r	—
Pisonia subcordata	—	—	—	o

Climbers and vines:

Capparis flexuosa	a	r	o	r
Cissus sicyoides	fr	r	fr	o
Rhynchosia reticulata	fr	o	—	—
Tragia volubilis	r	—	—	—

Bignonia unguis-cati	o	o	o	o
Lasiacis harrisii	o	—	—	—
Tournefortia volubilis	o	—	—	—
Cereus trigonus	—	o	r	r
Ipomoea muricata	—	—	—	r

In the ground layer only a few specimens of *Commelina virginica, Siphonoglossa sessilis, Ruellia tuberosa,* and some grasses are seen, together with a number of *Opuntia triacantha.* As the area is used for grazing land herbs are practically absent and regeneration does not take place.

Outside these plots only three other species were seen: *Crescentia cujete, Trema lima,* and *Capparis cynophallophora.*

Hill north-west of Zeelandia [9]. Altitude: 35 m above sea-level. Slope: north-east, gradient: 40 degrees.

In a strip 80 × 5 m, the following record was obtained.

Trees and high shrubs:

Pisonia aculeata	27 (18.1%)	*Pisonia fragrans*	4 (2.7%)
Capparis cynophallophora	22 (14.8%)	*Pisonia subcordata*	4 (2.7%)
Randia aculeata	21 (14.1%)	*Tamarindus indica*	3 (2.0%)
Malpighia punicifolia	14 (9.4%)	*Leucaena glauca*	3 (2.0%)
Capparis flexuosa		*Celtis iguanaea*	3 (2.0%)
(partly climbing)	13 (8.7%)	*Piscidia piscipula*	1 (0.7%)
Rauwolfia lamarckii	12 (8.1%)	*Melicocca bijuga*	1 (0.7%)
Acacia macracantha	8 (5.4%)	*Comocladia ilicifolia*	1 (0.7%)
Acacia tortuosa	6 (4.0%)	*Bursera simaruba*	1 (0.7%)
Pithecellobium unguis-cati	5 (3.4%)		

Shrubs: *Croton astroites* (fr), *Melochia tomentosa* (o).
Herbs and undershrubs: *Pedilanthus tithymaloides* (fr), *Rivina humilis* (r).
Vine: *Cissus sicyoides* (fr).

In the undergrowth, many *Opuntia triacantha* and some *Plumbago scandens* occur. In the higher parts, many *Cephalocereus* occur, in addition to the above-mentioned two species. On the patches of rock *Oncidium variegatum* and *Pitcairnia latifolia* are found. Relics of grasses were seen, but it appeared to be impossible to identify them. This bush reaches a height of 3½—4 m, overtopped by some trees such as *Bursera* and *Tamarindus.* Outside this strip, the following species were recorded: *Morisonia americana, Citharexylum spinosum, Jatropha gossypifolia, Bignonia unguis-cati, Triphasia trifoliata, Erythroxylon havanense, Myrcia citrifolia* and *Wedelia jacquinii.*

North of the above-mentioned strip the vegetation becomes less tall, whilst *Randia aculeata* and *Capparis cynophallophora* decrease in number. An increase in the number of the following species takes place: *Leucaena glauca, Malpighia punicifolia, Piscidia piscipula,* and *Pedilanthus tithymaloides.*

North-west of Gilboa Hill [10]. Altitude: about 140 m. Nearly flat.

Two plots 400 sq.m in area were enumerated.

Trees and high shrubs:

Malpighia punicifolia	42 (28.8%)	26 (21.8%)
Leucaena glauca	34 (23.3%)	23 (19.3%)
Trema lima	29 (19.9%)	36 (30.3%)
Capparis indica	11 (7.5%)	5 (4.2%)
Randia aculeata	11 (7.5%)	7 (5.9%)
Tabebuia pallida	8 (5.5%)	4 (3.4%)
Acacia farnesiana	6 (4.1%)	9 (7.6%)
Pithecellobium unguis-cati	5 (3.4%)	— —
Pisonia fragrans	— —	5 (4.2%)
Capparis flexuosa	— —	4 (3.4%)

The undergrowth is formed by only a few specimens of *Solanum racemosum* and

Myrcia splendens. The ground is densely covered by *Opuntia triacantha*. A few (more or less climbing) shrubs occur: *Pisonia aculeata* and *Tournefortia volubilis*.

On places more exposed to the wind a low shrub vegetation is found, in which *Croton flavens, C. astroites* and *Randia aculeata* dominate, whilst *Melochia, Opuntia, Melocactus, Pedilanthus, Krameria ixina* and *Cephalocereus* occur frequently. Scattered small trees are present: *Capparis indica, Acacia farnesiana, A. tortuosa, Malpighia punicifolia*, and *Citharexylum spinosum*. Among the herbs *Commelina virginica, Boerhavia, Plumbago scandens, Panicum adspersum, Setaria setosa*, and *Digitaria insularis* were noted.

Near Bomba Hill [11] a low, open vegetation was found, 70% of which consisted of *Croton flavens* and *C. astroites*, reaching a height of 75 cm: Croton thicket [XV]. In this layer *Lantana involucrata, Evolvulus sericeus* and many *Opuntia* occur. Scattered small trees and high shrubs are also present: *Acacia farnesiana, A. tortuosa, Malpighia punicifolia, Pisonia subcordata, Annona montana* and *Cephalocereus*. Herbs and undershrubs: *Borreria ocimifolia, Boerhavia* and some grasses. *Agave sisalana* and *Aloe vera* are remnants of former cultivation.

Little Mountains [12]. Altitude: 160 m above sea-level. Big stones are to be found everywhere.

In a plot of 600 sq.m the ground cover amounts to about 80%. The shrub layer reaches a height of 1¾—2 m and is overtopped by 19 trees:

Pisonia subcordata	8	*Pisonia fragrans*	4
Tabebuia pallida	4	*Bursera simaruba*	3

In the shrub layer *Croton flavens* is the most prominent species, covering 30% of the surface, whilst *Acacia farnesiana* is also very abundant, occupying 20—25% of the surface. *Randia aculeata, Pithecellobium unguis-cati*, and *Lantana involucrata* are very frequent, taking up 10, 5 and 5% respectively. Small shrubs of *Krameria ixina* are generally distributed, whereas *Wedelia jacquinii* and *Capparis flexuosa* are scarce. A few specimens of *Acacia tortuosa, Coccoloba uvifera* and *Leucaena glauca* are present. *Opuntia dillenii*, about 80 cm high, occurs in small groups, whilst *Opuntia triacantha* covers the ground in more open places. A few specimens of *Cephalocereus* were noted.

The ground layer is formed by a few scattered specimens of *Borreria podocephala, Bouteloua heterostega, Sida ciliaris, S. cordifolia* var. *althaeifolia, Siphonoglossa sessilis, Rauwolfia lamarckii*, and *Waltheria americana*. Climbers and vines: *Desmodium canum, Alysicarpus vaginalis*, and *Rhynchosia reticulata*. The epiphyte *Tillandsia utriculata* is present and the parasitic vine *Cuscuta americana* occurs frequently. No other species were collected here.

Mary Glory [13]. Altitude: 125—140 m above sea-level. Slope: south-east, gradient: less than 5 degrees.

Three plots 40 × 5 m were enumerated.

Bursera simaruba	16 (28.1%)	— —	— —
Randia aculeata	13 (22.8%)	11 (44.0%)	— —
Pisonia subcordata	11 (19.3%)	9 (36.0%)	9 (33.3%)
Capparis indica	5 (8.8%)	— —	2 (7.4%)
Cephalocereus	4 (7.0%)	— —	— —
Annona muricata	3 (5.3%)	— —	— —
Malpighia punicifolia	3 (5.3%)	— —	7 (25.9%)
Bourreria succulenta	2 (3.5%)	— —	— —
Rauwolfia lamarckii	— —	3 (12.0%)	— —
Pisonia fragrans	— —	2 (8.0%)	3 (11.1%)
Capparis flexuosa	— —	— —	3 (11.1%)
Acacia farnesiana	— —	— —	2 (7.5%)
Acacia tortuosa	— —	— —	1 (3.7%)

The undergrowth in the first plot consists of many *Cassia occidentalis*, while *Randia*

aculeata is frequent, especially on the more open places, together with *Lantana involucrata* and *Croton astroites*. *Pithecellobium unguis-cati, Solanum racemosum* and *Opuntia dillenii* are present, but only in small quantities. *Pedilanthus tithymaloides* is abundant. Herbs are absent. A few specimens of the epiphytes *Tillandsia utriculata* and *T. recurvata* and the semi-parasite *Phoradendron trinervium* occur.

In the second plot *Croton astroites* is very abundant, forming about 40% of the whole, whilst 20% is composed by *Randia aculeata. Lantana involucrata* is frequent. *Pithecellobium unguis-cati, Comocladia ilicifolia,* and *Opuntia* are rare. Only a few herbs are present: *Sida cordifolia* var. *althaeifolia, Paspalum laxum* and *Leptochloa domingensis.*

In the third plot *Croton flavens* and *C. astroites* make up about 40% of the whole, while *Lantana involucrata* accounts for 20%. *Randia aculeata* is frequent. The following species are present, but only in the form of a few specimens: *Pithecellobium unguis-cati, Pedilanthus tithymaloides, Rauwolfia lamarckii, Opuntia dillenii, O. triacantha, Melochia pyramidata* and *Waltheria americana.*

Outside these plots *Tabebuia pallida, Leucaena glauca* and *Clerodendron aculeatum* were noted.

At a somewhat lower altitude in the vicinity (80—90 m above sea-level) a secondary vegetation occurs in which the taller trees (up to 8 m) play an important role. However, the majority of these trees are of the *Melicocca bijuga* species. From the frequent traces of charcoal-burning encountered here it is easy to see that the area is still strongly under the influence of human activity. The following species were enumerated in eight plots 20 × 10 metres in area.

Trees and shrubs 4—8 m high:

Melicocca bijuga	32	*Rhacoma crossopetalum*	12
Pisonia subcordata	31	*Annona squamosa*	9
Cephalocereus	23	*Capparis indica*	9
Malpighia punicifolia	18	*Acacia tortuosa*	8
Pisonia fragrans	13	*Piscidia piscipula*	7
Leucaena glauca	13	*Caesalpinia ciliata*	6

Shrubs, less than 3 m high:

Croton flavens and *C. astroites*	25—30%	*Pedilanthus tithymaloides*	o
Lantana involucrata	10—15%	*Melochia tomentosa*	o
Rauwolfia lamarckii	fr	*Pisonia subcordata*	o
Leucaena glauca	fr	*Solanum racemosum*	o
Capparis baducca	r	*Randia aculeata*	o
		Capparis flexuosa	o

Herbs: Only a few *Commelina virginica* and *Paspalum laxum.*
Climbers: *Cissus sicyoides, Capparis flexuosa, Desmodium canum, Abrus precatorius.* Scattered groups of *Opuntia dillenii* occur, on which some specimens of *Oncidium variegatum* may be found.

Climbing the north-western slope of The Quill above Glass Bottle [14], we first pass through a secondary vegetation, composed of *Acacia farnesiana* to an extent of over 50%. This thorny thicket reaches a height of about 4 m, some other species in it being somewhat higher.

At an altitude of 160 m (gradient: 10—15 degrees) a plot was marked out and enumerated.

Trees and high shrubs:

	Height	Nrs.		Height	Nrs.
Acacia farnesiana	3½—4 m	23	*Capparis indica*	3½ m	2
Leucaena glauca	3½ m	7	*Capparis flexuosa*	3½ m	1
Pisonia subcordata	3½—4 m	4	*Tamarindus indica*	5 m	1
Citharexylum spinosum	2—3½ m	3	Coll. No. 4036	4 m	2
Tabebuia pallida	4½—5½ m	3	Coll. No. 4038	6½ m	1

Shrubs under 3 m in height: *Croton flavens* (a), *Randia aculeata* (a), *Pisonia subcordata* (r), *Lantana involucrata* (r), *Croton astroites* (r), *Capparis flexuosa* (v.r), *Schoepfia schreberi* (o), Coll. No. 4038 (o).

Climbers and vines: *Tragia volubilis* (a), *Rhynchosia reticulata* (fr), *Tournefortia volubilis* (fr), *Heteropteryx purpurea* (r), *Bignonia unguis-cati* (r), *Stigmatophyllon periplocifolium* (r). Herbs are practically absent.

Above 275 m [15], a forest is found, but signs of recent fellings prove that there is human activity in the neighbourhood. At an altitude of 340 m, a plot 60 × 10 m was enumerated.

Dominant trees:

Ceiba pentandra	5	*Bursera simaruba*	3
Tabebuia pallida	5	*Spondias mombin*	2
Hymenaea courbaril	4		

Smaller trees, forming a nearly closed canopy:

Nectandra coriacea	31	*Pisonia subcordata*	5
Linociera caribaea	27	*Symplocos martinicensis*	3
Maytenus elliptica	11	*Annona muricata*	1
Pisonia fragrans	5		

Shrubs: *Tabernaemontana citrifolia, Coccoloba diversifolia, Mapourea undata, M. eustatiana, Myrcia citrifolia* and *Eugenia axillaris.*
Climbers: *Cissus sicyoides, Hyperbaena domingensis, Smilax coriacea.*
Ferns: *Polypodium phyllitidis* and *Dryopteris subtetragona.*
Herbs: *Pharus glaber, Lasiacis harrisii* and *Scleria lithosperma.*

Outside this plot the following species were collected: *Fagara martinicensis, Allophylus occidentalis, Byrsonima spicata,* and *Porophyllum ellipticum.*

Near the top of The Quill, at the lowest part of the rim [16], a dry evergreen forest [XVI] occurs. Even here the vegetation has been affected by human interference; traces of recent fellings are frequently found. Apart from the dominants, many of the trees do not exceed 5 cm in diameter, and they are often somewhat shrubby. The dominants are composed of only a few different species. The shrub layer often becomes very dense. There is practically no ground layer, whilst the numerous stones are usually covered by mosses and *Pilea.* The sedge *Scleria* and the grass *Pharus* occur regularly, whilst *Anthurium cordatum* is present on more open spots. As the slope is rather stony and steep it proved impossible to enumerate regularly shaped plots 10 × 10 m in area. Two strips were therefore enumerated, one 50 × 5 m and the other 80 × 5 m. The following list shows the results of enumerating these strips, covering a total area of 650 sq.m.

Dominants:

	Height	Nrs.		Height	Nrs.
Tabebuia pallida	8—9 m	10	*Bursera simaruba*	7 m	1
Inga laurina	8 m	6	*Ficus lentiginosa*	10 m	1
Spondias mombin	8—10 m	5			

Lower-story trees:

	Height	Nrs.		Height	Nrs.
Maytenus elliptica	3½—4½ m	30	*Pisonia fragrans*	5 m	4
Linociera caribaea	5 m	23	*White rose tree* (No. 3566)	4 m	4
Nectandra coriacea	4—6 m	21	*Ternstroemia pedunculariis*	5 m	3
Pisonia subcordata	4½ m	11	*Daphnopsis caribaea*	4—5 m	2
Capparis cynophallophora	3½—5 m	8	*Krugiodendron ferreum*	4½ m	1
Guettarda scabra	4½—6 m	5	*Casearia decandra*	3—4 m	1

Low trees and high shrubs:

	Height	Nrs.		Height	Nrs.
Myrcia citrifolia	2½—3 m	52	*Tabernaemontana citrifolia*	2½ m	5
Ardisia coriacea	2 m	17	*Eugenia ligustrina*	2 m	fr
Eugenia axillaris	2—2½ m	11	*Mapourea undata*	2 m	fr
Coccoloba diversifolia	2—2½ m	6			

Ferns: *Polypodium pectinatum, P. lycopodioides, P. phyllitidis.*
Herbs: *Scleria lithosperma, Lasiacis harrisii, Pilea semidentata, Peperomia obtusifolia, P. glabella, P. acuminata, Pharus glaber,* and *Anthurium cordatum.*
Epiphytes: *Epidendrum ciliare* and *Tillandsia utriculata.*
Climber: *Clusia alba.*

It is possible to cross the rim and descend into the crater of this former volcano. The bottom of the crater [17] is rather flat, but very stony, especially in the western part. It is covered by dense forest. However, this forest has also suffered as a result of human activity. At the beginning of this century the governor of the island, Mr. G. J. van Grol, tried to bring parts of the area under cultivation. Traces of this attempt are still present in the shape of *Coffea arabica* and *Theobroma cacao,* whilst some trees of *Mammea americana* also occur here.

Especially in the eastern part, the forest is homogeneous, but rather open. Three tree stories can be distinguished, besides a shrub, sub-shrub and ground layer. The dominants form a very open discontinuous stratum, consisting of a few widely scattered trees. The middle-story and under-story trees do not form a closed canopy. The shrub layer is open and it is very easy to walk through it.

The height of the trees was gauged by visual estimation, but the stem-thickness was measured at breast height, i.e. about 1½ m above the ground. Two plots, one 40 × 10 m and the other 50 × 10 m, were enumerated in the eastern part of the crater floor. The combined results are given below.

Dominants 30—40 m:			
Pisonia fragrans	2	*Ceiba pentandra*	1
Spondias mombin	2		
Middle-story trees 13—27 m:			
Inga laurina	13	*Linociera caribaea*	1
Nectandra coriacea	6	*Pisonia fragrans*	1
Spondias mombin	3	*Pisonia subcordata*	1
Cecropia peltata	3	*Ficus urbaniana*	1
Symplocos martinicensis	3	*Phoebe elongata*	1
Myrcia citrifolia	2	*Ficus krugiana*	1
Nectandra krugii	2	Coll. No. 3661	3
Citharexylum spinosum	1		
Under-story trees 5—13 m:			
Nectandra coriacea	14	*Nectandra krugii*	2
Inga laurina	11	Coll. No. 3656	2
Myrcia citrifolia	10	*Cecropia peltata*	1
Coccoloba diversifolia	10	*Pisonia fragrans*	1
Hirtella triandra	2	*Ficus krugiana*	1
Chrysophyllum argenteum	2	*Quararibea turbinata*	1
Daphnopsis caribaea	2	*Myrcia splendens*	1
Shrubs:			
Piper reticulatum	8	*Samyda dodecandra*	3
Coccoloba diversifolia	7	*Tournefortia filiflora*	1
Piper dilatatum	5	*Coccoloba venosa*	1
Trichostigma octandrum	4	*Faramea occidentalis*	1
Nectandra coriacea	3		

Lianas: *Ficus krugiana, Gouania lupuloides, Smilax coriacea* and *Hyperbaena domingensis.*

Ground layer: *Pharus glaber, Asplenium cristatum, Lasiacis harrisii, Bolbitis cladorrhizaus* and *Polypodium pectinatum.*

In the southern part of the crater floor another plot was enumerated, covering 50 × 10 m.

Dominants 30—40 m:

Ceiba pentandra	2	*Phoebe elongata*	1

Middle-story trees 13—27 m:

Cecropia peltata	6	*Spondias mombin*	2
Linociera caribaea	3	*Pisonia fragrans*	1

Lower-story trees 5—12 m:

Chrysophyllum argenteum	4	*Hirtella triandra*	2
Quararibea turbinata	3	*Nectandra coriacea*	2
Theobroma cacao	3	*Inga laurina*	1

The shrub layer is very dense, but varies rather strongly in density from point to point. The following species were not uncommon: *Casearia decandra, Faramea occidentalis, Mapourea undata, Myrcia splendens, Palicourea domingensis, Piper reticulatum, P. dilatatum, Pisonia aculeata, Samyda dodecandra, Tournefortia filiflora,* and *Urera caracasana.*

Ferns are abundant in the ground layer: *Asplenium serratum, A. cristatum, Bolbitis cladorrhizaus, Dryopteris meridionalis, Polypodium phyllitidis, P. pectinatum,* and *Tectaria incisa.* The following herbs were noted: *Anthurium cordatum, Begonia retusa, Oplismenus setarius* and *Pharus glaber.*

Lianas and climbers: *Bignonia unguis-cati, Cissus sicyoides, Hyperbaena domingensis, Peperomia serpens, Philodendron dispar, P. oxycardium, Pisonia aculeata,* and *Smilax coriacea.*

The western part of the crater of The Quill is more open as regards the tree stories, whereas the shrub layer is much denser. Besides the species mentioned as occurring in the preceding plot, the shrub layer here includes *Celtis iguanaea,* many *Peperomia* and *Mapourea. Heliconia bihai* is present in great numbers. A few fallen trees are found and regeneration has started. Here, in particular, clans of *Heliconia bihai* occur, and some other typical species of the pioneers of the forest gaps are present: *Cecropia peltata, Cestrum laurifolium,* and *Miconia.* The saprophytes are represented by *Leiphaimos aphylla,* which occurs on the fallen trees. The stones and rocks are covered by mosses and ferns.

The slope of The Quill above Bengalen [18] was formerly cultivated. The gradient of the slope amounts to 5—10 degrees. Big stones are present. At an altitude of 170 m two plots, each 20 × 10 m in size, were enumerated:

Leucaena glauca	5	—	*Pisonia subcordata*	1	5
Hura crepitans	4	1	*Allophylus occidentalis*	—	4
Melicocca bijuga	2	—	*Myrcia citrifolia*	—	2
Tabebuia pallida	2	1	*Capparis cynophallophora*	—	1
Pisonia fragrans	2	4	*Annona squamosa*	—	1
Nectandra coriacea	2	1			

Shrubs: *Eugenia ligustrina* (a), *Capparis baducca* (fr), *Triphasia trifoliata* (fr), *Mapourea undata* (fr), *Celtis iguanaea* (r), *Chiococca racemosa* (r), *Pisonia fragrans* (o), *Melicocca bijuga* (o), *Randia aculeata* (o).

Climbers and vines: *Bignonia unguis-cati, Cissus sicyoides, Hyperbaena domingensis, Rhynchosia reticulata,* and *Tragia volubilis.*

Another plot, 50 × 10 m, was enumerated.

Trees 4—8 m high:

Nectandra coriacea	16	*Melicocca bijuga*	4
Pisonia subcordata	14	*Bursera simaruba*	3
Pisonia fragrans	11	*Tabebuia pallida*	3
Nectandra krugii	5	*Inga laurina*	2
Capparis cynophallophora	5	*Allophylus occidentalis*	1
Citharexylum spinosum	4	*Anacardium occidentale*	1

Shrubs:

Eugenia ligustrina	fr	*Tabernaemontana citrifolia*	r
Erythroxylon havanense	fr	*Capparis baducca*	o
Cassia bicapsularis	fr	*Casearia decandra*	o
Mapourea undata	r	*Linociera caribaea*	o
Annona squamosa	r	*Nectandra coriacea*	o
Eugenia jambos	o		

Climbers and vines: *Bignonia unguis-cati, Abrus precatorius, Cissus sicyoides, Smilax coriacea,* and *Tragia volubilis.*
Undershrubs: *Croton flavens, Lantana camera, Rivina humilis.*
Herbs: *Commelina virginica, Desmodium supinum, Pharus glaber,* and *Triumfetta barteriana.*

The lower part of The Quill, south of these plots, i.e. between Behind the Mountain and Soldiers Gut [19], is covered by thorny woodland, in which *Acacia* dominates, associated with species of the dry vegetation types: *Capparis indica, Randia aculeata, Capparis baducca, C. flexuosa, Croton flavens, Lantana involucrata, Opuntia, Melochia tomentosa,* etc.

In the higher parts [20], a forest is found which corresponds physiognomically with Beard's montane thicket. There is a closed stratum, the trees in which are 12—15 m high and long-stemmed. Only an occasional scattered small tree or high shrub occurs. Gradient of the slope amounts to about 35—40 degrees. In a plot 40 × 10 m the following species were recorded:

Pisonia fragrans	8	*Cordia sulcata*	2
Myrcia citrifolia	5	*Nectandra coriacea*	2
Citharexylum spinosum	3	*Symplocos martinicensis*	1
Linociera caribaea	3	*Allophylus occidentalis*	1
Tabebuia pallida	3	*Trema micranthum*	1
Byrsonima martinicensis	2	*Inga laurina*	1

Among the occasional low trees and high shrubs *Eugenia axillaris, Myrcia splendens, Mapourea undata, M. eustatiana* and *Piper dilatatum* occur.
The ground layer is usually densely covered with *Anthurium cordatum* and *Begonia retusa. Peperomia glabella* and *Pilea semidentata* frequently occur, growing mainly on the big stones. *Scleria lithosperma* is often seen.
Climbing Araceae are scarce, and an occasional orchid is found.

At the rim on this eastern side of The Quill [21] a rather open vegetation occurs in which *Clusia alba* is the most frequent species, followed in degree of abundance by *Ardisia coriacea, Ternstroemia peduncularis* and *Myrcia citrifolia.* Other species occur: *Tabebuia pallida, Nectandra coriacea, Inga laurina* and *Eugenia axillaris.* The stones are overgrown with mosses, *Anthurium cordatum, Pitcairnia latifolia* and some ferns.

The lower parts of the western slope of The Quill [22] are covered by a thorny woodland [XIII], 3—4 m high, overtopped by some *Bursera simaruba, Delonix regia, Pisonia subcordata,* etc. Several parts of this western slope are used as grazing land or are under cultivation.

At an altitude of about 220 m a plot 40 × 10 m was enumerated. The trees are generally less than 6 m high and the stems are rather thin. *Pisonia subcordata* is the dominant species, forming about 60% of the total. The shrub layer is sometimes very dense. Herbs are absent, except for an occasional grass.

Trees:

Pisonia subcordata	37	*Citharexylum spinosum*	3
Piscidia piscipula	9	*Coccoloba venosa*	3
Linociera caribaea	7	*Spondias mombin*	2
Tabebuia pallida	6	*Allophylus occidentalis*	1
Bursera simaruba	4	*Capparis cynophallophora*	1

Shrubs:

Eugenia ligustrina	a	*Wedelia jacquinii*	fr
Maytenus elliptica	a	*Mapourea undata*	fr
Chrysobalanus icaco	a	*Eugenia axillaris*	fr
Guettarda scabra	fr	*Comocladia ilicifolia*	fr
Casearia decandra	fr	*Randia aculeata*	fr
Erythroxylon havanense	fr	*Byrsonima crassifolia*	r

Climbers and vines: *Cissus sicyoides, Bignonia unguis-cati, Abrus precatorius,* and *Tournefortia volubilis.*
Epiphytes: *Tillandsia utriculata* and *T. recurvata.*
Semi-parasite: *Phoradendron trinervium.*
Herbs and undershrubs: *Scleria lithosperma, Bastardia viscosa, Desmodium canum.* In several places *Leucaena glauca* occurs in great numbers. It is probable that this part of the slope of The Quill was formerly under cultivation, at any rate very largely.

Higher up the following species become more prominent: *Pisonia fragrans, Linociera caribaea, Inga laurina, Tabebuia pallida, Citharexylum spinosum, Hymenaea courbaril, Trema micranthum,* and *Nectandra.* The shrub layer is more open, and an occasional *Begonia* or *Peperomia* is seen.

At an altitude of 450 m, near the rim of the crater, a layer of trees, 4—5 m high, overtopped by a few larger ones, is found again. The shrub layer is well represented, and consists mainly of Myrtaceae. Ferns are abundant, climbers and lianas are very small in number.
Dominants: *Ficus krugiana, Inga laurina, Lonchocarpus violaceus,* and *Hymenaea courbaril.*
Smaller trees: *Pisonia fragrans, Ternstroemia peduncularis, Coccoloba diversifolia, Nectandra coriacea, Daphnopsis caribaea, Pisonia subcordata, Linociera caribaea, Amomis caryophyllata,* and *Guettarda scabra.*
Shrubs: *Ardisia coriacea, Myrcia splendens, Myrcia citrifolia, Byrsonima crassifolia, Tabernaemontana citrifolia, Fagara trifoliata, Eugenia ligustrina, Piper reticulatum, Cassia occidentalis,* and *Mapourea undata.*
Climbers and vines: *Philodendron dispar, Passiflora laurifolia, Smilax coriacea.*
Ferns: *Polypodium pectinatum, P. lycopodioides, P. triseriale, P. phyllitidis, Elaphoglossum martinicense, E. petiolatum, Vittaria lineata.*
Herbs: *Pilea semidentata, Scleria lithosperma, Pharus glaber, Vernonia longifolia, Peperomia glabella, P. acuminata, P. obtusifolia.*
Epiphytes: *Catopsis nutans, Epidendrum ciliare,* and *E. difforme.*

At the highest point on the rim [23], elfin woodland [IX] is found. The gnarled trees reach a height of about 4 metres and are laden with epiphytic mosses. Among the angiosperms *Tillandsia usneoides, T. utriculata* and *T. recurvata* are the most important species. The elfin woodland consists almost entirely of *Clusia alba,* between which some *Ternstroemia peduncularis* and *Myrcia citrifolia* are seen. In the ground layer an occasional *Heliconia bihai* occurs, whilst *Begonia retusa, Peperomia acuminata,* and *P. glabella* are frequent. *Epidendrum ciliare* and *Stenorhynchus* are the epiphytic orchids. Only a few ferns were collected: *Polypodium phyllitidis, P. pectinatum,* and *Elaphoglossum martinicense.* There are few shrubs present: *Besleria lutea, Gesneria ventricosa,* and *Miconia impetiolaris.*

On White Wall [24], about 250—300 m above sea-level, the woodland is more xerophytic. It consists of 4-m high, often shrubby trees: *Trema lima, Rhacoma crossopetalum, Bursera simaruba, Pisonia subcordata,* and *Piscidia piscipula.* In this more or less closed thicket the following species are present: *Pithecellobium unguis-cati* (a), *Randia aculeata* (a), *Capparis indica* (fr), *Samyda dodecandra* (fr), *Eugenia axillaris* (fr), *Dipholis salicifolia* (fr), *Guettarda scabra* (fr), *Coccoloba diversifolia* (r), *Celtis iguanaea* (r), *Jacquinia barbasco* (r), *Rauwolfia lamarckii* (r).
The lower shrubs include: *Wedelia jacquinii, Croton flavens, Turnera ulmifolia, Ernodea littoralis, Myrcia citrifolia, Euphorbia articulata, Krameria ixina, Solanum racemosum,* and *Dodonaea viscosa.*
Herbs and undershrubs: *Waltheria americana, Borreria podocephala, Heliotropium angiospermum, Pappophorum pappiferum, Stylosanthes hamata.*
Climbers: *Galactia dubia, Bignonia unguis-cati,* and *Tournefortia volubilis.*
Epiphyte: *Tillandsia recurvata.*
This vegetation represents the dry evergreen bushland [XVIII].

It can be said that the following types of vegetation occur in the island of St. Eustatius:

CLIMATIC COMMUNITIES
Optimal formation
Pioneer forest
Montane formations
Montane thicket
Elfin woodland
Seasonal formations
Evergreen seasonal forest
Semi-evergreen seasonal forest
Deciduous seasonal forest
Thorny woodland
Leucaena thicket
Croton thickets
Dry evergreen formations
Dry evergreen forest
Evergreen bushland
Thorny woodland
Croton thickets
Littoral woodland
Vegetation of the rock pavement
Vegetation of rocky slopes
EDAPHIC COMMUNITIES
Strand scrub community
Hippomane woodland

CHAPTER VIII

DESCRIPTION OF COMMUNITIES

INTRODUCTION

The plant communities of the islands of the Windward Group are predominantly determined by climatic factors. Beard proposed a classification of the plant communities in the Windward and Leeward Islands (1944, 1949), which has also been accepted by the present author, except for a few alterations. The following communities may be distinguished in the islands of St. Maarten, Saba, and St. Eustatius.

PRIMARY CLIMAX COMMUNITIES	SECONDARY AND SUB-CLIMAX COMMUNITIES
CLIMATIC CLIMAX COMMUNITIES	
Optimal formation	
Rain forest [I]	
	Secondary rain forest [II]
	Tree fern brake [III]
	Miconia thickets [IV]
	Piper dilatatum thicket [V]
	Pioneer forest [VI]
Montane formations	
Montane thicket [VII]	Palm brake [VIII]
Elfin woodland [IX]	
Seasonal formations	
Evergreen seasonal forest [X]	
Semi-evergreen seasonal forest [XI]	
Deciduous seasonal forest [XII]	Thorny woodland [XIII]
	Leucaena thicket [XIV]
	Croton thickets [XV]
Dry evergreen formations	
Dry evergreen forest [XVI]	Woodland derived from dry evergreen forest [XVII]
Evergreen bushland [XVIII]	Thorny woodland [XIX]
	Croton thickets [XX]
Littoral woodland [XXI]	Vegetation of the rock pavement [XXII]
	Vegetation of rocky slopes [XXIII]
EDAPHIC CLIMAX FORMATIONS	
Mangrove woodland [XXIV]	
Herbaceous strand community [XXV]	
Strand scrub community [XXVI]	
Vegetation of salt flats [XXVII]	
Hippomane woodlands [XXVIII]	

In his publication of 1944, Beard proposed to name the six seasonal formations: evergreen seasonal forest — semi-evergreen seasonal forest —

deciduous seasonal forest — thorn woodland — cactus scrub and desert. He divided the montane formations into: lower montane rain forest — montane or temperate rain forest — palm brake — elfin woodland — frost woodland — mountain pine-forest — bamboo brake — páramo and tundra. The marsh or seasonal swamp formations were divided into: marsh forest — marsh woodland — palm marsh and savanna.

Beard thus distinguishes an optimal formation "where every condition for plant growth is as ideal as it can be in the tropics" and formation series "within which are structures and life-forms expressing every degree of transition from the optimum to extreme adversity". Each formation series comprises units arranged with regard to moisture relations. In the seasonal formations Beard distinguishes (1944) evergreen seasonal forest — semi-evergreen seasonal forest — deciduous seasonal forest — thorn woodland — cactus scrub and desert. Here the characteristic of the habitat is seasonal drought.

The mangrove and swamp forests occur round the coasts, along river banks and estuaries, or in tidal lagoons and salt ponds, as they are associated with high water-tables, due to low relief. In the case of the mangrove woodland the soil water is brackish, but it is fresh in the case of the swamp forest. The savanna is associated with an intermittent perched water-table due to low relief and special soil conditions.

Of the edaphic climax formations the mangrove woodland is the only one present in the islands of the Windward Group which is considered in this work.

The zonation of plant communities can be shown ideally on high volcanic islands. The starting-point of Beard's classification is rain forest, occurring in places where "the annual drought ceases to be effective and there is an abundant moisture supply all the year round". The area below this zone is under the influence of a relatively dry climate, resulting in a vegetation represented by either dry evergreen or seasonal forests, while immediately along the coastal margin lies a narrow and restricted zone under the influence of the salt-laden sea wind, which is desiccating and mechanically destructive. This leads to a dry evergreen woodland. Although precipitation continues to increase, and moisture is always in copious supply above the level of the rain forest, this forest does not continue to the mountain top. It gives way to a series of montane formations in which growth is again progressively reduced in stature and forms. These montane formations consist of lower montane rain forest, montane thicket and elfin woodland, or their secondary or sub-climax communities.

Some additions and corrections to this system are made by Asprey & Robbins (1953). They regard the evergreen seasonal forest (corresponding to the wet limestone forest of Jamaica) and lower montane rain forest as a faciation of typical rain forest. The cactus-thorn scrub is considered by Asprey & Robbins to be a faciation of thorn scrub,

and Beard's montane rain forest is classified by the two first-named authors as montane mist forest, whilst they regard the elfin woodland as an open, stunted faciation of mist forest.

CLASSIFICATION

The present author will distinguish the following communities, existing in the islands of St. Martin, Saba, and St. Eustatius.

CLIMATIC CLIMAX COMMUNITIES

Optimal formation

Rain forest [I]

The real rain forest, as known from the larger islands of the Antilles, does not exist here. It is possible that it was present in former times, but in that case only to a small extent, and restricted to Saba. However, in the deep ravines of Saba there is a type of vegetation which may be called "ravine rain forest", and which exhibits a physiognomical resemblance to the "Bergkloven-regenbos" of Surinam, as Professor J. Lanjouw orally informed me. *Myrcia citrifolia* is the most abundant species, reaching a height of 8—10 m. Associated are *Sloanea truncata,* 6 m high, and an unidentified species of *Drypetes,* 5—7 m high, whilst *Psychotria berteriana,* often somewhat shrubby, is abundant and generally 6 m high. Tree-ferns are abundant and *Euterpe globosa* occurs, but only in rather small quantities. The climbing Araceae *Philodendron dispar* and *P. oxycardium* are abundant, and *Marcgravia umbellata* is frequent. Stems and leaves are generally covered with Hepaticae. The shrub layer is rather open, and some shrubs of *Charianthus crinitus* are found. Ferns are abundant; they include *Blechnum occidentale, Nephrolepis rivularis, Polybotrya cervina, Tectaria trifoliata, Lonchitis hirsuta,* whilst *Selaginella flabellata* is very frequent. In the ground layer some scattered groups of *Heliconia bihai* are to be seen. Only one epiphyte was collected: *Tillandsia utriculata.*

Leaves are mesophyllous in size and all trees, at least as far as could be seen, are evergreen. Buttressing is absent, as well as stilt roots. This type of forest has not been mentioned as occurring in the Windward or Leeward Islands.

It has been described as occurring in Saba [5]. This forest has been classified within the rain forest communities, and here it is proposed to name this community the Myrcia-Sloanea type.

Secondary rain forest [II]

The greater part of Saba, roughly between the 500 and 600 m contour lines, was probably covered by rain forest in former times. Nowadays, as a rule, thickets of young trees are found here, rather variable in height from point to point. It is still possible frequently to come across species which were undoubtedly planted originally by human hands: *Citrus,*

Persea americana, Annona spp., *Artocarpus incisa, Coffea arabica, Theobroma cacao, Psidium guajava* and *Mammea americana.* The thickets are often very shrubby, forming a dense bush. The following species were noted, among others, in this area: *Symplocos martinicensis, Cordia sulcata, Nectandra coriacea, N. krugii, Clusia alba, Linociera caribaea, Citharexylum spinosum, Tabernaemontana citrifolia, Myrcia citrifolia, Fagara martinicensis, Hirtella triandra, Inga laurina, Myrcia splendens, Miconia laevigata, Mapourea undata.* Ferns are often abundant, and *Anthurium cordatum* is often frequently found in the ground layer. This secondary rain forest seems to resemble very closely that of Montserrat (Beard 1949, p. 105). It has been described as occurring in Saba [4].

Tree-fern brake [III]

This secondary community is known from Saba, where it forms a dense grove, 4 m high, of the tree-ferns *Cyathea arborea* and *C. antillana.* It follows the destruction of the rain forest by human activity as well as by fire. However, the latter is usually also caused by human activity. Although it is impossible to be certain on this point, it seems that this tree-fern brake occurs only in places which are usually hidden in the cloud cap. Anyhow, an abundant supply of moisture is a necessary condition of its growth. No trace of a shrub or ground layer is present, owing to lack of light.

These groves of *Cyathea* and *Hemitelia* are known from Dominica and St. Lucia, where they are found on poorly-drained soils. In St. Vincent and Grenada they seem to be rare (Beard 1949). They are described by Stehlé as occurring on Martinique (1938).

The community has been described as occurring in Saba [3].

Miconia thickets [IV]

These thickets occur at a somewhat lower altitude than those of the preceding type, and not as a belt along The Mountain, but more patchwise, on the slope, between 450 and 600 metres. *Miconia laevigata* and *Tetrazygia discolor* are the prominent species. Usually they form dense pure groves, but sometimes they are intermixed with *Besleria lutea, Gesneria ventricosa* or species mentioned as occurring in the secondary rain forest. Further investigation of the relation: rain forest — tree-fern brake and rain forest — Miconia thicket is necessary. These Miconia thickets are also known from Dominica, where *M. guianensis* plays a similar role, and from St. Lucia, where the species concerned is also *M. guianensis.* Stehlé (1938) mentions it from Martinique, in which *M. guianensis* and *M. trichotoma* are the most important species, accompanied by *M. furfuracea, Tetrazygia discolor, Conostegia calyptrata, Faramea occidentalis, Palicourea crocea, Symplocos martinicensis,* etc. He mentions it as occurring in Guadeloupe, near Bellevue, where *Miconia guianensis* and *M. laevigata* are associated with *Eugenia,* in ratios of 73%: 15% respectively, and near Desbonnes where these *Miconia* species

are associated with *Phoebe elongata* in ratios of 70%: 15%. *Inga ingoides* is present here. In St. Vincent and Grenada Miconia thickets are rarely seen. These thickets have been described as occurring in Saba [4].

Piper dilatatum thicket [V]

This community was seen between The Bottom and Saddle [11], forming a rather dense grove as a shrub layer between trees (mainly *Mammea americana*). It forms bush up to 2½ m high, in which *Piper reticulatum* is frequently encountered. It has been badly affected by human interference, as the wood is used for charcoal-burning.

The community is called by Stehlé "Taillis à Piper dilatatum" (Stehlé 1938, p. 243) in the case of Martinique, where *Piper dilatatum* is associated with *Piper medium, P. macrophyllum* and *Potomorphe peltata,* together with some other non-Piperaceae species.

Pioneer forest [VI]

This type occurs in the form of local patches composed of the species *Cecropia peltata, Acnistus arborescens, Heliconia bihai, Symplocos martinicensis* and some Lauraceae, along the slope of The Mountain in Saba [2], and in the crater of The Quill in St. Eustatius [17], in which latter location it occurs not in a rain forest but in a community that belongs rather to the evergreen seasonal forest. This type is frequently met with in the islands of the Antilles as well as in rain forests on the South American continent.

The vegetation types of the montane formations occurring in the islands are montane thicket in St. Eustatius; the sub-climax community palm brake in Saba; and elfin woodland in both Saba and St. Eustatius.

Montane formations

Montane thicket [VII]

This vegetation type was postulated by Beard in the Spanish edition of his "Climax vegetation in tropical America" (1946). The type in St. Eustatius agrees with the "steep windward slope-phase", as described by Beard from Grenada (1949). The forest is one-storied, and a shrub or sub-shrub layer is absent, although an occasional shrub may occur. Typical of this phase is the dense herbaceous ground-cover, replacing the woody undergrowth, formed by *Anthurium cordatum, Begonia retusa* and *Scleria lithosperma.* Piperaceae may frequently occur. Palms are not present, as they are absent altogether in St. Eustatius. Mosses are very abundant; the leaves are usually covered with epiphyllous hepatics. The trees are generally 12—15 m high, usually possessing small crowns, and are evergreen, except for *Tabebuia pallida.* The stems are slender, not exceeding 15 cm in diameter as a rule. *Pisonia fragrans* and *Myrcia citrifolia* are the predominant species here, whilst *Citharexylum spinosum,*

Linociera caribaea and *Tabebuia pallida* are very frequently to be seen. Climbers are scarce. As has already been said this type resembles the steep windward slope-phase of the montane thicket in Grenada, but floristically it differs very strongly, since there is possibly only one species (*Myrcia*) common to these two forests. (In Table XXI, p. 155 (1949), Beard includes all Myrtaceae species in one group: Myrtaceae spp.). In Grenada *Micropholis chrysophylloides* is dominant and forms 40% of the crop; the Myrtaceae group represents 19% of it, *Licania ternatensis* 11%, *Euterpe globosa* 9%, *Dacryodes excelsa* 5%, and *Richeria grandis* 4%. All these species are absent in St. Eustatius. Montane thicket is not known to be present in St. Kitts and St. Vincent, according to Beard (1949).

Palm brake [VIII]

Beard states that palm brake is a natural sub-climax community to montane thicket, replacing the latter on very steep slopes in geologically young areas. The soil is generally loose and liable to landslip. Stratification and canopy in the ordinary sense are absent. Height is very variable, the average height being perhaps about 13 metres, but stands 7 m or 20 m high are not unusual. The palm *Euterpe globosa* is characteristic and dominant. No shrub layer is present, but there is usually a very luxuriant herbaceous vegetation, in which ferns are dominant. Occasional patches of tree-ferns occur. The community occurs in the montane climate, with high, constant rainfall and humidity, on Yellow Earth and Lithosols.

This sub-climax community is known to be present in Saba, but is absent in St. Maarten and St. Eustatius. In Saba it occurs on the very steep slopes near the top of The Mountain [2], between 750 and 825 metres. *Euterpe globosa* is the dominant species and forms 50—75% of the crop.

Beard mentions this community as occurring in St. Kitts, between 400 and 600 m above sea-level. *Euterpe* is the dominant species, while 15% of the crop is contributed by *Cyathea arborea*. The remaining 25% is made up of small trees such as *Marila racemosa, Hedyosmum arborescens, Dacryodes excelsa,* Lauraceae and others. In Nevis, the top of the central mountain is covered by it above 550—700 metres. It appears to resemble the form found in St. Kitts. In Montserrat some additional species are present — *Hibiscus tulipiflorus* (endemic to the central Caribbees, and in many parts the most abundant tree), whilst *Richeria grandis* and *Sloanea dentata* are also found. As regards Dominica, Beard states that *Euterpe dominicana* is an important associate, whilst a number of species of the montane thicket and elfin woodland floras are also present. Hodge (1954), on the other hand, denies the existence of palm brake in Dominica, and classifies the area marked as palm brake on Beard's map as montane thicket and elfin woodland. On the leeward slope of Mt. Grand Magazin in St. Lucia a form of palm brake exists consisting

mainly of *Euterpe globosa,* with many Melastomes, *Tovomita* and *Hedyosmum* and occasional species of the rain forest flora.

In St. Vincent palm brake occurs above the 550 m contour line. *Euterpe globosa* is again the dominant species, whilst another *Euterpe* is also present. The flora consists of second-growth pioneers (*Freziera,* Lauraceae, *Miconia, Inga*). At the lower elevations rain forest species are commoner, and at high elevations elfin woodland species.

In Grenada, palm brake exists only in rather intimate relationship with elfin woodland. The landslides first become covered by mosses, which probably have the effect of stabilizing the soil. The next stage is a thicket of small tree-ferns (*Cyathea*) or *Heliconia bihai.* Still later the scar is colonized by *Euterpe globosa,* forming a patch of palm brake. The palms are usually stunted. Groves of *Euterpe globosa* occur in steep places on the Pitons du Carbet in Martinique, as well as on some of the windward slopes in Guadeloupe.

In Puerto Rico, the palm brake was described by Gleason & Cook as the "sierra palm forest", following the rain forest in the Luquillo Mountains above 600 metres. At this height the palm brake extends almost continuously round the mountain. Only a short distance above this altitude, the belt becomes cut into segments, a feature accentuated with increasing altitude, and the palms disappear completely not far below the higher summits. The palm brake is generally confined to the more sheltered sites, extending highest in the ravines and on the leeward sides of the peaks. The remainder of the highest parts of the peaks is covered by "mossy forest", a vegetation type similar to elfin woodland.

Asprey & Robbins (1953) mention a community that would seem to correspond to palm brake as occurring on the western slopes of the John Crow Mountains, but unfortunately it has not yet been investigated.

Elfin woodland [IX]

This type of vegetation occurs on the summits and the upper slopes of the highest peaks and ridges throughout the Caribbean islands. In agreement with Beard, it must be considered as a climatic climax formation. Asprey & Robbins (1953) regard the elfin woodland as an open, stunted faciation of mist forest. The latter corresponds with Beard's montane rain forest, and this seems to be a synonym for montane thicket — a term proposed in 1946. Elfin woodland is called "mossy forest" by Gleason & Cook.

Stehlé (1938) regards this type in Martinique as the "facies à *Clusia plukenetii* ou *Clusietum martinicense*" of "la sylve montagnarde". The latter is a forest of high altitudes, more or less stunted by strong winds, low temperature and high rainfall. It occurs on acid soils. On the other hand, Stehlé regards the Clusietum guadelupense as belonging to the "forêt de transition". The most important difference between these two

types is the fact that *Clusia plukenetii* is dominant in Martinique and *C. venosa* in Guadeloupe, apart from differences in associated species.

The formation is known in various forms throughout the tropics, and is variously called elfin woodland, cloud forest, mossy forest, mist forest and other names mentioned above. It usually occurs on peaks and ridges above 500 m; on slopes it is found only above 1,000—1,200 m.

Two types may be distinguished, one of them occurring in Saba, and the other at the highest point of the rim of The Quill, in St. Eustatius.

In Saba, at the top of The Mountain [1], the elfin woodland is dominated by *Freziera undulata* and *Rapanea ferruginea*. Here, it becomes impenetrable and stunted, especially on the more exposed sites. Tree-ferns are rather scarce, and *Euterpe* occurs only in the more open places. Several small spots are densely covered by *Anthurium cordatum* in the ground layer. There are many small climbers; *Philodendron* is particularly conspicuous. Epiphytes are abundant, most of them being mosses and ferns. Leaves are densely covered with epiphyllous hepatics.

The Statia type is dominated by *Clusia alba*, and may be considered as a consociation. Only a few other tree species are present, *Ternstroemia peduncularis* being the most prominent. Epiphytic orchids and ferns are less common. The ground layer is well developed; *Begonia* and Piperaceae are the most abundant species in it. Trees are extremely gnarled, and knee-shaped stilt roots are usually formed. The woodland does not exceed 5 m in height.

It is proposed to name the first type the Freziera-Rapanea association and the second the Clusia alba consociation.

In the Lesser Antilles the elfin woodland is usually of a mixed type, the typical species being present in nearly all the islands. Of the typical species enumerated by Beard (1949, p. 72), only a few are present in Saba and St. Eustatius. However, some of the species of elfin woodland also occur in the palm brake community.

Describing the elfin woodland in St. Kitts, Beard cites Box (1937): "Every limb of every tree is covered with tangled masses of sodden hanging mosses, aroids, orchids (*Ornithidium coccineum* is dominant among these), *Columnea hirsuta, Psychotria parasitica, Polypodium* spp. and filmy ferns; the beautiful *Utricularia montana* is not uncommon.... Where trees have fallen and rotted they are covered with a dense growth of the clambering fern (*Dicranopteris*), club-moss (*Lycopodium tortum*), mountain grass (*Isachne arundinacea*) or cutting sedges (*Scleria*). Herbaceous plants are abundant: among them may be mentioned *Lobelia* (*Tupa*) *cirsiifolia, Sauvagesia erecta, Viola stipularis, Galium hypsocarpum,* orchids (*Ponthieva petiolata, Malaxis spicata* and others), and the grasses *Paspalum nutans* and *P. conjugatum*". Elfin woodland, in St. Kitts, appears above 700 m, except on the upper part of Mount Misery, and reaches a height of about 4 metres.

In Nevis, it resembles the elfin woodland of St. Kitts and caps the summit of Nevis Mountain, but on parts of the old crater rim it gives way to the same páramo-like herbaceous growth as on the highest ground of St. Kitts (according to B e a r d).

In Dominica it appears on the upper slopes and the summits of the principal peaks. Height varies between 3 and 7 m. *Clusia venosa* forms 50% of the association, growing in large pure patches in a matrix of mixed growth, among which B e a r d mentions *Didymopanax attenuatum, Charianthus corymbosa, Freziera undulata, Hibiscus tulipiflorus, Euterpe globosa* and others.

In St. Lucia there is only one patch of elfin woodland — on top of the Gimie range. Floristically it corresponds with the preceding one, but *Clusia venosa* is not mentioned by B e a r d, and the same can be said of St. Vincent, while the elfin woodland in Grenada occurs only in rather intimate relationship with palm brake.

As has already been said the elfin woodland in Martinique is dominated by *Clusia plukenetii,* associated with *Oreopanax dussii, Miconia globulifera, Byrsonima martinicensis, Inga coruscans* and *Freziera undulata,* whereas in Guadeloupe *Clusia venosa* dominates, forming 65—90% of the crop, associated with *Cyrilla racemiflora, Myrcia microcarpa, Richeria grandis, Freziera undulata, Inga coruscans, Rapanea guianensis, Rondeletia stereocarpa* and *Didymopanax attenuatum.*

A s p r e y & R o b b i n s describe an elfin woodland in Jamaica, on the exposed summits and northern ridges of the Blue Mountains, above 1,700 m, where it reaches a height of 6—7 m; *Clethra alexandri* and *Clusia haretioides* are the dominant species there. A type dominated by *Clusia clarendonensis* is to be found on the wet limestone slopes of the John Crow Mountains. Several species are associated with this *Clusia* species.

The elfin woodland of Mt. Aripo in Trinidad is a consociation of *Clusia intertexta.* In Puerto Rico it occurs above 600 m on windward and exposed sites on the Luquillo Mountains, between the triangles of palm brake that occur in the more sheltered sites there. Though the species are nearly all different from those in the Lesser Antilles, physiognomically the type is homologous with the elfin woodland of these islands.

No sub-climax or secondary communities of this type are known to exist in the islands of St. Martin, Saba and St. Eustatius.

Seasonal formations

The seasonal formations occur in habitats where annual precipitation lies between 90 and 250 cm. The dry season may be not severe, moderately severe or severe. Three primary climax communities can probably be distinguished: evergreen seasonal forest, semi-evergreen seasonal forest and deciduous seasonal forest. The seasonal formations are generally an

expression of physical drought, and consequently deciduous trees are typical, rather than hard-leaved evergreens. Under the driest conditions, thorniness and microphylly become characteristic.

The seasonal formations are or were restricted to the lower parts of mountainous or hilly islands and consequently they have nowadays either disappeared or been affected by cultivation of these areas.

Evergreen seasonal forest [X]

The evergreen seasonal forest and semi-evergreen forest are closely related to the rain forest. There is only one example of the evergreen seasonal forest to be found in the islands, but it is not clear to what extent it has been modified by human interference. It is found in the crater of The Quill [17], a former volcano in St. Eustatius. There are five layers to be distinguished: a highly discontinuous emergent layer, a more or less closed middle-story tree layer, an under-story tree layer, a shrub layer and a ground layer. Lianas and climbers are abundant, epiphytes rather rare.

In the emergent layer only five species were noted in the plots enumerated. Two of these are deciduous: *Spondias* and *Ceiba*, both of which have compound leaves. In the middle story probably only two species are deciduous: *Spondias* and *Citharexylum*, whilst two species have compound leaves: *Spondias* and *Inga*. *Cecropia* may be considered as semi-deciduous. In the lower story one species has compound leaves: *Inga*. Outside the enumerated plots the species *Lonchocarpus violaceus*, *Swietenia mahagoni* and *Andira inermis* have compound leaves. Large plank-buttresses are seen in *Ceiba*, whilst *Cecropia peltata* is usually provided with stilt roots.

In the middle story, the following species are most prominent: *Inga laurina* and *Nectandra coriacea*. *Myrcia citrifolia*, *Coccoloba diversifolia*, *Nectandra* and *Inga* are most prominent in the lower story.

Height-class and diameter-class distribution of the trees in this forest are given in Fig. 12.

Several of these species seem to occur frequently in the rain forest in the islands of the Caribbean: *Symplocos martinicensis*, *Ficus urbaniana*, *F. krugiana*, *Cecropia peltata*, *Hirtella triandra*, *Quararibea turbinata*, *Nectandra krugii* and *Phoebe elongata*. Several other species, however, are rather frequent in the dry evergreen formations; among them, *Daphnopsis caribaea*, *Inga*, *Pisonia* and *Myrcia citrifolia*, may be noticed.

This forest type resembles the forest named by Stehlé (1938) "la forêt mésophytique" (mesophytic forest). He classifies it as the "Andira-Lonchocarpus association", since *Andira inermis* and *Lonchocarpus latifolius* are the most dominant species in association with *Hymenaea courbaril*, *Ormosia monosperma*, *Icica heptaphylla*, *Calophyllum antillanum*, *Ceiba antillana*, etc., as well as *Swietenia mahagoni*. The list of species published in 1938 differs only slightly from that published in 1945, but it is noteworthy that in the latter *Swietenia mahagoni* is not mentioned, whereas in the 1938 list it is given a prominent place among the associated

species of the forest. Stehlé states that this forest resembles that of Turner's Hall Wood in Barbados. Beard (1945), basing his remarks on Gooding (1944), points out that in Barbados this forest, at least in the parts of best growth, is evergreen seasonal forest.

Beard (1946) states that the evergreen seasonal forest in Trinidad is composed of a single association, the Carapa-Eschweilera association, in which five faciations are to be distinguished. Beard (1949) also classifies the forest at Morne Delice in Grenada as belonging to this same type. As he says, this forest has been affected by fellings and somewhat dwarfed by exposure of the site. Thirty component species were noted by him, all but three of them evergreen. About half these species are found

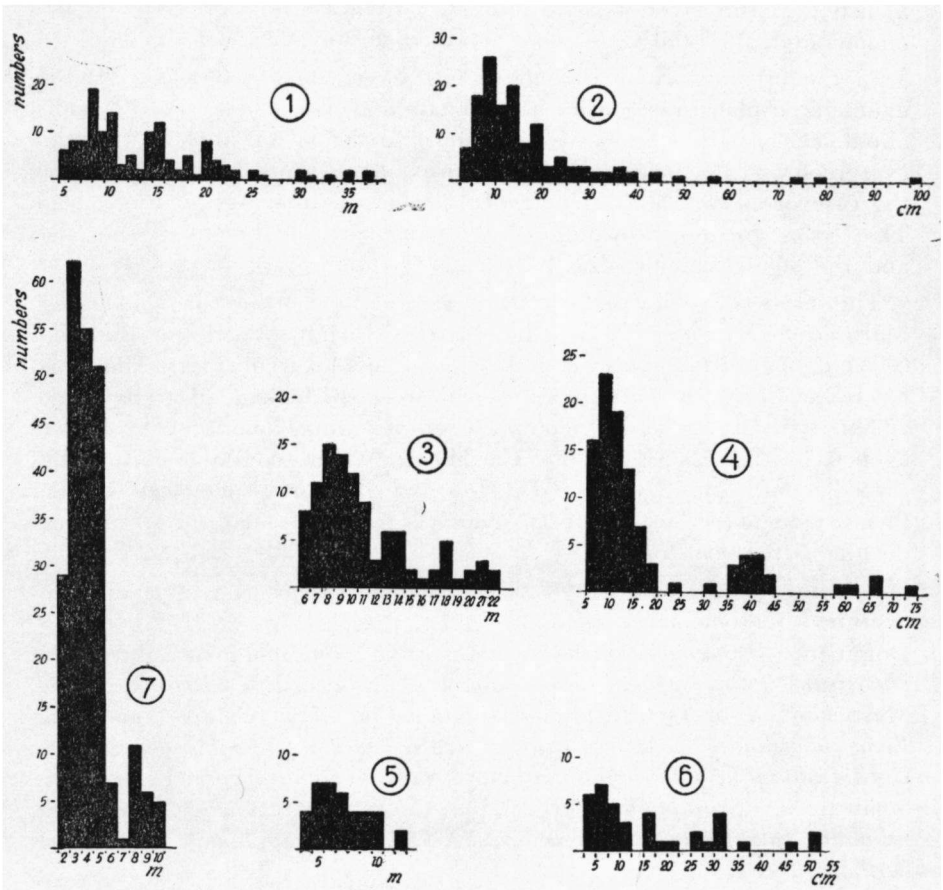

Fig. 12. Height class and stem diameter class of the trees in some forests on The Quill, St. Eustatius. — 1-2. Height and diameter distribution in evergreen seasonal forest on the bottom of the crater [17]. 3-4. Height and diameter distribution in semi-evergreen seasonal forest on the western slope. 5-6. Height and diameter distribution in degraded semi-evergreen seasonal forest on the eastern slope [18]. 7. Height distribution in dry evergreen forest on the rim of the crater [16].

in the rain forest flora, but none of the typical rain forest dominants are present. Most of the other species are dry evergreen.

There seem to be no examples of this forest type present in the other islands.

Semi-evergreen seasonal forest [XI]

The best example of this forest is to be found in St. Eustatius, on the northern and north-western slopes of The Quill, roughly between 250 and 350 m. Here the forest consists of an almost closed canopy of stout trees, about 20 m high, and a lower story between 6 and 15 m high. There is a distinct shrub layer, but the ground vegetation is scanty. In the plot enumerated [15], the vines were confined to only three species.

In the upper story nearly all species have compound leaves. In the enumerated plot three species had pinnate and two palmate leaves, whilst about 80% of the trees were deciduous. In the lower story all trees are evergreen and have simple leaves. Plank-buttresses are frequently seen in the case of *Ceiba*, whilst *Hymenaea* also has a tendency to form them. The leaves are generally mesophyllous in size. The height of the trees and the stem diameter distribution are given in Fig. 12.

The forest resembles the vegetation as described in the case of southern Martinique (Stehlé 1938), and Turner's Hall Wood in Barbados (Gooding 1944; Beard 1945), in the less luxuriant parts. The forest has been affected by cutting, and several relics of fellings are to be found.

This type of forest has generally been very much modified by human agency in the islands of the Caribbean, where constant cutting has turned it into "scrub woodland". However, it is often not clear whether this woodland is derived from semi-evergreen seasonal forest or from deciduous seasonal forest.

Beard (1949) enumerates the following species as typical of semi-evergreen seasonal forest (p. 77).

Dominants: *Hymenaea courbaril, Inga laurina, Simaruba amara, Brosimum alicastrum, Pouteria multiflora, Fagara martinicensis, Cedrela mexicana, Mastichodendron foetidissimum, Spondias mombin, Genipa americana, Ficus lentiginosa, Vitex divaricata, Hura crepitans, Ceiba occidentalis, Cordia alliodora, Chlorophora tinctoria* and *Nectandra coriacea.*

Small trees: *Chrysophyllum argenteum, Casearia guianensis, C. decandra, Dipholis salicifolia, Aiphanus erosa, Fagara monophylla, Daphnopsis caribaea,* etc.

In the shrub layer: *Faramea occidentalis, Guettarda parviflora, Tabernaemontana citrifolia, Coccoloba venosa, Bunchosia nitida* and *Eugenia monticola.*

Species occurring in this type as well as in the deciduous seasonal forest include *Bursera simaruba, Pisonia* spp., *Tabebuia pallida, Bourreria succulenta,* and *Capparis* spp.

Physiognomically, Beard defines the semi-evergreen seasonal forest (1944, p. 138) as "a two-storied forest with a more or less closed canopy formed by an upper story between 20 and 26 m and a lower story between 6 and 14 m.... most mature trees average about one-half meter in diameter. They fork or branch low down, and crowns are umbrella-shaped. Lianas seem to reach their optimum here.... Epiphytes are relatively scarce. Buttressing of larger trees may or may not be present.... Species confined to the lower story are almost evergreen but those attaining the canopy are mostly deciduous.... Compound leaves predominate in the upper story, simple in the lower. Leaf size is predominantly mesophyllous in the upper story, but there is some tendency to microphylly in the lower. There is a marked shrub layer of hard, woody, mostly myrtaceous bushes, and ground vegetation is scanty". So the mentioned above forest fits in well with this definition.

In St. Maarten, near the top of Sentry Hill, the vegetation corresponds rather closely to that of the group of the semi-evergreen seasonal forests. Four of the five dominants have compound leaves; two are deciduous. In the lower story all trees have simple leaves, one species is deciduous while another is probably semi-deciduous. A distinct woody shrub layer is present, and one of the species in it is spiny. Herbs and epiphytes are rather rare.

These are only the two least disturbed examples in the islands. Most of those that might formerly have been classifiable in this group have now disappeared or been degraded to scrub woodland. As already stated, this degraded woodland cannot be distinguished from that derived from deciduous seasonal forest. The sub-climax and secondary communities will be discussed after consideration of the deciduous seasonal forest.

Deciduous seasonal forest [XII]

This type of forest is defined by Beard (1944, p. 139) as follows: "A two-storied forest with canopy formed by the lower stratum between 3 and 10 m and an upper layer of scattered trees attaining 20 m. There are very few stout trees.... Stems fork and branch low down.... Lianas and arboreal epiphytes are rare. Trees are not buttressed, stilt roots are absent, but there are a few important armed species. Ferns and mosses are noticeable absentees.... Over two-thirds of the individuals composing the upper story are deciduous, though those confined to the lower story are almost evergreen.... Compound and simple leaves are about equally distributed in the upper story and simple leaves predominate in the lower. The lower story is largely mesophyllous, though containing many microphyllous species and these two leaf characters are evenly divided in the upper story.... Ground vegetation is remarkably scarce, the soil being commonly bare except where societies of terrestrial bromeliads cover the ground often for scores of square yards".

However, as the examples are badly damaged, there is no positive evidence for the taxonomic existence of this group. There are no marked differences between the tree layers of this type and those of the semi-evergreen seasonal type. There is a possibility that the former is only a more severely degraded woodland form of the latter. But on the other hand the ground layer of terrestrial bromeliads is a typical characteristic, whilst the shrub layer is usually more distinctive.

Along the western slope of The Quill a type of vegetation occurs that may probably be classified in this group. However, stands of *Leucaena glauca* indicate that at any rate a great part of the area concerned was once under cultivation. The tree layer is dominated by *Pisonia subcordata*, which forms slightly over 50% of the total crop. *Piscidia piscipula*, *Tabebuia pallida* and *Bursera simaruba* occur frequently. Half the tree species are deciduous, and half have compound leaves, two palmate and three pinnate. The shrub layer is very dense and varies greatly in composition from place to place. In the more open locations bromeliads and Cactaceae cover the ground. *Tillandsia utriculata* and *T. recurvata* are very abundant. *Scleria lithosperma* occurs frequently.

In St. Maarten, on the slopes of the hills around Cul de Sac, only a few stout trees are met with: *Pisonia fragrans*, *Morisonia americana*, *Hymenaea courbaril*, *Tamarindus indica*, *Tabebuia pallida*, and *Ficus urbaniana*. Of these species four have compound leaves and the majority are evergreens. Most species of the trees, which are mainly shrubby, have simple leaves and are largely evergreen. Neither buttressing nor stilt roots were observed. Among the shrubs Myrtaceae are frequently found, whilst whole fields have a dense *Opuntia* layer, especially on the lower ground. Epiphytes are rare, except on higher ground. Among the herbs and undershrubs many common roadside weeds occur. The leaves of the trees are generally mesophyllous in size. This area was undoubtedly once covered by a type of seasonal forest, which was probably intermediate between semi-evergreen and deciduous in character.

Owing to more severe human interference in the areas formerly covered with semi-evergreen or deciduous seasonal forest, the woodlands are still more degraded in these islands or have been replaced by a secondary woodland or thicket.

Thorny woodland [XIII]

Except for some parts of the Low Lands, the lower parts of St. Maarten are entirely covered by this. *Acacia* plays an important role in the community, varying from 20 to about 80% of the total crop. In several parts specimens of *Malpighia punicifolia* and *Randia aculeata* become very numerous and often make it uncertain whether the community is derived from a deciduous forest or represents a thorny thicket derived from dry evergreen forest. *Opuntia* is very frequent in the ground or undershrub layer, forming a growth varying from very dense to rather open.

In Saba thorny woodland exists only in very small plots, and may be left out of consideration.

In St. Eustatius a very good example is to be found round the foot of The Quill; on the slope of the former volcano; and on the southern slope of Panga. On the slope of The Quill above Glass Bottle over 50% of the crop consists of *Acacia farnesiana,* whilst *Leucaena glauca* is the second most abundant species — a species typical of areas abandoned after cultivation. It resembles the "brousse à Acacia" in Martinique described by Stehlé (1938). In the northern part of the island it also occurs rather frequently in small areas, but there it is intermixed with such species as *Pisonia, Capparis, Citharexylum, Pithecellobium,* and others.

Leucaena thickets [XIV]

These thickets occur sporadically in the northern part of St. Eustatius, between The Bottom and Mary's Point in Saba, and occasionally in St. Maarten on the slopes of the hills around Cul de Sac. They usually cover not more than a few square metres and become intermixed with *Capparis, Acacia, Pisonia,* etc.

Croton thickets [XV]

These thickets are "the most impoverished of any of these (seasonal) communities. They consist of a low open scrub up to 8 ft high on the driest, poorest, most degraded sites...." (Beard 1949, p. 80). However, they may also be derived from dry evergreen forests (l.c. p. 82). They seem to exist in nearly pure stands in other islands of the Antillean arc. Stehlé (1938) gives two types of the "taillis à Croton":

1. "Taillis à Croton d'origine édapho-climatique" where, on the better sites *Croton corylifolius* is the crop-former with *Myrcia, Eugenia, Coccoloba* and *Cerdana,* whilst *Croton niveus* and *C. populifolius* appear on the poorer soil.
2. "Taillis à Croton d'origine pyrophytique", following burning and composed of *Croton balsamiferum* and *C. subglaber.* Stehlé mentions a "taillis à *Croton balsamiferum*" on Guadeloupe, associated with *Melochia tomentosa,* whilst this thicket is sometimes formed mixed with remains of the "taillis à *Acacia*", but more often with Cactaceae.

In St. Maarten the most degraded Croton thickets occur on the peninsulas near Fort Amsterdam and near Burgeux Bay. Associates are *Lantana, Opuntia, Melocactus, Solanum racemosum* and *Corchorus; Conocarpus* also occurs here, but only in very small quantities. This layer is overtopped by a few scattered specimens of *Acacia, Plumiera alba, Malpighia glabra.*

It is not always clear whether the Croton thickets in the islands of Saba and St. Eustatius have been derived from seasonal or from dry evergreen forest.

Dry evergreen formations

The dry evergreen formations occur in relatively dry areas, but they are "the expression of physiological rather than physical drought" (Beard 1949). The species typical of these formations are hard-leaved evergreens; under drier conditions, microphylly is characteristic, but never thorniness. Three formations are usually considered to be dry-evergreen: "dry evergreen forest", "evergreen bushland" and "littoral woodland".

Dry evergreen forest [XVI]

Beard states (1949) "the bulk of the woodland which appears to belong to this type is very heavily damaged and it is not possible to form any reliable conception of the original structure". He recognized the woodland at Praslin, St. Lucia, and the majority of the dry scrub woodlands of Dominica, as belonging to this type. Stehlé (1938) cites the Fagara-Myrcia associes and Pimenta stands, which also belong to the dry evergreen forests. In the least disturbed examples there is an upper canopy layer, a lower story of small trees, a shrub layer and a ground layer. Ground vegetation is sparse. The predominant components are hard-leaved evergreens. Typical species of this forest are (Beard 1949, p. 81): *Pimenta racemosa, Coccoloba pubescens, Tabebuia pallida, Manilkara bidentata, Eugenia* spp., *Pisonia fragrans, Bursera simaruba, Calophyllum antillanum, Inga laurina, Fagara microcarpa, Hymenaea courbaril, Diospyros ebenaster, Byrsonima spicata, Buchenavia capitata, Rheedia latiflora, Ilex macfadyenii, Rhytycocos amara,* and *Coccothrinax barbadensis.* Small trees: *Guettarda scabra, Maytenus elliptica, Coccoloba diversifolia, Daphnopsis caribaea, Linociera caribaea, Ternstroemia peduncularis, Clusia plukenetii, Cornutia pyramidata, Casearia guianensis, Amyris elemifera, Calliandra tergemina,* and *C. purpurea.* Shrubs: *Faramea occidentalis, Myrcia citrifolia, Ixora ferrea, Ardisia coriacea, Fagara trifoliata, Tabernaemontana citrifolia* and *Tetrazygia angustifolia.*

In the best example in the islands, near the lowest part of the rim of The Quill, in St. Eustatius [16], the dry evergreen forest consists of an upper canopy layer, that was probably once closed but is nowadays open at several points owing to cuttings; a lower story of small trees, consisting either of saplings or of shrubby or crowded trees; and a shrub layer. In the more open spots a ground layer is present, and here the stones are often covered with mosses. Only one tree is fully deciduous, but *Tabebuia pallida* and *Spondias mombin* tend to be evergreen. The smaller trees are evergreen, the leaves usually shiny and mesophyllous in size but generally smaller than in the dry evergreen seasonal forests. Several species have more or less peeling bark. *Myrcia citrifolia* is very abundant in the shrub layer, but also occurs very frequently as a shrubby tree, whilst in the lower tree story *Maytenus, Nectandra coriacea* and *Linociera caribaea* are the most numerous species. In the plot enumerated *Tabebuia pallida* was the most abundant species in the upper story. It frequently appears in the monophyllous leaf-form; if the leaf is compound, the

number of leaflets is generally reduced. These features thus correspond well with those of the type as described by Beard (1949) from Praslin, St. Lucia. The height class distribution of the trees is given in Fig. 12.

At the western side of the rim [22], essentially the same vegetation occurs, but *Pisonia fragrans* and *Ternstroemia peduncularis* are more abundant. In the upper story nearly all species are evergreen, but the majority have compound leaves. In the shrub layer Myrtaceae are most frequent, and the ground layer is well developed, *Peperomia* usually being the prominent species.

The northern part of St. Eustatius is largely covered with secondary woodland, very variable in composition. Several trees and shrubs of the seasonal formations, as well as species of the evergreen formation, are present. It is not clear to what formation the original vegetation must have belonged, but it was probably intermediate between deciduous seasonal and dry evergreen. Several species are present, undoubtedly owing to former cultivation: *Melicocca bijuga, Tamarindus indica, Citrus, Annona* and others. The area is still being affected by cuttings to obtain wood for charcoal-burning. The most severely degraded vegetation in this area is represented by Croton thickets.

Woodland derived from dry evergreen forest [XVII]

This woodland is to be found in Saba on the western slope of Parish Hill and Great Hill [10] and between The Bottom and Middle Island [15]. *Guettarda, Eugenia, Myrcia, Citharexylum, Pithecellobium, Chiococca racemosa, Croton* and *Lantana* are the most abundant species which go to form this shrubby, very dense woodland, about 5 m in height. It is overtopped by such species as *Morisonia americana, Tamarindus indica, Tabebuia pallida,* and *Trema lima.*

In St. Maarten a secondary woodland is found between Experiment and Guana Bay [9]. *Pithecellobium, Capparis, Comocladia ilicifolia, Malpighia, Fagara, Samyda* and other species, together with *Croton, Melochia, Opuntia, Lantana* and others, form an impenetrable growth of shrubby trees and rather tall shrubs, which are certainly of dry evergreen origin.

Evergreen bushland [XVIII]

This category was adopted by Beard in 1949, following Warming (1909). The latter regards his "evergreen tropical bushland" closely related to the Mediterranean maquis, and describes it as follows: ".... some other isles of the Antilles that have but a slight rainfall are largely clothed with a grey, desolate, useless and scorching bushland, between whose thorny, tangled shrubs and low trees one cannot penetrate without the aid of an axe" (p. 301). Beard applies the name to the bushland which is rather common in the Antillean islands but restricted to the limestone areas, in which, however only a few species are thorny or prickly. Several species of this formation, regarded as typical, occur in the "dry evergreen forest" or in "littoral woodland".

The type occurs only in the Low Lands of St. Maarten [11], in places not too severely affected by human activity. In the least affected parts, the spiny Acacia is absent, while the only prickly species are *Comocladia ilicifolia, Pithecellobium unguis-cati* and an occasional *Bumelia obovata.* The deciduous species *Plumiera alba, Bursera simaruba* and *Tabebuia pallida* are also present. The other species usually have shiny, hard or fleshy leaves. Nanism frequently occurs. The shrub layer is generally rather high, and a definite stratification is absent. Climbers are not frequent and mosses are absent. *Tillandsia* is the only epiphyte. Two species of the high trees have compound leaves; in the shrub layer, three species. The ground layer consists only of scattered tufts of sedge and grass. Typical species are *Canella alba, Jacquinia berteri, Phyllanthus epiphyllanthus, Samyda dodecandra, Coccoloba krugii* and *Ernodea littoralis. Bursera simaruba* is the only species with peeling bark. *Plumiera* contains a white latex, and *Pisonia* and *Bursera* have water-storing trunks.

In the parts more affected by human agencies a thorny woodland [XIX] is found, representing a sub-climax. It consists of a dense growth, mainly of Mimosaceae, in which *Acacia* and *Pithecellobium* are very prominent, together with *Lantana* and *Croton.* The ground is often densely covered with *Opuntia* growths. This sub-climax may probably be correlated with the Pithecellobium-Acacia associes of Grande Terre in Guadeloupe (Stehlé 1935).

In St. Eustatius a type of vegetation, undoubtedly belonging to the evergreen bushland, is found on the calcareous top of White Wall [24]. It consists of shrubby trees, overtopped by a few larger ones. Three species have compound leaves, whilst the others are evergreens. Many of the component species have microphyllous leaves, which are often rough and scabrous. Shiny or fleshy leaves are also found. Epiphytes are present, but only two species were seen, i.e. of the genus *Tillandsia.* This type may be correlated with the "facies calcaire à *Krugiodendron ferreum-Forestiera rhamnifolia* var. *martinicensis*" of the "forêt xérophytique" described as occurring in Martinique by Stehlé (1938) and named the "association à *Krugiodendron ferreum-Forestiera rhamnifolia* var. *martinicensis*". *Krugiodendron* was not found in the strip, but occurs rather frequently in several places; *Forestiera,* however, is absent in St. Eustatius.

Croton thickets [XX]

These thickets probably also exist in the islands of Saba and St. Eustatius. However, it is not always clear whether they have been derived from seasonal or from dry evergreen forest.

Littoral woodland [XXI]

According to Beard (1944) this formation is "developed along the seashore above high-water mark and not yet subject to inundation. It is, however, subject at all times to strong winds carrying salt spray which

is deposited on the leaves of the plants. Typically the formation consists of low gnarled or windswept trees and shrubs presenting their crowns to the wind in the form of dense domes or flat laminae edge-on. Leaves are generally simple, fleshy, very shiny, covered on the upper surface with a thick layer of cuticle which is able to counter the dehydrating effect of a coating of salt and is an effective protection against powerful drying winds" (p. 141—142).

Littoral woodland is rather a series of closely associated formations than a single formation, ranging from low stunted bushes to tall evergreen woodland. It consists mainly of *Coccoloba uvifera, Chrysobalanus icaco, Erithalis fruticosa, Coccoloba diversifolia, Pisonia fragrans,* and *Calophyllum antillanum. Conocarpus erecta* and *Tabebuia pallida* are often frequently found.

Stehlé considers it to be the sandy facies of the deciduous sub-type of his xerophytic forest.

Littoral woodland is entirely absent in Saba. In St. Eustatius it occurs only in two places: at Venus Bay [2], where it takes the form of a low littoral hedge of *Conocarpus erecta* shrubs, depressed by wind action; and along Concordia Bay (a better developed example) [1].

It is still better developed in St. Maarten, especially along the beaches of the Low Lands [14], [15], where *Coccoloba* dominates, associated with *Conocarpus erecta, Erithalis fruticosa, Thespesia populnea, Lantana involucrata,* and an occasional *Tabebuia pallida. Tournefortia gnaphalodes, Suriana maritima* and *Scaevola plumieri* are often to be found. The formation also occurs along some bays on the east coast of the island [17], [18].

Vegetation of the rock pavement [XXII]

This usually rather poor vegetation on soil-less and sea-swept stone pavements is to be seen in St. Eustatius, on the steep slope of Sugar Loaf [4], where *Strumpfia maritima,* a few small shrubs of *Coccoloba uvifera,* one specimen of *Jacquinia barbasco* and some *Urechites lutea* are found. A much denser growth occurs on the limestone south of Oysterpond, St. Maarten [26]. The most prominent species here are *Croton, Lantana, Erithalis fruticosa,* and *Ernodea littoralis,* forming a dense scrub overtopped by *Bumelia obovata, Rhacoma crossopetalum* and *Jacquinia barbasco. Strumpfia maritima* and *Melocactus* are very frequent.

Vegetation of rocky slopes [XXIII]

This vegetation is very variable in structure and composition. Usually it is composed of *Opuntia, Melocactus, Lantana involucrata, Croton, Pedilanthus tithymaloides, Coccoloba uvifera, Plumiera alba, Tabebuia pallida, Jacquinia barbasco, Erithalis fruticosa* and *Conocarpus erecta,* whilst in St. Maarten *Euphorbia petiolaris* frequently occurs.

Mangrove woodland [XXIV]

The greater part of the mangrove woodland in St. Maarten has been strongly affected by human activity. Very locally, it might be possible to distinguish the Rhizophora consocies and the Avicennia consocies, but *Laguncularia* and *Avicennia* are generally intermixed, owing to cutting. *Batis maritima, Eleocharis caribaea, Sporobolus virginicus* and other halophytes are associated. It has been described as occurring in St. Maarten at the following localities: [12], [13]. For discussion, reference should be made to the description of the coastal communities in Part I.

The herbaceous strand community [XXV]

This is best developed in St. Maarten, and the prominent species *Ipomoea pes-caprae* and *Canavalia maritima* are present. Among other species *Cakile lanceolata* and *Lepidium virginicum* are usually found — two species absent in the islands of the Leeward Group. It has been described as occurring in St. Maarten at the following localities: [14], [15], [17], and [18]. For discussion, reference should be made to the description of the coastal communities in Part I.

The strand scrub community [XXVI]

This vegetation, consisting mainly of *Tournefortia gnaphalodes* and *Suriana maritima,* has been described as occurring at the following localities: [14], [15], [17], and [18]. For discussion, reference should be made to the description of the coastal communities in Part I.

Vegetation of salt flats [XXVII]

This vegetation type is absent in Saba and St. Eustatius. It has been described as occurring in St. Maarten at [1]. For discussion, reference should be made to the description of the vegetation of salt flats and salinas in Part I.

Hippomane woodlands [XXVIII]

In this vegetation *Batis maritima, Sesuvium portulacastrum,* and other halophytic species are associated with *Hippomane mancinella.* It is absent in Saba. In St. Eustatius it occurs between Oranjestad and Gallowsbay [5], and near Tumble Down Dick Bay [6]. It occurs frequently in St. Maarten, especially in the lower parts along the south coast. For discussion, reference should be made to the description of the Hippomane woodlands in Part I.

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