

STUDIES IN WEST INDIAN SOILS

(XII) THE AGRICULTURAL AND  
FOREST SOILS OF ST. LUCIA

BY

F. HARDY and G. RODRIGUES

*(The Imperial College of Tropical Agriculture, Trinidad, B.W.I.)*



*Via colendi hard facilis*

Price Five Shillings

JANUARY, 1947

## CONTENTS

	PAGE.
(I)—INTRODUCTORY .. .. .	I
(II)—TOPOGRAPHY : PHYSIOGRAPHICAL REGIONS .. .. .	I
(III)—CLIMATE : RAINFALL : TEMPERATURE : HUMIDITY : PREVAILING WINDS .. .. .	2
(IV)—AGRICULTURE : NATURAL VEGETATION : AGRICULTURAL LANDS : CHIEF CROPS.. .. .	3
(V)—GEOLOGY : GEOLOGICAL HISTORY .. .. .	4
(VI)—LITHOLOGY .. .. .	6
(VII)—SOIL FORMATION : SOIL-FORMING FACTORS : EFFECTS OF EROSION AND TRANSPORTATION .. .. .	6
(VIII)—THE CHIEF SOIL-TYPES OF ST. LUCIA : CLASSIFICATION .. .. .	7
(A) AZONAL SOILS :	
(1) LITHOSOL .. .. .	7
(2) COLLUVIAL AND SANDY ALLUVIAL SOILS .. .. .	7
(B) INTRAZONAL SOILS :	
CALCIMORPHIC :	
(3) BROWN EARTH SOIL .. .. .	7
(4) YELLOW EARTH SOIL .. .. .	7
HYDROMORPHIC :	
(6) TERRAS SOIL .. .. .	7
(7) SHOAL SOIL .. .. .	7
(C) ZONAL .. .. .	7
RESIDUAL .. .. .	7
TRANSPORTED (CLAYEY ALLUVIAL) .. .. .	7
(5) RED EARTH .. .. .	7
DISTRIBUTION OF SOIL-TYPES .. .. .	7
(1) CENTRAL REGION : FOREST SOIL DETERIORATION. HISTORY OF THE BANANA INDUSTRY. HETEROGENEITY OF THE INTERIOR SOILS. PERIPHERAL PARTS. ALLUVIAL FLATS .. .. .	7
(2) MID-WESTERN REGION .. .. .	12
(3) SOUTH-WESTERN REGION (CHOISEUIL-VIEUX FORT)	
SHOAL SOIL : ALLUVIAL SOIL .. .. .	12
(IX)—LABORATORY DATA FOR SOIL SAMPLES	
(A) SUGAR-CANE SOILS : DISCUSSION : NUTRIENT DEFICIENCIES : MANURIAL EXPERIMENTS .. .. .	15
(B) CACAO AND CITRUS SOILS : DISCUSSION : NUTRIENT DEFICIENCIES : SPECIAL IMPORTANCE OF ORGANIC MATTER IN CITRUS SOILS : MANURIAL EXPERIMENT ON LIMES .. .. .	17
(C) PEASANTS' PROVISION CROP SOILS .. .. .	20
(X)—CHEMICAL AND MINERALOGICAL TRANSFORMATIONS INVOLVED IN SOIL FORMATION IN ST. LUCIA .. .. .	20
(1) MORNE GIRAUD SHOAL SOIL : RESULTS : DISCUSSION .. .. .	20
(2) VIEUX FORT ALLUVIAL SOIL : RESULTS : DISCUSSION .. .. .	22
(XI)—SOIL EROSION :	
(A) FLOWING MOVEMENTS : SOIL-CREEP, TALUS-CREEP, ROCK-CREEP, EARTHFLOW, MUDFLOW, DÉBRIS AVALANCHE .. .. .	23
(B) SLIDING MOVEMENTS : SLUMP, DÉBRIS-SLIDE, DÉBRIS-FALL, ROCK-SLIDE, ROCK-FALL .. .. .	23
THE RAVINE POISSON DÉBRIS AVALANCHES .. .. .	24
OTHER EXAMPLES OF DÉBRIS AVALANCHE .. .. .	24
OTHER KINDS OF LAND MOVEMENTS .. .. .	24
(XII)—SOIL CONSERVATION AND ANTI-EROSION MEASURES.	
MORNE GIRAUD ANTI-EROSION EXPERIMENTS .. .. .	25
(XIII)—SOIL RENOVATION .. .. .	26
SUMMARY .. .. .	28
REFERENCES .. .. .	30
APPENDIX : TABLES OF LABORATORY DATA .. .. .	31
LABORATORY METHODS OF SOIL ANALYSIS .. .. .	46
ROUGH SOIL-MAP OF ST. LUCIA	
RAINFALL MAP OF ST. LUCIA	

## STUDY IN WEST INDIAN SOILS

# (XII) THE AGRICULTURAL AND FOREST SOILS OF ST. LUCIA

BY

F. HARDY AND G. RODRIGUES

### (I)—INTRODUCTORY

THIS report describes a field reconnaissance carried out in St. Lucia during April, 1941, within a period of 13 working days, and presents the results of the laboratory examination made at the College of some 320 soil samples then collected, mostly from 34 profile pits specially dug for the purpose at various sites in the island, chiefly in cacao, lime or sugar-cane fields. A few typical peasants' holdings were also sampled for surface soil. The analytical results are tabulated in the Appendix, which includes brief descriptions of several forest sites examined by Dr. J. S. Beard (Assistant Conservator of Forests, Trinidad and Tobago), who kindly placed his notes at our disposal and gave us much valuable information about the interior forest lands of the island which he explored in 1945. We are deeply indebted to Dr. Beard for this help.

Previously, Mr. H. H. Croucher, Lecturer in Chemistry at the College, visited St. Lucia in the summer of 1929 and collected numerous surface and subsurface soil samples representative of the cultivated lands. These samples were analysed at the College and a report on their main features was written by him and published in May, 1930, by the Government of St. Lucia (1).

Finally, in March, 1936, Mr. E. A. Walters, then Superintendent of Agriculture in St. Lucia, collected soil samples from the Quillesse district in the south-central part of the island in connection with a proposed land settlement scheme. These samples were also analysed at the College and a report on them was written by the present authors. The laboratory data then obtained are presented as part of the Appendix of this Report and the main findings are incorporated in the text.

We were conducted over the Soufriere district of St. Lucia by Mr. R. G. Fennah, Entomologist for the Citrus Pests Investigation, to whom we owe gratitude for help and guidance. Also, we wish to record our thanks to Mr. E. T. Ward and to Mr. G. B. Gregory, Superintendent and Assistant Superintendent of Agriculture of St. Lucia, for making arrangements for our tour and for accompanying us on some of our journeys. Finally we

are greatly indebted to Mr. C. C. Skeete, Director of Agriculture for the Windward Islands, for kindly reading the proof of this report and offering suggestions for its improvement.

### (II)—TOPOGRAPHY

St. Lucia lies in latitude 14°N and is the second largest island of the Caribbean Volcanic Arc; it belongs to the Windward group of the Lesser Antilles islands. It is separated from Martinique on the north by a channel 24 miles wide and 4,500 feet deep, and from St. Vincent on the south by a channel 20 miles wide and 2,000 feet deep. The island is 25 miles long by 13 miles wide, 233 square miles in area, and roughly lenticular in shape.

The middle part of St. Lucia is mountainous and comprises a longitudinal main ridge with offset spurs that run down to the coasts on either side, together with a series of more-or-less independent subsidiary peaks in the south, conferring a general hummocky aspect to the scenery. The highest mountain (Morne Gimie) is 3,145 ft. high, and there are several more having heights between 2,000 and 3,000 ft. The most imposing peaks are Gros Piton and Petit Piton (2,619 and 2,461 ft.), situated on the south-west coast, which rise at a steep angle (about 55°) sheer out of the sea. The northern and southern ends of the island are much less mountainous. The northern part consists of small hills, mostly less than 400 ft. high. The southern part (Vieux Fort) is a nearly flat plain, 4 square miles in area, slightly raised above sea-level and terminating in a bold promontory.

The valleys between the off-shoots of the main ridge are broad and flat; three of them (Cul-de-Sac, Roseau and Mabouya) are occupied by large sugar-estates. By contrast, the valleys of the western and the south-western districts, and of the Vieux Fort area, are narrow and deep, resembling the ghaunts of the southern mountainous part of Montserrat.

St. Lucia stands on a submarine bank which extends 5 miles north and south, 2 or 3 miles east but only a short distance west of the present island. The depth of water at the border of the bank is

180 to 240 feet, increasing rapidly over the edge of the bank to nearly 600 ft. The coastline is deeply indented by delta-headed bays where the broad mature valleys of the larger rivers open out into the sea. Between the bays, the hill-spurs have been truncated by marine erosion and now form a succession of vertical cliffs, particularly well-marked along the mid-west coast. The edge of the southern plain is also cliffed, though fronted by a narrow beach covered by relatively shallow water.

*Physiographical regions.*—There are three main physiographical regions in St. Lucia which owe their differentiation to geological history and development.

(1) The first region comprises the older and larger central part of the island, and includes the axial range and its offshoots, as well as the isolated mountains and hills occurring beyond its ends. The land-forms of this region are all mature and subdued by long-continued denudation and show no clear traces of the original individual volcanoes of which they form the residues.

(2) The second region comprises the mid-western section extending along the coast-line from the south side of Roseau Bay southwards to Soufriere and perhaps beyond to Gros Piton. It extends inland for about 5 miles and includes some of the highest and steepest mountains in St. Lucia, for example, M. Gimie (3,145 ft.), Piton Canaries (3,012 ft.), M. Paix Bouche (2,455 ft.), M. Tabac (2,270 ft.) and M. Parasol (2,010 ft.), as well as the two great Pitons. Its land-forms are younger and less modified by erosion and denudation than those of the main ridge. The mountain slopes are dissected by steep-sided V-shaped valleys which have hanging mouths. The beach shelves rapidly to great depth at no great distance from the shore along this part of the coastline. The only active soufriere in St. Lucia occurs in this region.

There is some doubt as to the exact limits of this mid-western volcanic section. It may properly start north of Roseau Valley and end north of Soufriere Valley, in which case the Pitons district would comprise another and separate region of undetermined relationships. Possibly the two Pitons are resistant "spines" or extruded rocky plugs of the kind that was thrust out of the crater of Mt. Pelée in Martinique at the end of the 1902-03 eruptions, though it soon disintegrated and disappeared. The relatively large breadth of the Soufriere Valley and the occurrence of a wide re-entrant delta at its mouth suggest that this valley may belong to the maturely dissected older region first described.

(3) The third region comprises the south-western section extending from Choiseuil to Vieux Fort and inland to a point in the southern end of the axial range near M. Grand Magazin. It consists of a huge fan-shaped glacis or mudflow, probably built up as a series of "black cloud" deposits that originated from an undetermined explosive volcano

or volcanoes situated high up in the main mountain mass. This broad sheet of fragmental volcanic material slopes gently seaward at an angle of about 6° and spreads around several old subdued and isolated hills belonging to the first region in the vicinity of Vieux Fort which it has linked together, forming from the most southerly hill the terminal promontory of the island (Moule-à-Chique). The surface of the glacis has been scoured longitudinally into deep, narrow, canyon-like channels, reminiscent of the Montserrat "ghauts". Six of these occur between Choiseuil and Laborie; they are successively crossed by bridges on the main road. One of them, occupied by the River Dorée, is 150 feet deep at the bridge and only 6 feet wide at the narrowest place between the vertical walls.

### (III)—CLIMATE

*Rainfall.*—The rainfall distribution in St. Lucia is shown in the accompanying map which indicates its effectiveness in deciding soil moistness. Highest rainfalls (over 100 inches a year) occur in the central ridge of mountains. Here the soil is *continuously wet* all the year round, there being no month with rainfall less than 4.0 ins., so that rainfall greatly exceeds evaporation for every month of the year. The particular rainfall-recording stations where these data were obtained are named in Table I. There are 10 stations for which the recorded mean annual rainfall is 100 ins. or more, with all months fully wet.

In addition, there are 32 stations which registered a mean annual rainfall of over 70 ins. though generally less than 100 ins. Here there are no really dry months having rainfall 2.4 ins. or less, and at most 4 months having medium rainfall lying between 2.4 and 4.0 ins., so that 8 to 10 months of the year are fully wet and evaporation never exceeds rainfall in any month. The soil is *continuously moist* at these places.

Stations which have registered a mean annual rainfall of magnitude less than 70 ins. are relatively few in number in St. Lucia (Table I). Thus, according to Mohr's classification, only 6 stations show a *weak dry season* and only 6 others show a *marked dry season*. These stations have an annual rainfall generally lying between 70 and 50 ins., although some have more than 70 ins. They occur within a coastal belt only about 1 mile wide on the average. The driest areas occur at Vieux Fort in the southern promontory and at Cap in the extreme north of the island. Here the mean annual rainfall is less than 60 ins. and 2 or 3 months have rainfall 2.4 ins. or less, during which evaporation exceeds rainfall, causing a well-marked dry season. This rainfall régime is suitable for sugar-cane, which has formed the main crop at Vieux Fort for many years. The more important sugar-producing areas in the north, namely, Cul-de-Sac, Roseau and Dennery, lie partly in the continuously wet zone and partly in the continuously moist zone, so that ripening is retarded and conditions are not so dry in the dry season as necessary for satisfactory reaping.

**Table I**  
**Rainfall Regimes in St. Lucia**  
(BASED ON MOHR'S CLASSIFICATION OF RAINFALL)

GROUP I(A)				GROUP I(B)				GROUPS II and III			
CONTINUOUSLY WET				CONTINUOUSLY MOIST				DISTINCT DRY SEASON			
Mean annual rainfall 160-100 ins.				Mean annual rainfall 100-70 ins.				Mean annual rainfall 70-50 ins.			
Central highlands				Central highlands				North and south extremities			
<i>Dry Med. Wet</i>				<i>Dry Med. Wet</i>				<i>Dry Med. Wet</i>			
Quillesse (161)	0	..	0 .. 12	Errard (94)	0	..	1 .. 11	WEAK DRY SEASON			
Warwick (134)	0	..	0 .. 12	Vanard (107)	0	..	2 .. 10				
Barré l'I (132)	0	..	0 .. 12	Prospect (102)	0	..	2 .. 10	Giraud (97)	1	..	2 .. 9
Uplyme (132)	0	..	0 .. 12	Mt. d'Or (101)	0	..	2 .. 10	La Perle (87)	1	..	2 .. 9
Rav. Pois. (120)	0	..	0 .. 12	Soucis (100)	0	..	2 .. 10	Doree R. (65)	1	..	4 .. 7
Woodlands (119)	0	..	0 .. 12	Dauphin (97)	0	..	2 .. 10	St. Urbain (61)	1	..	4 .. 7
Belle Plne. (114)	0	..	0 .. 12	Border (97)	0	..	2 .. 10	Roseau (84)	2	..	1 .. 9
Cul-de-Sac (112)	0	..	0 .. 12	Retreat (83)	0	..	2 .. 10	Union Vale (82)	2	..	1 .. 9
Guesneau (104)	0	..	0 .. 12	Marquis (83)	0	..	2 .. 10	<b>Means (80) 1 .. 2 .. 9</b>			
Parc (100)	0	..	0 .. 12	Resource (79)	0	..	2 .. 10				
				Fonds (76)	0	..	2 .. 10	MARKED DRY SEASON			
				Richford (75)	0	..	2 .. 10				
				La Caye (72)	0	..	2 .. 10	Troumassee (62)	2	..	3 .. 7
				Beausejour (109)	0	..	3 .. 9	Black Bay (60)	2	..	3 .. 7
				La Perle (96)	0	..	3 .. 9	Beausejour (59)	2	..	3 .. 7
				Rabot (95)	0	..	3 .. 9	Reduit (64)	3	..	1 .. 8
				Ruby (94)	0	..	3 .. 9	Point Sable (57)	3	..	3 .. 6
				Bot. Sta. (89)	0	..	3 .. 9	Moule-a-Ch. (50)	3	..	3 .. 6
				Belair (86)	0	..	3 .. 9	<b>Means (60) 2 .. 3 .. 7</b>			
				Londonderry (84)	0	..	3 .. 9				
				Union (84)	0	..	3 .. 9				
				Cul-de-Sac (83)	0	..	3 .. 9				
				Choiseuil (81)	0	..	3 .. 9				
				Union Sta. (87)	0	..	3 .. 9				
				Canelles (72)	0	..	3 .. 9				
				Manikin (70)	0	..	3 .. 9				
				Inverfoil (70)	0	..	3 .. 9				
				Retraite (69)	0	..	3 .. 9				
				Corinth (78)	0	..	4 .. 8				
				Barracks (75)	0	..	4 .. 8				
				Choc (74)	0	..	4 .. 8				
				Govt. House (64)	0	..	4 .. 8				
<b>Means (125)</b>	<b>0</b>	<b>..</b>	<b>0 .. 12</b>	<b>Means (85)</b>	<b>0</b>	<b>..</b>	<b>3 .. 9</b>	<b>Means (70)</b>	<b>2</b>	<b>..</b>	<b>2 .. 8</b>

*Temperature.*—This ranges from 64°F. to 93°F. during the year at Castries near sea-level. At higher altitudes in the interior of the island temperatures are much lower. The hot season extends from May to October and the cool season from December to March.

*Humidity.*—Relative humidity is high, varying from 66 per cent. to 95 per cent. at the hottest time of the day in different seasons. During the early morning before dawn the humidity is mostly 100 per cent. and dew forms copiously.

*Prevailing winds.*—St. Lucia lies in the hurricane zone but it is less liable to storms than islands farther north. There have been no destructive hurricanes in recent years.

**(IV)—AGRICULTURE**

*Natural vegetation.*—The original vegetation of St. Lucia consisted almost entirely of forests of different kinds. It showed a concentric zonation of forest types corresponding to the regular increase of rainfall with altitude. In the narrow coastal strip, where the mean annual rainfall lies between 50 and 70 inches but where a marked dry season exists, the original vegetation was probably a deciduous kind of low forest, though only few traces remain because of its long-continued exploitation for timber and fuel or its destruction prior to agricultural development (2). This coastal zone is now mostly occupied by stunted second-growth bush consisting chiefly of *Croton* species.

The next zone further inland lying at altitudes between 200 and 400 feet formerly consisted of semi-evergreen and evergreen forests developed under a wetter climate with rainfall between 70 and 80 ins. a year, in which the dry season is less evident or entirely absent. These forests also have been almost completely destroyed by man and are now represented only by second growths.

At higher elevations where the climate is continuously wet and the rainfall high, ranging from 80 to 100 inches a year, the vegetation comprises true mountain rain forest. This becomes very luxuriant where the conformation of the land offers shelter, but, as exposure to wind increases on the hill-crests and mountain ridges, the forest is somewhat stunted though dense, culminating on the highest peaks at elevations above 1,500 feet in thickets comprising gnarled stunted trees with no undergrowth. Much of this mountain forest has been damaged by agricultural exploitation and only a relatively small area (about 10,000 acres) of virgin crown-land forest now remains, as, for example, in the Castries Waterworks Reserve in the Piton Flore district and the main-ridge forest occupying the high land north of Quillesse.

*Agricultural lands.*—It is estimated that, out of a total area of 152,000 acres comprising St. Lucia, only about 23,000 acres were under cultivation in 1938 <sup>(3)</sup>. A part of this is under shifting cultivation and is not continuously worked. There are, in addition, about 12,000 acres of pasture land. Agriculture is divided between estates and small-holdings. Peasants for the most part own their land, but a certain amount of estate land is worked on the share system. There are a number of squatters in the interior forest lands. In 1942 the area under estates was about 100,000 acres, that owned by peasants about 37,400 acres, leaving 15,000 acres of Crown lands <sup>(4)</sup>. Agricultural development in St. Lucia has been restricted by the existence until recent years of alternative sources of employment, for example the coaling of ships at the wharves in Castries. The recent decline of the bunkering trade and the closure of outlets for immigration have accentuated the need for the extension of peasant agriculture. One of the main functions of the recently enlarged Agricultural Department in St. Lucia will be the progressive utilisation of land under systems of small-scale agriculture.

*Chief crops.*—The chief crops cultivated by estates are sugar-cane and coconuts, with cacao and limes as minor crops. These crops are also cultivated by peasants in small holdings, but mostly peasants grow ground provisions, vegetables and various fruits. Some estates provide part-time employment to peasants. An export trade in bananas grew up some years ago but it came to an end during the recent war through lack of shipping. The history and development of the banana industry in St. Lucia during the years 1922-41 are fully dealt with in a later section.

The approximate acreages under various crops in 1944 were: cacao 2,500, limes 1,500, sugar-cane 3,000, coconuts 4,600, food crops 8,100, and bananas 300 acres <sup>(5)</sup>. The sugar industry is the present mainstay of the island and the largest source of employment. Its confinement to the alluvial flats in which the sugar-estates are situated precludes centralisation in one large factory. The lime industry is suffering from a general dying-out of the cultivations, as in Montserrat and other West Indies islands at the present time; the cacao industry is also in decline.

#### (V)—GEOLOGY

The only published account of the geology of St. Lucia is that written by K. W. Earle in September, 1923 <sup>(6)</sup>. Some notes on the physical geography of the island are included in a book written by W. M. Davis, a distinguished American geomorphologist who spent nine days on the island <sup>(7)</sup>. Much of the information contained in the Royal Society's publication on the volcanic history and petrology of Montserrat written by A. G. MacGregor in 1937 <sup>(8)</sup> is applicable to St. Lucia.

*Geological history.*—MacGregor writes: "It may be taken as well established that intermittent local volcanic activity has been going on along the main volcanic arc (of the Lesser Antilles) for a period that is very long from a human standpoint, and to be measured certainly in millions of years."

Following MacGregor's method of tabulating the geological history of Montserrat as a sequence of volcanic events, the following summary is offered to indicate the probable relationships between the three main volcanic regions of St. Lucia and their mode of formation.

## THE PROBABLE GEOLOGICAL HISTORY OF ST. LUCIA

<i>Geological period</i>	<i>Volcanic events</i>	<i>Approximate age</i>
(I) LATE MIOCENE OR EARLY PLIOCENE EMERGENCE	Eruptions that formed the main mass of the island (Region (1))	10,000,000 years ago
(II) PLIOCENE TO EARLY PLEISTOCENE PERIPHERAL SUBMERGENCE	Coastal and subaerial denudation of main mass	8,000,000 ,, 2,000,000 ,,
(III) PLEISTOCENE (GLACIAL) PERIPHERAL EMERGENCE (formation of conti- nental ice-sheets)	Eruptions of mid-western volcanoes (Region (2))  Eruption of volcano or volcanoes that formed the great south-western glacis (Region (3))	40,000 ,,  25,000 ,,
(IV) RECENT (POST-GLACIAL) PERIPHERAL SUBMERGENCE (melting of ice- sheets)	Subaerial denudation of all volcanoes in St. Lucia. Coastal denudation producing present submarine bank and sea-cliffs	20,000 ,,
(V) SEA-LEVEL AS AT PRESENT DAY	Subaerial and coastal denudation continuing	Present day

The above scheme indicates that the volcanic materials forming the central region or main mass of the island have been subjected to rock weathering and land denudation for a very long period of time. This accounts for the mature topography, the subdued rounded land-forms and the broad shallow valleys, as well as the almost complete obliteration of the initial volcanic cones and craters. The ancient volcanic materials consisted largely of lava flows, although massive agglomerates and beds of cinders, ash and dust were also deposited in considerable quantity. Much of this fragmental material has been swept away from the interior parts of the island, exposing the central core of solid rock. Outcrops of lava may nowadays be seen in road cuttings in the central region and at a few places round the coast, for example in the headlands south of Castries harbour.

The lapse of time during which denudation was going on before the Late Pleistocene outburst of volcanic activity occurred was apparently very extensive, probably well over 6 million years. Activity was first renewed in the western part of the island. Subsequently, it was continued or recrudesced as black cloud eruptions that formed the great south-western glacis. During this time the island had emerged considerably, owing to the removal of enormous quantities of water from the ocean by the formation of extensive continental ice sheets which marked the Great Ice Age. When deglaciation occurred later, through the melting of the ice in geologically Recent times, the return of the water caused an apparent partial submergence during which the submarine bank which now encircles the island was carved out by marine erosion and the ends of the hill-spurs were truncated by wave-action, giving rise to the present-day sea-cliffs.\*

The age of the Late Pleistocene eruptions which

\* MacGregor (8) points out that this explanation of the formation of marine shelves and truncated spurs which are common around West Indies volcanic islands, due to T. Wayland Vaughan (1919) and supported by R. A. Daly (1935), is more satisfactory than the coral-reef theory of coastal protection postulated by W. M. Davis (?).

built up the mid-western section or second volcanic region of St. Lucia is probably about the same as that of the eruptions which began the formation of the Soufrière Hills in Montserrat, since an active soufriere occurs in the middle of the area inland from Petit Piton which seems to be in the same stage of development as Gage's Soufriere in Montserrat. All the active soufrieres of Montserrat occur in the Soufrière Hills, which were the last formed of the island's volcanoes. According to MacGregor's table, the Soufrière Hills volcano began to erupt about 40,000 years ago, and this is the age accordingly assigned to the mid-western St. Lucia volcanoes. Only extinct soufrieres occur in the Centre Hills which are the oldest of the Montserrat Pleistocene volcanoes, whose age is estimated at about 500,000 years, so that the mid-western volcanoes of St. Lucia must be much younger than this.

A further check on the age of the mid-western volcanic section of St. Lucia is afforded by the occurrence of fossiliferous coral limestone at Stonefield Estate above Malgretout lying a little to the north of Petit Piton at elevation of about 100 to 150 feet. Here there are two small limestone exposures, one 50 feet higher than the other. The identity of the fossils (which include many of the forms listed by MacGregor from the Roche Bluff limestone of Montserrat) indicate that the age of the limestone could not be earlier than Pleistocene. Similar outcrops of Pleistocene limestone have been recorded from other West Indies volcanic islands, for example Grenada, Dominica, St. Kitts, and St. Eustatius. In each case the outcrops are situated at elevations well above the present-day sea-level. In order to explain their almost ubiquitous occurrence in the Caribbean Volcanic Region, it has been suggested (?) that widespread banks of coral were first formed over the older volcanic residuals before the younger cones were built up, and that, during these later eruptions, masses of limestone were detached from the ocean bed

and uplifted by the new ejecta. The occurrences could equally well be explained, however, by postulating a general uplift of the whole area during or after the volcanic activity had taken place.

The age of the volcano or volcanoes which erupted the material forming the great south-western glacis of St. Lucia, comprising the third topographical region, must be somewhat less than that of the mid-western volcanoes, judging by the immature features of the river valleys or ghauts that occur over the glacis, and may be assessed at about 25,000 years (Late Pleistocene).

The most recent major geological event which apparently affected the whole island was a general uplift of some 50, 100 or 150 feet which produced the flat plain of the Vieux Fort district in the south and the raised beaches of the Gros Islet district in the north, as well as the limestone outcrop above mentioned. Certain of the subdued northern hills may once have been independent islands rising out of lagoons that occupied the submarine bank before its final submergence (?). The infilling of the lagoons by alluvial material, much of which is calcareous, having probably been derived from fringing coral reefs, coupled with the slight land elevation, has converted the area into a series of linked alluvial flats and broad beaches of recent origin.

#### (VI)—LITHOLOGY

The chief rock-types comprising the volcanic rocks of St. Lucia, including both fragmental materials and lavas, are the same as those of the other West Indian volcanic islands, namely, andesites and basalts (<sup>6</sup>). The chief felspar present is labradorite and the chief ferromagnesian minerals augite and hypersthene. Magnetite and olivine also commonly occur. Many of the newer andesites are rich in quartz and resemble bandaite (labradorite-dacite), which is the chief rock-type of Montserrat (<sup>8</sup>). Some contain mica as well as quartz and thus approximate to diorites. The quartz weathers out as clear glassy crystals resembling fine white sugar, and the mica is usually chloritised to golden-yellow spangles; both products are common in alluvial materials, surface-wash and soil, particularly, though not exclusively, within the south-western glacis region. The coarsely crystalline igneous rock comprising the two great Pitons contains characteristic pink-coloured quartz, phenocrysts of labradorite or andesine and elongated crystals of augite or hornblende, set in a grey fine ground-mass (<sup>6</sup>).

The igneous rocks of which the old basement lava-flows are composed show marked concentric or "onion" weathering. The rounded kernels are usually covered with crusts of orange-coloured gibbsitic laterite which gives rise to Red Earth by resilication, as in Grenada (<sup>9</sup>).

The fragmental rocks resemble those of the other volcanic islands, for example Montserrat. They include agglomerates, breccias, cinders, grits, sands, ash and dust. The agglomerate boulders

may reach enormous size; they are generally sub-angular or angular. Fine horizontally-stratified ash-beds occur in the north, where they may be seen in coastal or road sections; they are apparently not true water-laid tuffs (<sup>6</sup>).

#### (VII)—SOIL FORMATION

*Soil-forming factors.*—The formation of a fertile soil from any given parent rock is brought about by the operation of four chief factors, namely, climate, vegetation, topography and time. It is not intended here to discuss in detail the mode of operation of these factors, since the subject has recently been fully dealt with in the case of the Montserrat soils described in a previous report (<sup>10</sup>).

Some of the parent fragmental rocks of St. Lucia closely resemble those of Montserrat, for example the "black cloud" deposits comprising the southern glacis in the south-western Vieux Fort district and the newer volcanic agglomerates occurring in the mid-western region near the great Pitons. On the other hand, old volcanic lava is much more conspicuous in St. Lucia than it is in Montserrat, and river alluvial and delta deposits are much more widespread and common in St. Lucia. The same climatic, vegetational and topographic factors have been operative and are just as important in St. Lucia as in Montserrat and the other West Indies volcanic islands, although minor differences may be noted. For example, the magnitude of the mean annual rainfall is much greater and the area subject to relatively high rainfall (over 70 ins. a year) is much more extensive in St. Lucia than in Montserrat, so that the original natural vegetation of St. Lucia must have been more luxuriant and must have shown a wider distribution of rain forest and wet-seasonal forest than that of Montserrat. This intensification of the rainfall factor and the vegetational factor has doubtless been responsible for the higher degree of rock weathering which is evident in St. Lucia and the greater accumulation of organic residues contributing to the upper humic soil layer. The time factor has perhaps been largely responsible for the deep rock weathering and the extensive accumulation of soil organic matter in the older central parts of St. Lucia which have been exposed to climatic and vegetational agents of soil formation for a much greater length of time than has any part of Montserrat with the possible exception of the Silver Hill district, which, however, is relatively much drier.

*Effects of erosion and transportation.*—The rate of soil formation, as determined by the efficacy of soil-forming factors operating in any particular area, depend largely on the relative rate of soil removal by erosion and transportation. This in turn depends on topography as well as on time. The greater the slope, the more likely is the soil to be removed as fast as it is formed, leaving a continually-bare rock surface. Other conditions besides slope also affect the rate of soil removal, for example the degree of protection afforded by the vegetation, and the infiltrability, permeability and depth of the soil or its parent material. Thus,

on exposed steep slopes in immaturely-developed country, only the most pervious parent materials, appropriately protected by a cover of vegetation, can resist or escape erosion, whereas, on level topography, such as flat hilltops, plateaus and low-lying plains, erosion is greatly reduced and soil formation and accumulation proceed unchecked. These various circumstances are well illustrated by the conditions occurring in St. Lucia and by the main features and distribution of the chief soil-types.

### (VIII)—THE CHIEF SOIL-TYPES OF ST. LUCIA

*Classification.*—In accordance with the principles of soil formation considered fully in the Montserrat report (<sup>10</sup>) and amplified in the last section, the chief soil-types developed in St. Lucia may be named and classified as follows:—

- |   |                   |
|---|-------------------|
| (A) FRESH, UNALTERED, LOOSE PARENT FRAGMENTAL VOLCANIC MATERIALS. | <i>Soil-types</i> |
| (1) LITHOSOL  |                   |
| (2) COLLUVIAL AND SANDY ALLUVIAL SOILS                            | AZONAL            |
| (B) PARTLY-WEATHERED, LOOSE PARENT MATERIALS.                     |                   |
| (3) BROWN EARTH—from coarse materials                             | INTRAZONAL,       |
| (4) YELLOW EARTH—from fine-grained materials                      | CALCIMORPHIC      |
| (C) WELL-WEATHERED, LOOSE PARENT MATERIALS.                       |                   |
| (5) RED EARTH—  |                   |
| (i) RESIDUAL  | ZONAL,            |
| (ii) TRANSPORTED (CLAYEY ALLUVIAL)                                | " LATERITIC "     |
| (D) PARTLY TO WELL-WEATHERED, CEMENTED PARENT MATERIALS.          |                   |
| (6) TERRAS SOIL—partly cemented below                             | INTRAZONAL,       |
| (7) SHOAL SOIL—well-cemented and indurated below                  | HYDROMORPHIC      |

These soil-types are fully described, with the exception of Red Earth, in the Montserrat Report (<sup>10</sup>).

*Distribution.*—The distribution of the soil-types in St. Lucia is indicated in the accompanying reconnaissance soil map. The sites where the profile soil samples were taken are shown by ordinary numbers in circles, and where surface samples were taken in peasants' holdings, by small Roman numerals. The numbers correspond to those given in the tables of laboratory data forming the Appendix. The areas occupied by the different soil-types correspond closely with the physiographical regions differentiated in an early section, as follows.

#### (I) CENTRAL REGION

The geologically-oldest and the topographically most mature part of St. Lucia was originally mainly occupied by *Residual Red Earth* soil which had developed typically over a thick layer of uniform intensely-weathered parent materials derived from basaltic and andesitic lavas and

agglomerates comprising the basement rocks of the island. The fact that the red clayey parent material has been profoundly weathered and leached by the heavy rainfall operating over a long period of time implies that most of the mineral nutrient elements (potassium, calcium, magnesium and phosphate) have long since been removed and lost. The residues remaining consist, therefore, almost solely of a highly acid mixture of kaolinic clay, quartz and red iron oxide which has in itself no value whatever as a medium for plant life. During rock-weathering, a considerable amount of nutrient bases and phosphate, liberated from the original primary minerals, was progressively fixed, however, by growing vegetation and eventually returned to the surface of the soil and incorporated into the forest litter. Thus, when the forest had reached its climax development, a rich reserve of plant nutrients had accumulated in the surface humic layer, whence it was available for circulation and usage by successive generations of living vegetation. The subsequent felling of the luxuriant forest immediately interrupted this circulation of nutrients and exposed the soil with its accumulated nutrient organic reserves to removal and loss through solution, leaching, transportation and surface erosion.

*Forest soil deterioration.*—The drastic changes which ensued when the forest was felled for the purpose of establishing a banana industry in the central mountainous humid region of St. Lucia have been graphically described by E. A. Walters, formerly Superintendent of Agriculture in St. Lucia (<sup>11</sup>), (<sup>12</sup>), and by C. W. Wardlaw, Pathologist in charge of Banana Research at the College (<sup>13</sup>), (<sup>14</sup>), (<sup>15</sup>).

*History of the Banana Industry of St. Lucia.*—The first clearings of about 200 acres in extent were made in Crown-lands forest in 1922 in the Ravine Poisson area on the Castries-Dennery main cross-country road at an altitude of about 400 feet. The annual rainfall here is 100 inches. The topography is rugged and consists of steep ridges and narrow valleys. Preparation for planting consisted in felling the larger trees and cutlassing and burning the underbush. Later, the clearings were extended southwards in the direction of M. Lacombe in the middle of the main ridge of the island. The total area cleared and planted up to the end of 1926 was about 5,000 acres. Panama disease by this time had rendered the original banana area unprofitable and it was therefore abandoned. Soon afterwards the promoting company became insolvent and further development ceased.

The banana industry of St. Lucia was revived in 1933, when a Canadian banana company arranged to buy and ship fruits abroad. Banana nurseries were opened in the Mahaut Valley in the mid-western region, at Quillesse and at Barre de L'Isle near Ravine Poisson in the central region,

and in the Dennery Valley in the north-eastern part of the island. By the end of 1935, some 830 acres of new banana land had been established, mostly by peasants. A special land settlement scheme had been devised for the Quillesse district and a cross-country road (Murray Road) had been opened up to the east coast at Micoud to give access to it. This scheme was modified in 1937 in recognition of the general unsuitability of the terrain and the need of conserving the remaining forest lands. The unusually rainy weather of 1938 severely damaged the existing banana cultivations, and this, together with the cessation of steamer transport during the War, finally brought about the downfall of the industry for the second time in twenty years.

A dismal picture is drawn by Wardlaw<sup>(14)</sup> of the conditions existing within the St. Lucia abandoned banana lands. The following three abstracts, taken from his article, will suffice to indicate the nature and extent of the changes that had occurred.

(1) "The entrance to the Ravine Poisson is now (1928) a grass-grown barren waste with an occasional short-lived peasant's garden. The roadways and tracks . . . are now overgrown with bush and here and there obliterated by land-slides. . . . The soil in its virgin state was fertile. . . . In the course of a few years, however, high precipitation, rapid and extensive soil erosion and depletion of organic matter, coupled with the lack of any adequate system of conservation, have led to marked soil deterioration. The Gros Michel banana, which requires good soil conditions to flourish, thus finds itself in open competition with a native weed flora less exacting in its requirements, and is slowly being ousted. The dominant weed flora which has appeared in the Ravine Poisson plantations consists of *Cecropia palmata* (Trumpet Tree), *Sciadophyllum* (an Araliad) and *Cyathea* sp. (a tree fern)."\*

(2) "In the Cul-de-Sac Crown Lands, opened in 1923 and abandoned in 1926, the country consists of steep hillsides dissected by gullies. In the latter the Gros Michel is still holding its own, but on the open hillsides between the gullies the plants are being overgrown by bush of which a species of *Miconia* is dominant."

(3) "Adjacent to the Ravine Poisson are the Crown Lands of Cendre d'Cie and Vanard. These were also planted in bananas in 1924 and abandoned in 1926. Here again bananas on the exposed hillsides are overgrown by *Cecropia*, *Sciadophyllum* and *Cyathea*, while occasional groups of good plants are still prominent in localised spots. In all these districts one cannot fail to be impressed by the close relation between the survival of the Gros Michel and the quality and condition of the soil."

\* This account was written in late 1928; in 1938 following a period of continuous rains unprecedented in the recent history of the island, a severe débris-avalanche or landslide occurred in the Ravine Poisson area. (See under Soil Erosion).

In order to identify the nature and extent of the factors operating to produce soil deterioration in the abandoned banana lands, Wardlaw carried out a comparative study of peasants' gardens of different ages<sup>(14)</sup>. In preparing a "garden", the peasant fells the trees down the slope and burns the wood and the undergrowth to effect speedy clearance. The land is then used for growing ground provisions for a couple of years; subsequently it is abandoned and allowed to go back into bush, or it may be grazed if a grassy hillside results. The wastage by oxidation of organic matter and the exposure of the land to sun and rain that result from this procedure are sufficient under the rigorous climatic conditions that obtain in the central region of St. Lucia to cause such a high degree of soil degeneration that even common root-crops cannot be grown satisfactorily. The area of forest land which has been cleared and abandoned in this way is already very considerable.

The main soil features of four different areas of virgin forest land in St. Lucia are described by Wardlaw from shallow profile observations<sup>(14)</sup>. He notes that, although the "amount of accumulated surface leaf-mould was not observed to be great", the thickness of the layer below, consisting of "dark, loamy soil in good condition, with uniform texture and roots distributed downwards", may be considerable, ranging from 12 to 24 inches, and passing gradually into weathered rock below. Near the crests of ridges, "at least twenty inches of weathered soil with the top four to six inches rich in organic matter were found". The hilltop soils, however, are not so good as those lower down.

By contrast, the soil of abandoned banana lands and peasants' gardens is "poor in organic matter", and comprises "a sticky, clay-like soil (which directly) overlies partially-weathered volcanic rock below or passes into an intractable yellow clay subsoil". The chief difference which was found to distinguish the soil of untouched areas of forest land, accounting for their superior fertility as contrasted with worn-out abandoned lands, was the greater depth of their soil parent material that has been modified by the infiltration or incorporation of organic matter. This difference was thought to depend "to a great extent on the texture of the soil and its capacity for absorbing organic matter". Thus, some stiff clays absorbed very little organic matter and developed a humic layer of thickness no more than 3 or 4 inches, with a sharp line of demarcation between it and the clay. Most of the St. Lucia soil parent materials, however, consist of "open, crumbling, weathered rock, highly suitable for the absorption of plant remains"; they may therefore initially be very fertile.

From these pertinent observations and conclusions, fully supported by the independent observations recorded by Walters<sup>(12)</sup>, Wardlaw concludes that "one of the main reasons for the great difference between virgin land and abandoned areas lies in the fact that the forest soil is kept in position, even on steep hillsides, and is not subject

Table II  
Organic Status of Soils of Central Region as Affected by Exploitation

NATURE OF SITE	Sand (%)	I.T.	Re-action (pH)	O.M. (%)	Total N (%)	C/N ratio	Avail. nutr. (mhos $\times 10^{-6}$ )	Rate of soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O
(A) NATURAL FOREST LAND										
<i>(a) Untouched and undisturbed</i>										
LCA. 130. River flat .. ..	14	—	5.2	18.0	—	—	—	—	11	190
128. Slope .. ..	36	41	5.2	11.0	.56	11.4	115	13	9	106
132. Road cutting .. ..	52	36	5.4	10.6	.47	13.0	144	51	10	171
147. Slope .. ..	36	41	5.8	5.8	.33	10.2	197	11	5	72
145. Flat .. ..	51	33	6.7	3.5	—	—	113	101	25	565
<i>(b) Cleared or cut over and regrown</i>										
LCA. 118. Brow flat .. ..	13	72	5.2	27.0	.77	20.4	295	0	10	191
120. Brow slope .. ..	32	51	5.6	12.9	.59	12.7	135	28	8	120
151. Slope .. ..	34	46	6.0	11.6	.51	13.2	156	31	6	498
124. River flat .. ..	29	46	4.6	8.5	.37	13.2	137	0	20	193
126. Slope .. ..	67	20	6.2	5.9	.29	11.9	181	23	18	1,140
(B) CLEARED FOREST LAND										
<i>(c) Peasants' gardens</i>										
LCA. 149. Garden .. ..	44	42	6.2	11.9	.57	12.1	206	56	14	239
140. New clearing .. ..	47	45	5.7	11.1	.48	13.6	189	111	49	395
134. Nursery .. ..	51	40	5.6	10.0	.43	13.5	132	34	32	553
155. Slope, garden .. ..	36	49	5.1	8.4	.42	11.5	96	0	23	202
115. Garden .. ..	34	41	5.8	7.6	.39	11.3	186	151	47	373
143. New clearing .. ..	32	45	5.9	5.6	.27	11.9	153	154	40	931
136. Nursery .. ..	48	28	6.0	4.2	.22	11.3	83	106	17	140
153. Slope, garden .. ..	48	30	6.4	3.0	.13	13.5	74	49	22	319
158. Slope, garden .. ..	27	45	5.5	2.8	.16	10.2	36	7	9	124
122. Cut over slope .. ..	55	33	6.2	2.6	.24	6.2	56	6	8	128
138. New clearing .. ..	48	29	6.5	1.5	.09	9.1	44	26	11	84

to the violent erosion which has proved so destructive over "exposed areas", and has removed "all the rich loose surface soil, leaving behind the less-friable poorer under-layers".

The possibility of natural regeneration in deteriorated lands and the length of time required to regain a high state of fertility is discussed by Wardlaw in the concluding section of his article; it will be considered in a later part of this report.

*Heterogeneity of the interior soils.*—The great variability in the visible features, as displayed in shallow profile sections, of the soils of the central region of St. Lucia, caused by their differing degree of surface erosion dependent on their past history of exploitation, abandonment and regeneration, is evident from the descriptions and laboratory data for the representative series of soil samples collected by E. A. Walters in the Murray Road (Quillesse) district in March, 1936, and afterwards analysed at the College. The full analytical results are tabulated in the Appendix (See under section (C), from which Table II has been constructed to show this variability).

In Table II, the sites are arranged according to their degree of disturbance into two main groups, namely, (A) natural forest sites, which have either been left untouched or have been cleared but have

become covered over again by forest-growths more or less resembling the original forest, perhaps by the coppicing of the old stumps, and (B) clearings and gardens made by peasants. In each section the sites are arranged in order of organic matter content (top 6 inches of soil). It should be noted that surface litter was removed before sampling, although in certain cases of garden soils some litter may have become incorporated by agricultural operations.

The data in Table II clearly indicate the great variability in the surface soils depending mainly on their past vicissitudes, but no useful purpose would be served by a detailed consideration of the numerical values. The sites where soil samples were collected in the untouched natural forest were either flat or sloping, and most were located in the vicinity of Piton Cochon. The sites where samples were collected in cleared and re-grown forest also included both flat and sloping land but most of the garden sites were hilly.

Only three soil-profiles were actually sampled by us in the central region of St. Lucia. The most typical of the Red Earth soil sampled was that seen at Ti Rocher (No. (22)), where Red Earth has developed in thick masses over quartz andesite (dacite) belonging to the old Miocene basement rocks and showing marked onion weathering. The

main features of this profile closely resemble those of typical Red Earth as developed in Grenada (9). The country here is densely settled by peasants who practise shifting cultivation with frequent burning. The main crop is cassava. Soil erosion is very prevalent.

The two other Red Earth soil profiles were seen at Quilesse. The site of one of them (No. (20)) was obviously an erosion "dump" or mass of avalanche débris; that of the other (No. (21)) occurred in the face of the scar in the hillside opposite whence the avalanche had come. Neither of the soils is typical Red Earth. The thin soil overlying fresh unaltered parent rock, consisting either of lava, agglomerate and finer fragmental material exposed when débris avalanches and landslides that are common in this region carry away the mature surface soil and its parent weathered material, comprises *Lithosol* and should strictly be mapped as such. The second profile mentioned above represents a soil of this kind. Similar occurrences, marking the sites of other débris avalanches, occur at frequent intervals along the Quilesse Road, as well as in many other places in the central region of St. Lucia, where shifting cultivation or banana clearings have deprived the land of its forest protection, especially on steep slopes.

When the bouldery and stony kinds of *Lithosol* are exposed to the agents of rock-weathering by deep soil erosion, they gradually produce the parent materials from which *Brown Earth* soil develops. The surfaces of the boulders acquire thin lateritic crusts, and their interiors decompose and soften, liberating rusty deposits of iron oxide and showing steely-blue smears of manganese oxide along the cracks. Around the rotting rock, a calcimorphic kind of clay develops, having neutral reaction and a coarse cloddy structure. Eventually, under the continued action of high temperature and high rainfall (provided the under-drainage is unimpeded), *Brown Earth* will eventually change into Red Earth.

In the central region, all stages may be observed

between mature Red Earth\* and its *Lithosol* erosional phase, and between *Lithosol*, *Brown Earth* and Red Earth in their developmental phases, as for example in the banks of the Quilesse Road freshly cut at the time of our visit. Consequently, the area should not be mapped as uniform Red Earth, but rather as a complex with Red Earth, *Brown Earth* and *Lithosol* as its main components. This procedure has accordingly been followed in the provisional soil map of St. Lucia issued with this Report.

During his forest surveys, J. S. Beard recorded the occurrences of Red Earth, *Brown Earth* and *Lithosol* along each of twelve main traverses which he carried out within the Central Region. The sum of the measured linear exposures of Red Earth were about 9 miles, of *Brown Earth* 5 miles, and of *Lithosol* 5 miles. The approximate proportionate areas occupied by each of the three soil-types were thus 60, 20 and 20 per cent. respectively. Beard noted that compact Red Earth Soil generally occupies the hill crests covered by undisturbed mountain rain forest. The valleys, hollows and bottom lands covered by lowland rain forest are likewise occupied by Red Earth, although the coloration tends to be yellow or orange rather than red, doubtless because of less complete dehydration of the soil parent material. The slopes, however, are covered by an intermediate forest type, or where very steep, by a poor open kind of forest containing many palms. Here the soil comprises *Brown Earth* and *Lithosol*, the latter generally occupying the steepest or middle part of the slope where the surface soil is least stable and where slippage movements have the most frequently occurred.

The forest soil profiles described by Beard (see Section D, Appendix Tables) show this sequence clearly. Sites F3, F4 and F5 are *Red Earth* sites and occur on gentle slopes occupied by lowland rain forest. Their coloration varies from yellow or yellow-brown to orange and red. The last site (F5) is perhaps not quite typical, being too shallow. Site F2 is a *Brown Earth* site and is very bouldery

\* Two specimens of *Red Earth* soil parent materials, collected from the Quilesse road-bank at 2 ft. depth, were chemically analysed. The results for the clay fraction are presented below. The first sample was crimson in colour, and was probably derived from a quartz-free andesite. The second was tawny-brown or orange and was associated with an outcrop of basalt.

RESULTS OF BULK CHEMICAL ANALYSIS OF CLAY FRACTIONS (2μ)

Sample	SiO <sub>2</sub>		Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	K <sub>2</sub> O	H <sub>2</sub> O	Molecular ratios	
	Quartz	Combd.							SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>
	Per cent. oven-dry material									
LCA.										
(1) 358. Crimson ..	0.7	40.6	33.8	11.0	0.03	1.16	0.03	14.1	2.03	0.43
(2) 361. Orange ..	0.7	40.2	33.9	12.0	0.03	0.91	0.15	14.1	2.01	0.43

An amount varying between 7 and 17 per cent. of alumina absorbs alizarin and is probably *gibbsite* (Al<sub>2</sub>O<sub>3</sub>.3H<sub>2</sub>O) or perhaps colloidal alumina. The rest of the alumina is combined. To balance the free alumina a proportionately large amount of free silica must also be present so that the silica-alumina ratio is maintained as 2.0, the ideal ratio for kaolinite which is the characteristic mineral of Red Earth. Total potash and lime are particularly low in amount in these samples which closely resemble each other in composition.

below. No example of forest *Lithosol* is described. (The remaining sites described by Beard are outside the central region.)

The Red Earth-Lithosol-Brown Earth sequence is a true topographical-erosion catena and appears to be widespread throughout the central region of St. Lucia, even within areas where the forest has not been disturbed or has suffered least interference by man, for erosion is a natural geological phenomenon and occurs continuously on the slopes to lesser or greater extent. The effect of tree-felling, cutlassing and burning is merely to encourage or accelerate natural erosion, so that, in clearings, banana plantations and peasants' gardens, the mature soil-cover with its nutrient-rich humic surface layer, is rapidly removed and fresh volcanic rock is exposed, thus starting a new cycle of soil formation.

*Peripheral parts of the Central Region.*—The circumstances and conditions described in the last two sections apply more particularly to the region of the main central ridge. Further north and eastward to the coast the topography becomes less rugged and comprises rolling country with rounded hills and broad shallow valleys and flats. The exposed Miocene basement rocks have here become consolidated, indurated and cemented into *Shoal*. The formation of this hard impervious material may partly have gone on under sea-water during the Post Glacial submergence, when conditions favouring mineral hydrolysis, hydration and the production of new secondary clay minerals generally prevailed. The final slight emergence which followed this period of inundation, and which gave rise to the present-day raised beaches of the southern and northern ends of the island, elevated the peripheral area sufficiently high to expose the shoal as a narrow belt running almost completely round the island (see soil map). The origin of the shoal is therefore most likely geological and not pedological as would be the case had it evolved from *Lithosol* or *Yellow Earth* by the mere sealing-up of the B-horizon of the profile.

The rainfall over the coastal shoal belt of St. Lucia is lower and the surface drainage is more sluggish than over the rest of the central region. These circumstances, coupled with the greatly-impaired internal drainage of the parent rock itself, have developed a hydromorphic type of soil (*Shoal Soil*) similar to that occurring in the northern part of Montserrat, for example, at Iles' Bay and Olveston<sup>(10)</sup>. The development of shoal soil, as indicated by the results of chemical and mineralogical analysis of profile samples collected near the soil conservation experimental area at Morne Giraud (Site No. (24)), is described in a later section. The shoal soil at this place consists of 12 inches of black, humic, gravelly clay merging into pale brown-pink, very stiff, horny, cracked clay overlying, at 20 inches depth, hard grey-speckled shoal of unknown thickness.

Erosion has removed most of the topsoil over the shoal of the coastal belt and of the Gros Islet district in the north. Little agricultural land remains and the ground is mostly occupied by

thorn bush. The cemented rock consists chiefly of conglomerate comprising rounded boulders and stones resembling coarse concrete.

The shoal of the east coastal belt and the north merges near Cap with the peculiar calcareous coral-sand alluvium of the raised beaches which has already been noted. An example was investigated in profile at Cap (No. (25)). The soil here is a hard, dark chocolate-red, stoneless clay overlying at 30 inches depth, hard speckled shoal of unknown thickness.

*Alluvial flats of the Central Region.*—The three large river valleys occupied by sugar estates (Cul-de-Sac, Roseau and Dennery) have been carved out of the old Miocene basement rocks during their profound denudation and afterwards filled with alluvium eroded off the hills. The alluvial material thus mostly consists of Red Earth. It must have been continually replenished by humic hill-wash so that its fertility originally was doubtless relatively high. Such "living" river alluvium comprises one of the very best kinds of soil parent material. Nine examples of alluvial soil were investigated in the three valleys mentioned (Nos. (26) to (34) inclusive) and one further north in Union River Valley (No. (23)) in the lands of the Agricultural Experiment Station.

The general appearance of the sugar-cane alluvial soil profiles does not suggest that they are typical "living" soils. One of them (Roseau 2, Site No. (30)) indeed shows marked humic stratification indicating the occurrence of one, or possibly more, old buried soils, and another profile (Dennery 1, Site No. (32)) also shows faint signs of humic stratification, but the rest have normal profiles, dark-coloured on top, grading downwards at about 30 inches into orange-red, yellow-brown or yellow, non-humic transported silt, silty-loam or loam. All the soils show unmistakable signs of former impeded drainage which has produced in their profiles characteristic hydromorphic features such as a marked rusty mottling just below the humic layer, and a grey coloration ("gley") in the subsoil below the 48-inches depth. In addition, abundant sepia spots, rich in manganese oxide, occur in some of the profiles along with the rusty mottling. This feature is believed to develop best where the climate shows a marked dry season during which water moves upwards in response to surface evaporation.

The northern clayey river alluvial soils would strictly be classed pedologically as *Half-Bog Soils* (Intrazonal, Hydromorphic). One of them (Roseau 3, Site No. (31)) is a true *Bog Soil*; its profile shows a superficial layer of loose coarse sand, 10 inches thick, overlying cheesy black peat to 43 inches depth, separated by a one-inch layer of white clay from a mass of partly-decayed fibrous brown wood. It is said that a swamp covered the area around this site about 60 years ago. The swamp has since been artificially drained and the land brought into sugar-cane cultivation.

The nutrient status of these alluvial soils will be considered later. Certain differences exist between the soils of the different valleys, indicating

differences in the kind of parent material. Thus it is likely that the alluvium of the Roseau Valley has been at least partly derived from the newer sandy volcanic deposits comprising the mid-western district next to be described, whereas that of the Cul-de-Sac Valley has been solely derived from the old Red Earth clayey residual accumulations of the central region (see soil map). The Dennery deposits probably had a more mixed and variable origin.

### (2) MID-WESTERN REGION

The mid-western, geologically-young, mountainous region, having rugged immature topography, is mostly occupied by Brown Earth, although Yellow Earth may also be associated with it as well as Shoal in the narrow coastal belt, and sandy Alluvial soil in the small estuaries and river flats. Four examples of Brown Earth were studied in profile in the Soufriere district within the mid-western region (Nos. (1), (6), (7), (8)), and two examples of river Alluvial Soil (Nos. (2), (10)).

The land surface here is covered with large boulders. The northern section inland from Canaries possibly comprises a mature dissected glacis composed of tuff and conglomerate associated with a basaltic lava flow whose lithological features may be observed in the truncated headlands and coastal cliffs exposed between Anse La Raye and Soufriere. The lower slopes of this glacis are occupied by thorn scrub and the soil appears to be geological *Shoal*, not unlike that occurring along the eastern coast. No examples were examined.

The *Brown Earth* soils typically developed in the Soufriere district are exceedingly stony and are generally underlain by masses of boulders. The stones and smaller boulders near the land surface are more or less soft and rotten, but the larger rocks still show hard unweathered kernels. Red-brown sandy soil occupies the spaces between the boulders; the soil samples had to be picked out, they consist mostly of this sandy material.

The *Alluvial* soils as examined at Soufriere and Anse Mamin, lying to the north, are fine-sandy and humic to about 12 inches, below which there is a mass of rounded boulders with layers of coarse sand and grit between.

The main road going south from Soufriere crosses very rugged country with masses of huge black boulders strewn over the land. Small steep hills alternate with narrow rocky valleys running down to the low ground at the foot of the steep scree of the two great Pitons. There are three "etangs" in this district, that is, small lakes having floating "sud" which supports an island vegetation consisting of bush and grass on which cattle feed.

### (3) SOUTH-WESTERN REGION (CHOISEUIL-VIEUX FORT)

*Yellow Earth and Terras Soils.*—The geologically newest and the topographically least mature part of St. Lucia is occupied by Yellow Earth and Terras Soil, which have developed over the thick

"black-cloud" deposits that form the gently-sloping glacis originating near M. Grand Magazin and spread fan-wise down to the southern and south-western coasts. The Terras soil is represented by one of the Morne Lezard profiles (Site No. (4)). This has been derived from gritty volcanic ash nearly devoid of stones but containing abundant small glassy quartz crystals. Incipient cementation occurs in the 12 to 36-inch layer. The cement is a clayey material which renders the soil tough and leathery. The topsoil is black in colour and highly acid in reaction (pH 5.3) but the terras below is red-brown and somewhat variegated; its reaction is only slightly acid (pH 6.6). The uncemented ash below is soft, bright brown, coarse and quite loose, at least down to 105 inches depth.

A second terras soil profile (No. (5)), also examined at Morne Lezard, is slightly abnormal in that it is located in a hollow spot that might once have held an "etang"; this soil shows certain hydromorphic features.

The third Morne Lezard soil (No. (3)) is a sandy river *Alluvial Soil* occurring at the bottom of the ravine of the River Dorée about 2 miles inland. The site is in a small cacao field near an old sugar-mill. The sandy profile shows no unusual features.

Terras Soil occurring on the southern glacis was also examined in a road cutting going down to Union Vale Estate (Site No. (9)). The site lies on the extreme western edge of the glacis, but the profile is not quite typical. It shows hard, compact, cemented pink terras between 12 and 32 or 48 inches. The soil is brown and highly acid (pH 5.6); the terras is less acid (pH 6.1).

The only other site where glacis Terras Soil was examined and sampled lies within the Vieux Fort area at La Retraite sugar-estate (Site No. (17)) near the foot of Beausejour Hill. The profile shows a 36-inch layer of humic hill-wash on top, overlying quartzose volcanic ash, cemented below 58 inches into greyish-yellow hard terras. Reaction differences are not very great in this profile. A deep pit dug by the American military authorities in the vicinity of this last site and due south of it at La Resource estate showed 9 inches of red-brown, uniform, sandy-loam soil, sharply overlying hard, rusty-speckled clay, with a terras layer starting at 24 inches and changing gradually below 54 inches into stoneless, loose, greenish-grey unaltered volcanic ash or sand alternating with layers of fine gravel and coarse grit. Another similar pit, still further south, showed a similar sequence except that the terras layer was deeper and thinner. Evidently considerable variation, both lateral and vertical, occurs in the Terras soil profiles developed over the south-western glacis, and only detailed augering and mapping in the field could decide their relationships and distribution.

*Shoal Soil.*—The old residual hills that emerge above the level of the lower slopes of the glacis and the alluvial flat that merges with it in the Vieux Fort district are covered by Shoal Soil re-

sembling that occurring in the north of St. Lucia. One example was investigated at Black Bay estate (Site No. (16)). This shows the usual stiff, horny clay soil, black on top, shading into dull brown, speckled grey and rusty-red with the sandy disintegration products of the parent rock and charged with numerous small, partly-decomposed stones, sharply overlying, at 16 inches depth, a mass of small grey boulders and rounded pebbles filled in with coarse rusty sand, the whole cemented hard in a clayey matrix. Many of the boulders have laterite crusts and spheroidal shells, characteristically forming the outer layers of weathered basic igneous rocks. The reaction profile is highly acid throughout (pH 5.8 in the soil to pH 4.9 in the shoal). The soil is evidently highly leached and devoid of bases, denoting an advanced stage of maturity. The surface layer contains abundant black, shot-like pisoliths rich in manganese oxide (6.3 per cent. MnO), a hydromorphic feature which denotes marked waterlogging in wet weather followed by uplift of water in the dry season. In many respects this soil, therefore, resembles *Ground-Water Podzol*, which is a Hydromorphic Intrazonal soil-group. The cemented layer is undoubtedly "geological shoal", which probably developed mostly under sea-water during the Post-Glacial submergence.

Near the Black Bay site and further south across the main road is a water-well which supplies staff-houses in the vicinity. This well struck water at 52 feet. It shows a concrete-like *shoal* near the top composed of boulders and pebbles set in a hard sandy-clay matrix, merging, at 36 inches, into a bed of firmly-cemented sand and small stones, overlying, at 66 inches depth, loose, uncemented, yellow volcanic ash of indefinite depth. Between 45 and 50 feet this ash is hard and well cemented. The most striking feature of the deep profile, however, is the occurrence, immediately below the second hard zone, of a layer, 4 to 6 inches thick, of pure-white powdery calcium carbonate. The cement of the zone above consists also of the same substance. Below the lime layer the ash is again loose, soft and uncemented. Evidently, therefore, the limit of water penetration in this area is about 50 feet, for lime is usually deposited deep down in the soil profile where downward percolation of water ceases.

*Alluvial Soil.*—The soils covering the raised beach at Vieux Fort, comprising about 4 square miles of flat land, now an American military base and aerodrome, were formerly utilised for sugar-cane growing. The first sugar estate in St. Lucia was established there in 1765. A large land settlement was inaugurated in this area in 1937 by the Government of Barbados for selected Barbadian immigrant peasants.

The Vieux Fort lands originally comprised nine sugar estates having a total area of 4,274 acres. The Barbadian Settlement consisted of 6,000 acres of land, of which 750 acres were in sugar-cane, 400 acres in coconuts, 4,250 acres in pasture, and 600 acres undeveloped. The canes were sent to a central factory for grinding. The annual rainfall

at Vieux Fort lies between 50 and 60 inches; an irrigation scheme was laid down to provide additional water from hill-streams.

Seven (7) soil profiles (Site Nos. (11) to (15) inclusive, and (18), (19)) were examined and sampled in the raised-beach alluvial area. In addition, 8 deep pits dug on the flats by American army engineers were inspected. The first three of these profiles, in La Tourney estate, were situated on low-lying ground. They showed a hard, black, cracked sandy-clay, 12 inches deep, merging into brownish-green (khaki), stiff horny clay sharply overlying, at 18 to 36 inches depth, partly-cemented incipient terras. The content of stones was nowhere very high; glassy quartz crystals were plentiful in all layers. The tough clay was spotted sepia and lined with black smears in the cleavage cracks; these proved to be chiefly manganese oxide; their accumulation is presumed to be caused by uplift of water in the dry season. The subsoil below 12 inches depth contained appreciable common salt in amount sufficient to be toxic to sugar-cane plants. The soils of this low-lying area, although classed broadly as Alluvial, show obvious affinities to *Solonetz* (White Alkali or Saline Soil; Halomorphic, Interzonal) as well as to *Terras*. They are covered over with variable thicknesses of sandy hill-wash derived from the higher grounds to the west and north. The chemical composition and possible identity of the clay fraction of the Vieux Fort alluvial soil is separately considered in a later section (Section X).

The next two profiles (Nos. (14), (15)), in Beausejour estate, are situated on a slightly elevated (40 feet) plateau in the mid-northern part of the Vieux Fort area. They show hard, black, cracked clay soil merging downwards through a layer of brownish-green (khaki) stiff clay into incipient terras at about 24 inches depth. The terras is composed of rusty iron-stained, grey-speckled sand. The black clay soil contains manganiferous pisoliths ("shot") and the green clay is lined with black partings of manganese oxide, indicating impeded drainage. Common salt in toxic amount is present below 12 inches depth. These profiles thus closely resemble the last and would be classified in the same way.

The last two profiles (Nos. (18), (19)), in St. Urbain estate, are situated in a depressed area about 7 acres in extent, lying between the low hills and the sea in the north-east part of the Vieux Fort area. The surface soil is spongy jet-black clay, full of glassy quartz crystals and some black "shot", changing at 6 inches to greenish-grey stiff clay overlying, at 30 to 45 inches, tawny-rusty incipient sandy terras. It is salty below 12 inches depth. This alluvial soil shows hydromorphic as well as saline features and may originally have been a *Half-Bog* (mangrove swamp) soil.

The profiles exposed in the deep pits dug by the military authorities within the southernmost part of the Vieux Fort area between the main road and the promontory showed a thick layer of hard black swamp clay changing downwards into green-grey stiff clay and underlaid by incipient sandy terras,

**Table III**  
**Laboratory Data for Sugar-Cane Soils**  
(TOP 6-INCH LAYER)

Site No.	Sugar estate	Gravel (%)	Crse. Sand (%)	Silt and clay (%)	I.T.	Re-action (pH)	O.M. (%)	Total N (%)	C/N ratio	Avail. nutr. (mhos × 10 <sup>-6</sup> )	Rate of soln. (p.p.m.)	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O (p.p.m.)
(A) RIVER ALLUVIAL SOILS													
(26)	Cul-de-Sac 1 .. ..	0	9	39	29	5.9	3.4	.16	12.3	205	40	17	89
(27)	Cul-de-Sac 2 .. ..	0	5	43	35	5.5	3.1	.16	11.2	199	49	7	115
(28)	Cul-de-Sac 3 .. ..	0	6	50	43	4.8	5.5	.20	15.8	157	(121)	23	70
(29)	Roseau 1 .. ..	0	12	41	33	5.2	3.4	.17	11.3	84	18	24	91
(30)	Roseau 2 .. ..	0	31	37	24	6.4	3.0	.10	18.3	212	48	32	175
(31)	Roseau 3 .. ..	6	28	39	28	(7.4)	(9.5)	(.29)	(19.2)	(665)	(200)	28	184
(32)	Dennery 1 .. ..	0	11	37	29	5.2	2.7	.15	10.2	88	9	17	69
(33)	Dennery 2 .. ..	21	16	38	31	5.4	4.7	.22	12.6	218	12	(145)	98
(34)	Dennery 3 .. ..	1	22	34	27	5.1	2.2	.13	10.0	77	10	9	60
			16	40	30	5.4	3.5	.16	12.4	155	26	20	106
(B) COASTAL ALLUVIAL SOILS : VIEUX FORT													
(11)	La Tourney 1 .. ..	15	20	64	25	6.0	4.5	.22	11.6	305	25	34	128
(12)	La Tourney 2 .. ..	7	(63)	(2)	(0)	6.2	1.8	.10	10.9	117	6	27	104
(13)	La Tourney 3 .. ..	14	31	57	19	5.9	2.1	.12	10.1	219	20	8	85
(14)	Beausejour 1 .. ..	24	42	42	12	6.3	2.5	.13	10.9	199	23	10	134
(15)	Beausejour 2 .. ..	23	41	44	12	6.2	2.2	.13	10.0	229	12	11	103
(18)	St. Urbain 1 .. ..	0	21	65	33	6.2	6.0	(.29)	12.1	244	(195)	19	155
(19)	St. Urbain 2 .. ..	18	17	72	31	6.2	3.2	.19	9.8	148	26	17	122
			28	57	22	6.1	3.2	.16	10.8	209	19	18	119
(C) TERRAS AND SHOAL SOILS													
(17)	La Retraite .. ..	30	50	33	10	5.5	2.7	.13	11.8	150	19	29	66
(16)	Black Bay .. ..	51	51	34	10	5.8	2.3	.15	9.3	76	20	8	64
FOR COMPARISON													
<i>Barbados</i> :		Black soil .. ..	..	..	..	36	7.8	2.5	.14	12.0	—	—	211
		Red soil .. ..	..	..	..	33	7.2	3.6	.22	10.4	—	—	180
<i>Trinidad</i> :		Black soil .. ..	..	..	..	45	7.4	3.9	.19	11.5	—	125	22
		Red soil .. ..	..	..	..	—	5.4	2.3	.16	8.3	—	19	19
<i>St. Kitts</i> :		Volc. ash soil .. ..	..	..	..	12	6.8	3.2	.11	16.8	—	—	84
<i>Jamaica</i> :		Alluvial (Vere) .. ..	..	..	..	27	7.4	2.9	.17	9.6	—	188	77
		Black (St. Ann) .. ..	..	..	..	25	7.6	6.1	.18	18.1	—	220	59
<i>British Guiana</i> :		Alluvial .. ..	..	..	..	50	6.0	3.5	.19	10.6	—	—	23
LIMITS OF ADEQUACY													
SUGAR-CANE SOILS (Top 6 inches)		Sands and Loams (I.T., 0-30)						Silts and Clays (I.T., 30-60)					
		Total N %	Avail. P <sub>2</sub> O <sub>5</sub> p.p.m.	Avail. K <sub>2</sub> O p.p.m.	Total N %	Avail. P <sub>2</sub> O <sub>5</sub> p.p.m.	Avail. K <sub>2</sub> O p.p.m.						
		0.15	25	120	0.20	35	180						

except for pits near a hill which partly exposed decomposed old residual material consisting of much-weathered stones and gravel. The depth of the water-table in this area at the time of inspection (mid-April) was between 3 and 10 feet, and the surface of the land lay at about 10½ feet above sea-level.

#### (IX)—LABORATORY DATA FOR SOIL SAMPLES

The methods used in soil analysis at the College are described at the end of this report. The full laboratory data for the soil profiles are tabulated in the Appendix. Data for the top 6-inch layers

Table IV  
Exchangeable Bases in Vieux Fort Sugar-Cane Soils

Site No.	Sugar Estate	Depth of sample (ins.)	Reaction (pH)	Crowther and Basu's method	Hissink's method (NaCl leaching)		Sum	Percentage saturation by calcium (%)
				H	Ca	Mg		
				(mg. equiv. per 100 g. soil)				
(11)	La Tourney 1 .. ..	0-6	6.0	3.5	15.6	12.6	31.7	49.2
	„ sub. .. ..	18-24	7.3	2.2	13.7	12.9	28.8	47.3
(15)	Beausejour 2 .. ..	0-6	6.2	4.9	9.5	8.7	23.1	41.1
	„ sub. .. ..	18-24	5.8	6.6	8.1	9.8	24.5	33.1
(19)	St. Urbain 2 .. ..	0-6	6.2	8.8	19.3	14.1	42.2	45.8
	„ sub. .. ..	18-24	5.0	11.0	16.8	16.4	44.2	38.0

of profiles and of composite surface 6-inch samples specially collected in peasants' plots are brought together in the following three tables (Tables III, IV, V). They are discussed below under the chief crops.

#### (A) SUGAR-CANE SOILS

Samples of these soils were procured, as has already been stated, in the three large northern river alluvial flats and in the southern Vieux Fort coastal alluvial area. The values for soil constants of the top 6-inch layers are summarised in Table III. Exchangeable base contents are given in Table IV.

*Discussion.*—The following facts emerge from a consideration of the laboratory data for the topsoils of typical sugar-cane soils of St. Lucia.

(1) *Texture.*—This is variable and ranges from sands through loams and silts to clays. The northern river alluvial soils are mostly silty-loams. The south-western coastal alluvial soils at Vieux Fort are mainly sands, though their St. Urbain representatives are silty-loams.

(2) *Reaction.*—This is markedly acid (pH 5.4) in the northern soils but not so acid (pH 6.1) in the Vieux Fort soils.

(3) *Organic matter and nitrogen.*—These are medium in amount in all the soils. Carbon-nitrogen ratio is variable but mostly above the value 10.0 believed to denote a high degree of humification. The Vieux Fort soils are humified to a greater extent than the northern soils, which probably contain greater amounts of decomposing cane-trash.

(4) *Electrical conductivity values.*—The values for "available nutrients" are high, especially in the Vieux Fort soil, mainly because of the presence in them of common salt. "Rate of solution" values throughout are very low, denoting paucity of fresh hydrolysable minerals.

(4A) *Common salt in the Vieux Fort soils.*—Sodium chloride was determined on all the topsoils (0-6 ins.) and many of the subsurface soils (6-12 ins.) and subsoils (12-18 ins.) by the silver nitrate titration method. The results showed that none of the surface soils contains harmful amounts of salt (toxic concentration of sodium chloride for sugar-cane, 900 p.p.m. NaCl). The highest value is 410 p.p.m. NaCl for the Beausejour topsoil, site No. (14). The St. Urbain topsoils contain about twice as much salt as the surface soils, and the subsoils three times as much. Toxic concentrations occur below 12 ins. depth in the St. Urbain soils. The presence of salt in cane-juice is likely to interfere with the crystallisation of sucrose.

(5) *Available phosphate.*—This is low in practically all the St. Lucia sugar-cane soils and is their most striking and significant chemical feature, having important bearing on their responsiveness to fertilisers.

(6) *Available potash.*—This is medium-low in the majority of the soils. It is particularly low in the old Terras and Shoal sugar-cane soils of the Vieux Fort district.

#### *Nutrient deficiencies:*

(a) *Nitrogen.*—It is known that the sugar-cane plant requires large quantities of *available* nitrogen, preferably nitrate-nitrogen, for high yields. The degree of nitrification of soil organic nitrogen varies considerably, depending partly on soil-type and partly on carbon-nitrogen ratio, as well as on such factors as water-supply, aeration and degree of acidity. "Nitrifying efficiency" in soils in general ranges between 1 and 10 per cent. or over according to published literature<sup>(16)</sup>. For typical West Indies soils, it lies around 3.4 per cent., so that a soil containing, say, 0.15 per cent. of total nitrogen (for example, an average northern river alluvial soil in St. Lucia) should be capable of producing about 50 parts per million of nitrate under ideal conditions, equivalent to 6½ cwt. per acre of

sodium nitrate manure, or to about 5 cwt. of ammonium sulphate which is a relatively large dressing. Nevertheless, in order to maintain high yields, sugar-cane soils usually require extra treatment with nitrogenous manures, particularly when their total nitrogen content is less than 0.20 per cent. (if they are heavy soils), or when their nitrifying efficiency is below the average value. The majority of the St. Lucia sugar-cane soils appears to contain less than the border-line amount of total nitrogen (Table III); they are not so rich in this component as some other well-known West Indies sugar-cane soils.

(b) *Phosphate*.—According to the figure for the limit of adequacy for available phosphate given at the bottom of Table III, the St. Lucia sugar-cane soils are all *very deficient in available phosphate*. This is a common feature of many West Indies sugar-cane soils and one that has so far received little critical investigation by manurial experiments. Pot-tests recently carried out in Trinidad (17) have shown that phosphate deficiency can be fully rectified only by very heavy dressings of phosphatic manure of the order of 5, 7 or 9 cwt. of superphosphate per acre (18). This is chiefly because certain types of soil are capable of absorbing and fixing in a form unavailable to plants large quantities of added phosphate. These facts explain why the customary small dressings of the order of 1, 2 or 3 cwt. per acre of phosphatic manure have failed in the past to give appreciable response when applied to sugar-cane soils in the British West Indies. The larger dressings are not likely to be remunerative, however, unless they are combined with heavy dressings of nitrogenous fertiliser (ammonium sulphate), of the order of 4, 6 or 8 cwt. per acre. If high dosages of the two kinds of manure are added together at the same time, spectacular increases in yield of sugar-cane may be expected for phosphate-fixing soils initially deficient in available phosphate. The main effect on the sugar-cane plant of the high phosphate treatment is a marked increase in the degree of tillering; the high nitrogen dressings enable the abundant tillers to develop into mature stems, thus greatly increasing the yield of sugar per acre.

(c) *Potash*.—According to the standards tentatively established for potash, many of the St. Lucia sugar-cane soils are deficient also in available potash, and this deficiency should be made good if high yields are expected. Certain kinds of soil are capable of fixing potash in unavailable (non-exchangeable) form, possibly as secondary hydrous mica. This subject has not yet been experimentally explored in British West Indies sugar-cane soils, and no undoubted cases of potash-fixing soils have yet been disclosed.

(d) *Lime*.—Apparently for highest yields, other growth factors being favourable, sugar-cane soils should contain abundant exchangeable lime and a reaction value near neutrality, say pH 6.5 to 7.0. In order to impart a desirable calcium status, acid sugar-cane soils should therefore be limed, best to half-saturation content of exchangeable calcium,

by the addition and thorough admixture by ploughing of finely-ground limestone (19). In cases where the lime requirement is excessively high, necessitating large expenditure on limestone for thorough liming, coarser limestone may be applied by the placement method around the stools or alongside the furrows. Such treatment often satisfies the plant's need of nutrient calcium (20). No specific determinations of lime requirement have been made on the St. Lucia sugar-cane soils. The data for exchangeable bases in some of the Vieux Fort samples (Table IV) indicate that the topsoils are not particularly in need of lime, since their degree of saturation by exchangeable calcium is almost 50 per cent. and their reaction values above pH 6.0.

*Manurial experiments on sugar-cane in St. Lucia.*

—Manurial experiments on sugar-cane have been carried out by the Department of Agriculture at Roseau Estate since 1932 (21). The variety used was BH 10(12). The first trials involved ammonium sulphate alone in dressings of 200 to 600 lb. per acre, with a basal dressing of pen manure, 15 tons per acre. The yield data for plant-canes reaped in March, 1933, showed no statistically significant differences between the treatments. Maximum returns were given by the 300 lb. acre dosage, i.e., 47.6 tons of cane per acre, as against 37.9 tons given by the control plots, an increase of 26 per cent. The experiment was repeated on the first ratoon crop, and a further, similar though larger, experiment was laid down on plant-canes at Roseau in 1933. The ratoons gave highest yields with the 600 lb. acre dosage, but the plant-canes gave best results with the 450 lb. acre dressing.

In 1934, potassium sulphate was applied, together with ammonium sulphate, to the control plots. The results obtained were again not statistically significant. They indicated that 300 lb. acre is the optimum dosage of ammonium sulphate, and that further benefit might accrue from the addition of potassium sulphate. Similar results were also obtained in 1935 on ratoon crops. In 1935, a new manurial experiment was laid down at Roseau. It involved potassium sulphate, 2 cwt.ac., and superphosphate, 1 cwt.ac., applied to land growing plant-canes that had received a basal dressing of 15 cwt.ac. pen manure, 3 cwt.ac. ground limestone and 1 cwt.ac. ammonium sulphate. Again the results obtained were not statistically significant, nor were significant results obtained the year after with the first ratoon crop. The highest increment for plants and first ratoons together was only 0.84 tons per acre, or 1.1 per cent. more than the control. The manurial experiments appear to have been discontinued in 1938.

Evidently some unidentified limiting factor is seriously affecting the growth of the sugar-cane at Roseau Estate. Judging by the laboratory soil data for this estate given in the Appendix Tables, Sites No. (29) and No. (30), this limiting factor may be *available phosphate*, which is only 24 and 32 p.p.m. at the two sites, being less than the provisional limit of adequacy for phosphate,

**Table V**  
**Laboratory Data for Cacao and Citrus Soils**  
 (TOP 6-INCH LAYER)

Site No.	Estate	Crse. sand (%)	Silt and clay	I.T.	Reaction (pH)	O.M. (%)	Total N (%)	C/N ratio	Avail. Nutr.	Rate of soln.	Avail. P <sub>2</sub> O <sub>5</sub>	Avail. K <sub>2</sub> O
									(mbos × 10 <sup>-6</sup> )	(p.p.m.)	(p.p.m.)	(p.p.m.)
(1)	Ruby .. .. Cacao	45	29	11	6.3	2.2	.15	8.7	115	34	95	92
(2)	Soufriere 1 .. Limes	41	30	14	6.1	2.1	.13	9.5	114	32	97	82
(3)	Mon Lezard 1 .. Cacao	77	14	0	7.0	2.2	.12	10.6	162	182	60	171
(4)	Mon Lezard 2 .. Limes	66	16	0	5.8	3.0	.15	11.8	133	0	14	74
(5)	Mon Lezard 3 .. Limes	54	23	6	6.0	2.5	.13	11.3	144	32	18	181
(6)	Soufriere 2 .. Limes	48	26	4	5.8	2.1	.12	9.8	90	24	26	82
(7)	Robot .. .. Limes	65	19	2	5.3	1.4	.09	9.8	106	10	42	163
(8)	Hermitage .. Cacao	49	25	9	6.5	3.4	.16	12.0	150	85	22	(353)
(10)	Anse Mamin .. Limes	54	22	6	6.4	2.9	.09	*(18.4)	(313)	28	(129)	(814)
<b>Means</b>		<b>56</b>	<b>23</b>	<b>6</b>	<b>6.1</b>	<b>2.4</b>	<b>.13</b>	<b>11.7</b>	<b>127</b>	<b>50</b>	<b>47</b>	<b>121</b>
Union Vale .. Cacao		—	—	10	6.9	2.7	.14	11.1	90	67	117	185
Union Ex. St. .. Limes		—	—	48	6.8	2.4	.15	10.5	68	37	15	77
* Contaminated with charcoal.												
FOR COMPARISON												
<i>Trinidad :</i>												
Chocolate Soil .. .. Cacao				43	7.2	6.0	.34	9.6	216	175	343	309
Brasso Sand .. .. Cacao				22	6.6	3.3	.25	8.4	132	131	53	455
River Estate Sand .. Cacao				23	5.9	2.1	.14	8.6	—	—	25	62
<i>British Honduras :</i>												
Stann Creek Alluvial .. Grapefruit				35	5.5	4.3	.23	10.4	—	35	19	241
LIMITS OF ADEQUACY (TOP 6 INS.)												
		Sands and Loams (I.T., 0-30)			Silts and Clays (I.T., 30-60)							
		Total N	Avail. P <sub>2</sub> O <sub>5</sub>	Avail. K <sub>2</sub> O	Total N	Avail. P <sub>2</sub> O <sub>5</sub>	Avail. K <sub>2</sub> O					
		(%)	(p.p.m.)	(p.p.m.)	(%)	(p.p.m.)	(p.p.m.)					
Cacao soils .. ..		0.15	30	100	0.20	50	160					
Citrus soils .. ..		0.10	50	200	0.12	85	320					

namely, 35 p.p.m. The contents of available potash in the Roseau soils are also low, though variable, namely 91 and 175 p.p.m., with provisional limit of adequacy 180 p.p.m.

It is therefore suggested that experiments be run with heavy dressings of superphosphate, added together with various dosages of ammonium sulphate, since it has been shown in Trinidad that, with increasing amounts of superphosphate, ammonium sulphate is better utilised by sugar-cane plants growing in phosphate-fixing ferruginous soils lacking available phosphate.\*

#### (B) CACAO AND CITRUS SOILS

Soils growing cacao and citrus (mainly West Indian limes) in St. Lucia are mostly confined to

the mid-western region, particularly the Soufriere district.

Data for top 6-inch layers for the few soil-profiles in cacao and citrus fields that were investigated are brought together in Table V.

\* Preliminary trials of this nature have already given promising results at Roseau Estate. Canes planted in May, 1946 (variety B34104), gave 50 per cent more tillers and 25 per cent longer stems when treated with superphosphate and ammonium sulphate at the respective rates of 6 and 7½ cwt. per acre as compared with canes treated at the customary rate of 2 and 4 cwt. per acre of these manures. The manager expects that the higher dressings will give an increase in yield when the canes are reaped at one year old of about 66 per cent which should be highly remunerative.

*Discussion.*—The following generalisations may be adduced from the laboratory data in Table V.

(1) *Texture.*—All the soils are sands; most are light sands having coarse sand contents over 50 per cent.

(2) *Reaction.*—Most of the soils are only slightly acid, but the degree of acidity is variable.

(3) *Organic matter and nitrogen.*—These are medium-low in amount, with relatively high carbon-nitrogen ratio (nearly 12.0), denoting the presence of appreciable decomposing plant litter such as dead leaves.

(4) *Electrical conductivity values.*—These are all fairly high, but not abnormally high, denoting soils of medium fertility.

(5) *Available phosphate.*—This is very variable. Highest values are given by the Alluvial soils and lowest by the more-leached Brown Earth and Terras soils.

(6) *Available potash.*—This also is variable and tends to be low, especially in the Soufriere Valley soils, in which it is less than 100 p.p.m. The values for the two last soils in the table are abnormally high; these soils may have been treated or contaminated with wood-ashes.

*Nutrient deficiencies.*—Provisional values for adequacy of phosphate and potash whereby the data may be gauged, are given at the bottom of Table V. The limits differ widely for cacao and citrus respectively; the data should therefore be considered separately under these heads.

(a) *CACAO SOILS.*—As a result of experience gained during the past 16 years from field and laboratory investigations of the cacao soils of Trinidad, Tobago and Grenada, described in previous Reports <sup>(22)</sup>, <sup>(23)</sup>, <sup>(24)</sup>, and in the Annual Reports on Cacao Research at the College, as well as in special articles <sup>(25)</sup>, the following generalisations may be put forward to indicate the nutrient requirements of cacao and the probable responses to differential manuring.

(1) *Nitrogen.*—Most cacao soils in Trinidad, Tobago and Grenada appear to contain adequate supplies of nitrogen. Productive sandy cacao soils generally contain 0.15 per cent. or more of total nitrogen; the best sandy cacao soils of Trinidad and Tobago contain, on the average, about 0.25 per cent. When they contain below 0.15 per cent. of total nitrogen, they may respond to artificial nitrogenous manure *provided that the soil is in good biological condition*, and that the root relations are satisfactory. Good biological condition is chiefly decided by micro-organic activities which ensure the proper breakdown of plant residues (litter), the incorporation of the final products into the soil, and the liberation of growth-promoting hormones and other biological substances considered to be essential to the complete nourishment of the tree and the suppression of pathological organisms that may damage its root-system. Cacao soils in good biological condition exhibit relatively-

high carbon-nitrogen ratios, generally above 8.5 for sandy soils. They usually give good yields but they may still respond to additions of nitrogenous fertilisers. Soils having low carbon-nitrogen ratios (below 8.5 for sandy soils), on the other hand, show unbalanced nutrition; their yields of cacao are usually depressed by nitrogenous manuring. Nitrogenous manuring is more effective in Grenada, where cacao is grown without shade, than in Trinidad and Tobago where shade trees are generally provided.

(2) *Phosphate.*—Values below 30 p.p.m. may be regarded as denoting deficiency of available phosphate in sandy cacao soils. Response to phosphate manuring of deficient soils is not necessarily assured, however, although immediate and large percentage increases in yield have indeed been obtained in Trinidad with superphosphate where initial yields were low and the biological condition of the soil was unsatisfactory. The best dosage of superphosphate proved to be about 2 lb. per tree. Response may be traced either to an improved biological condition of the soil (micro-organisms and mycorrhizal fungi require phosphate for growth and reproduction), or to an improved root-system (phosphate is known to stimulate root formation). Response to phosphate may also be manifest by a greater absorption of potash by the cacao tree <sup>(26)</sup>. It is doubtful if any of the soils growing cacao in St. Lucia would benefit from phosphate manuring, although trials should be made to test the possibility.

(3) *Potash.*—Values for exchangeable potash below 100 p.p.m. may be considered as denoting potash deficiency in sandy cacao soils. Potash seems to be the key to successful growth and thriftiness of cacao <sup>(27)</sup>. Response to potash manures has been marked on some potash-deficient sandy cacao soils in Trinidad; for example, River Estate Sand. The best dosage has proved to be about 3 lb. of potassium sulphate per tree. Potash shortage in cacao is often revealed by the appearance of marginal leaf-scorch <sup>(28)</sup> and by excessive shedding of young fruits <sup>(27)</sup>. Potash and nitrogen manures act reciprocally on cacao; balanced nutrition is indicated by a relatively low ratio (less than 1.0) of nitrogen to potash (N/K<sub>2</sub>O) in the leaf <sup>(26)</sup>. The need for potash manure is greatest where overhead shade is provided, particularly if the shade is too dense. Potash manuring arrests decline in yield owing to soil deterioration in cacao fields, whereas nitrogen manuring often hastens it. Potash manure gives appreciable residual effects carried over a number of years. The discriminate use of potash manures on cacao soils known to be lacking in potash should be encouraged in St. Lucia.

(4) *Calcium.*—Most of the productive West Indian cacao soils are distinctly acid in reaction and have a relatively low lime status. In spite of this, beneficial response to liming has not been obtained with cacao in Trinidad and Tobago, though it has been claimed for some estates in Grenada. Calcium and potassium are reciprocal in action; a high content of available (exchange-

able) calcium in the soil diminishes the uptake of potassium (and of magnesium). Hence calcareous soils (eroded marl soils) are not generally suitable for cacao growing.

*Note.*—An exceptionally productive sandy cacao soil was sampled for chemical analysis at Union Vale Estate, near Soufriere, St. Lucia (see bottom of Table V). The average yield of the whole estate for the period 1926-30 was over 1,500 lb. of dry cacao per acre for trees of age 25 to 30 years.\* The soil contained only border-line contents of soil organic matter and nitrogen but it was rich in available phosphate and potash. High yields cannot be attributed to the nutrient factor alone; other ecological factors are of equally great importance and doubtless contributed to the high yield.

(b) *CITRUS SOILS.*—The nutrient requirements and response to manuring of the different kinds of citrus (limes, grapefruit, oranges) appear to be approximately the same, although they would necessarily vary with soil-type, age of tree and size of tree or of crop. The general question of grapefruit manuring has been discussed by us in a report on some soil-types of British Honduras<sup>(29)</sup> and in a special paper<sup>(30)</sup>, from which the following notes are taken.

(1) *Nitrogen.*—Productive citrus soils contain variable amounts of total nitrogen, but they generally have to be heavily manured with nitrogenous fertilisers when the crop is grown commercially. Provided the root-systems of the trees are functioning satisfactorily, and the water and air supplies of the soil are adequate, nitrogen status *per se* is not of much direct importance. The dosage of nitrogenous manure is usually gauged more by the age of the tree and the magnitude of the potential crop than by the kind and composition of the soil. Too much nitrogen causes citrus fruits to produce an excessive proportion of rag or albedo and a general coarseness and excessive thickness of the rind, and also to diminish the sugar-acid ratio of the juice.

(2) *Phosphate.*—Nothing very definite is known about the phosphate requirements of citrus. The evidence afforded by manurial experiments on grapefruit in Trinidad does not indicate any particular need of phosphate although the soils are markedly deficient in this nutrient. Doubtless most of the citrus soils of St. Lucia are deficient in phosphate, except some alluvial representatives, and phosphate should be included in manurial mixtures, at least as a safeguard, until more is known of its specific need by citrus trees.

(3) *Potash.*—This nutrient seems to be even more important for citrus than for cacao. Adequacy has been tentatively set at 200 p.p.m. for sandy citrus soils, so that most of the St. Lucia lime-

growing soils would appear to be in need of potash manuring. Marked response to potash manure has been obtained with grapefruit in Trinidad growing in a soil containing 77 p.p.m. exchangeable potash. Reciprocal relationship has been established between potash and nitrogen in citrus nutrition<sup>(26)</sup>. For the full utilization of nitrogen in the soil or added as manure an adequate amount of potash must also be provided.

(4) *Lime.*—The lime status of the soil appears to be a particularly important matter in the general question of the fertility of citrus soils. The facts supporting this contention are fully set out in the British Honduras Report<sup>(29)</sup>; they mainly concern the chemical composition of citrus leaf-ash and citrus fruit-ash and the effects of liming on fruit quality which is closely related to chemical composition. At River Estate in Trinidad the leaf-ash of grapefruit growing alongside cacao on the same rather acid, lime-deficient soil, contained twice as much lime as the leaf-ash of cacao, implying that grapefruit, unlike cacao, is a "voracious lime feeder"<sup>(30)</sup>.

Calcium and potassium are reciprocally related in the mineral nutrition of citrus; hence too much available (exchangeable) calcium in the soil may suppress the uptake of potassium to such an extent that potash starvation may occur. Moreover, too high a calcium status is usually associated with alkaline reactions (values above pH 7.0) owing to the presence of excess of hydroxyl ions. Excessive alkali precipitates iron and manganese, as well as essential trace-elements such as zinc, nickel, cobalt, and copper. Lack of iron causes chlorosis ("lime-induced chlorosis") and absence of the other elements causes various "deficiency diseases". Hence the liming of citrus soils for the purpose of raising their calcium contents must be practised with great caution so as to avoid both general and local development of harmful alkalinity.

*Special importance of organic matter in citrus soils.*—The organic matter status of citrus soils appears to possess peculiar significance in the general nutrition of citrus trees. For example, the continued use of fertilisers at the St. Augustine Experiment Station in Trinidad brought about a general decline in the grapefruit crop after about 7 years' successive annual applications. The decline is stated to have been stopped and the conditions rectified by the use of pen manure, which was accordingly included in subsequent standard manurial mixtures.

The reason for the beneficial effects which pen manure apparently exerts or which a well-developed natural organic profile imparts to citrus soils is not understood. Soil organic matter may in some way induce or maintain balanced nutrition with respect to nitrogen, phosphate and potash, or it may encourage or control the development of the most suitable kind of root-system for the absorption and full utilisation of the essential nutrient elements. The general problem of the dying-out of limes in the British West Indies is discussed in the Montserrat Report<sup>(10)</sup> from the point of view of soil deterioration and the results

\* Information communicated by Prof. C. Y. Shephard, Jan., 1931; Soil samples were procured by Mr. A. F. Nichols, Assistant Superintendent of Agriculture, in June, 1932.

of recent investigations carried out by the Citrus Entomologist (R. G. Fennah).

*A manurial experiment on limes in St. Lucia.*—A manurial experiment on limes budded on sour-orange stock was laid down in July, 1932, at the Union Experiment Station, near Castries, on heavy alluvial soil<sup>(31)</sup>. It comprised 16 plots each one-quarter of an acre with guard rows, arranged in a Latin square. The treatments were: (a) ammonium sulphate, (b) potassium sulphate, (c) superphosphate, and (d) no treatment (control). A mixed mulch of bay leaves, lemon grass and *Crotalaria sericea*, 5 tons to the acre, was applied as a basal treatment. Growth and fruiting during the following 3 years was irregular; root damage by weevil larvae was reported in 1935; withertip and scale insects also damaged the shoots. The crop reaped that year was twice as great from the potash-treated plots as from any other. There was not much to choose between the yields of the other plots, the actual barrels of fruit reaped being (a) 5.2, (b) 10.7, (c) 4.1 and (d) 5.2, a ratio of 1: 2: 0.8: 1.

The soil of the experimental area was analysed at the College (see Table IV; data for Union Experiment Station). The results showed a total nitrogen content in the top 6-inch layer of 0.15 per cent. and available phosphate and potash contents of 15 and 77 p.p.m. respectively. Thus the soil initially contained a bare sufficiency of nitrogen but was markedly deficient in phosphate and especially in potash. The responses obtained by manuring accord with these facts. Unfortunately, no combinations of manures were tested. The experimental area was taken over in 1936 for trials of insecticides and weevil investigations and crop recording was thereafter suspended. No further reference to the experiment occurs in any annual report after 1938.

### (C) PEASANTS' PROVISION CROPS

Laboratory data are given in the Appendix Tables, Section (B), for the top 6 inches of soil collected within nine representative peasants' holdings situated in the north of St. Lucia, not far from Castries. The sites are marked on the provisional soil map and numbered (i) to (ix).

(1) Four sites occur on Morne Fortune near the southern main road out of Castries. These are all Red Earth sites. The soil is a highly acid silt-loam containing medium-low amounts of organic matter and nitrogen with a medium carbon-nitrogen ratio (10.2). The mean content of available phosphate is very low (only 11 p.p.m.) and that of available potash medium-low (131 p.p.m.).

These peasants' red soils are utilised chiefly for growing breadfruit, mango, banana, sugar-cane, pigeon-pea, cassava and sweet potato. They occur on steep slopes, but an attempt at contour banking has been made in order to reduce soil erosion. No yield data could be obtained, but it is evident from the analytical data that the soils should benefit

markedly by treatment with fertilisers, among which superphosphate in heavy dressings is suggested as especially worthy of trial. Judging by the low pH values (pH 4.6 to 5.5), the soils might also respond to thorough liming.

(2) Three other Red Earth sites were sampled in the Grande Riviere-Postlethwaite district in the Union Valley. The results of analysis of their surface soils are very similar to those of the first group. Their nitrogen contents are higher, however, but their contents of available phosphate and potash are lower. These soils should also benefit from liming and manuring, particularly with superphosphate.

(3) The remaining two sites are on Shoal soil which occurs as a belt near the coast around Choc. The analytical data show that both soils are silty-clays, markedly acid in reaction (pH 5.6), containing medium amounts of organic matter and nitrogen with medium carbon-nitrogen ratio (10.6). Their mean available phosphate content is very low (10 p.p.m.), but available potash differs in amount, being low in one (100 p.p.m.) but twice as high in the other. These Shoal soils occupy flattish land; they should benefit from liming and manuring as in the previous cases.

### (X)—CHEMICAL AND MINERALOGICAL TRANSFORMATIONS INVOLVED IN SOIL FORMATION IN ST. LUCIA

The following transformations have been studied with St. Lucia materials: (1) those between shoal derived from old basement rocks and its superimposed soil, as developed at Morne Giraud in the north of the island at Site No. (24), and (2) those between the parent material and the soil of the Vieux Fort alluvial soil-type.

*Morne Giraud Shoal Soil.*—The place where the first set of profile samples was collected is on the same hillslope as that on which the Morne Giraud anti-erosion experiment was laid down, to be described later. The profile shows black, stony, clay soil (pH 6.1), 12 inches thick, grading into hard, horny, dull brown-pink clay subsoil (pH 5.3), sharply overlying, at 20 inches depth, speckled, grey, concrete-like shoal (pH 5.8) of undetermined thickness. The soil and subsoil were deeply and widely cracked.

*Results of chemical analysis.*—Bulk chemical analyses were carried out by the fusion method on the clay fraction only (2 $\mu$  grade size). The silt-and-clay content of the topsoil was about 33 per cent. and of the clay subsoil 45 per cent.; very little silt-and-clay could be separated from the shoal, which was therefore finely ground for analysis. Quartz was determined by the tri-acid digestion method. Gibbsite was tested for by the alizarin-absorption method, but none was found. Magnetite was present only in traces. All the alumina and ferric oxide was therefore present in the combined state. The analytical results are given in Table VI.



TABLE VII  
**Geological Shoal Soil Profile** (Morne Giraud)  
*Results of exchangeable base determinations*

(VALUES ARE MILLIGRAM EQUIVALENTS PER 100 GRAMS)

	pH	Hissink's method (NaCl extraction)					Rice Williams' method (N/2 acetic acid extraction)							
		H	Ca	Mg	Na	Sum	1st litre				1st and 2nd litre			
							Ca	Mg	Na	Sum	Ca	Mg	Na	Sum
(A) <i>Topsoil</i> (1) 0-6.. ..	6.1	5.2	18.5	5.3	0.8	29.8	15.6	5.4	0.8	21.8	19.1	9.5	(0.8)	29.4
(B) <i>Clay subsoil</i> (3) 12-16 ..	5.6	9.9	16.9	10.6	1.7	39.1	8.0	5.8	3.2	17.0	16.3	12.3	(3.2)	31.8
(C) <i>Shoal</i> (6) 22-28 ..	5.4	6.0	12.9	8.0	1.7	28.6	3.5	2.8	3.3	9.6	13.5	10.1	(3.3)	26.9

The evidence so far afforded by these data suggests that this particular shoal profile is a "Geological Shoal", for the shoal itself had apparently already suffered profound alteration before uplift and exposure and before its derived soil had developed over it. There are no traces left of the original ferromagnesian minerals and feldspar, and the general appearance of the substratum suggests profound mineral decomposition. The only conspicuous change that has subsequently occurred is a softening of the upper part of the shoal, presumably brought about by the partial rehydration of its silica content.

The initial cemented shoal has a hard gritty feel and its mechanical analysis shows a high content of coarse sand (70 per cent.) and no silt-and-clay. On the other hand, the softened clay and the soil above contain much less sand and more silt-and-clay. Apparently, however, the coarse sand fraction of the shoal itself consists of highly hydrated material; the sample obtained by fine grinding, on analysis, gave 12.4 per cent. loss on ignition. The shoal contains very little quartz or other primary mineral, so that *its sand fraction must consist of hardened fine crumb or aggregates for which the name "pseudo-sand" is suggested*, for it is likely that the component sandy grains are pseudomorphs of original feldspar crystals that were present in the parent andesitic rock.

The essential clay-mineral nature of the pseudo-sand comprising the hard geological shoal at Morne Giraud was further demonstrated by laboratory determination of its exchangeable base content. The results are given in Table VII.

Two methods of exchangeable base measurement were applied. The first (Hissink's method) involves extraction with molar common salt solution; the second (Rice Williams' method) employs semi-normal acetic acid as extracting reagent though it is less effective than salt solution in stripping the exchangeable bases from the adsorptive clay colloid. When acetic acid extraction is repeated several times and the extracts separately analysed it is found that the total amount of extracted

exchangeable bases equals that obtained by the more drastic extraction with salt solution. This fact is clearly indicated by the data in Table VII, which show that, not only do the topsoil and the clay subsoil contain fair amounts of exchangeable calcium and magnesium, but the shoal also contains practically as much exchangeable material and would therefore be regarded as a highly-adsorptive colloid. The rather high proportionate amount of exchangeable magnesium present in each of the samples analysed is noteworthy. The finding that geological shoal is markedly colloidal though granular has considerable practical significance; it means that the hard shoal, if suitably broken up and treated with lime and fertilizers, should easily be convertible into fertile soil. It is to all intents and purposes merely a hardened clay which has retained its valuable essential chemical property, namely, a high base exchange capacity, but which, when appropriately comminuted by some mechanical means or other (for example, by chopping with heavy hoes) may be rendered permeable to water and air without fear of drainage impedence. The comminuted material is sufficiently stable to withstand disintegration under repeated wetting and drying and in this respect it simulates inert sand.

(2) *Vieux Fort Alluvial Soil*.—The site of the profile samples chosen to represent the Vieux Fort type of clayey alluvial soil was No. (11), La Tourney 1. The profile shows black, horny, tough, clay soil (pH 6.8) 12 inches thick, merging below into a stiff brownish-green or khaki clay (pH 7.5) having abundant manganiferous black concretions, uniform to the full depth of the profile to 42 ins. Judging by the facts that the site is low-lying and that the profile samples contain appreciable sodium chloride, increasing in quantity with depth, this soil has probably developed over volcanic ash that was submerged for a long time under the sea or occupied the bottom of a lagoon. The parent material thus resembles a true water-laid volcanic tuff.

**Table VIII**  
**Vieux Fort Alluvial Soil Profile (La Tourney 1)**  
*Results of chemical analysis of clay fractions*

Depth (ins.)	Percentage composition									Molecular ratios	
	SiO <sub>2</sub>		Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	K <sub>2</sub> O	H <sub>2</sub> O	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	
	Quartz	Comb.	Comb.	Comb.					Al <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	
	CLAY FRACTIONS										
(A) Topsoil 9-12 .. .. .	4.2	47.7	24.5	11.7	0.13	1.24	0.16	10.6	3.61	0.37	
(B) Subsoil 18-24 .. .. .	5.5	47.2	22.3	11.7	0.27	1.34	0.10	9.5	3.59	0.41	
(C) Parent material 36-24 ..	7.2	46.9	21.7	10.8	0.78	1.46	0.08	8.7	3.69	0.44	
				Kaolinite ..	Al <sub>2</sub> O <sub>3</sub> .2SiO <sub>5</sub> .2H <sub>2</sub> O				2.00	0.50	
				Beidellite ..	Al <sub>2</sub> O <sub>3</sub> .3SiO <sub>3</sub> .3H <sub>2</sub> O				3.00	0.33	
<i>Results for quartz-free materials recalculated to constant alumina content</i>											
(A) Topsoil .. .. .	—	45.7	23.4	11.2	0.12	1.19	0.15	10.1	—	—	
(B) Subsoil .. .. .	—	49.5	23.4	12.3	0.28	1.41	0.10	9.9	—	—	
(C) Parent material .. .. .	—	50.5	23.4	11.6	0.84	1.58	0.09	9.4	—	—	
<i>Losses and gains between (a) parent material and subsoil, (b) subsoil and topsoil</i>											
(a) Parent and subsoil .. .. .	—	-1.0	—	+0.7	-0.56	-0.17	+0.01	+0.5	—	—	
(b) Subsoil and topsoil .. .. .	—	-3.8	—	-1.1	-0.16	-0.22	+0.05	+0.2	—	—	

*Results of chemical analysis.*—Bulk chemical analyses were made on the clay fraction ( $2\mu$  grade size) of soil samples collected at 9 to 12, 18 to 24 and 36 to 42 inches depths. The silt-and-clay content was about 66 per cent. in each sample. The analytical results are given in Table VIII and should be compared with those in Table VI.

*Discussion.*—The data, like those for the shoal profile, show a marked constancy of composition in the three materials analysed, particularly in the quartz-free material. There has apparently been little profile differentiation in the chemical sense. The ratio values are nearer those for beidellite, or other clay-mineral of the high-shrinking montmorillonite type, rather than kaolinite, which is what would be expected from the peculiar origin of the parent clay or tuff. The exchangeable base status of the soil and subsoil of this alluvial material (Table IV) is similar to that of the corresponding layers of the shoal (Table VII).

#### (XI)—SOIL EROSION

The fact that soil erosion is simply accelerated geological erosion induced by man's activities has

already been stressed in an earlier section. The notion has been previously expounded and applied in the discussion on soil erosion in Montserrat (<sup>10</sup>). A convenient classification of land movements, suggested by C. F. Stewart Sharpe (<sup>32</sup>), was therein employed in order to aid the systematic description of typical examples. The same scheme may be applied to soil erosion in St. Lucia, as follows:—

#### (A) FLOWING MOVEMENTS:

##### LAND-FLOW; LAND-CREEP

- (I) *Slow* (i) Soil-creep, (ii) Talus-creep, (iii) Rock-creep.  
 (II) *Rapid* (iv) Earthflow, (v) Mudflow, (vi) Débris-avalanche.

#### (B) SLIDING MOVEMENTS:

##### LANDSLIDE; LANDSLIP

- (vii) Slump, (viii) Débris-slide, (ix) Débris-fall, (x) Rock-slide, (xi) Rock-fall.

This classification distinguishes flowing movements from sliding movements involving slip-planes. In St. Lucia, both kinds are widespread

in the central region where the predominant soils are Red Earth, Brown Earth and Lithosol in complex association. Here the ground was originally closely covered by mountain rain forest which, however, has been largely destroyed during agricultural exploitation over the greater part of the region and has been replaced by the natural regeneration of a much poorer type of second-growth forest or bush, or in some places by herbaceous weeds and pasture grasses. Where the original primeval forest has disappeared and its place has been taken by much less-protective kinds of vegetation, soil erosion has there been most rife. The removal of the humic soil in the eroded places has exposed the soil parent material, or even the parent rock, and has left conspicuous bare patches which take many years to cover over.

Perhaps the commonest kind of land movement in St. Lucia is *débris-avalanche*, but since this generally starts with a *débris-slide* the two might conveniently be considered together. Their main features may best be indicated by reference to an actual example which occurred recently within the old abandoned banana lands at Ravine Poisson in the upper Cul-de-Sac river valley. It was here that the first clearings were made in Crown lands forest when the St. Lucia banana industry was first established in 1922, as has been described in an earlier section.

*The Ravine Poisson débris-avalanches.*—This series of catastrophic earth movements occurred on 22nd November, 1938, after three weeks of unprecedented rainfall amounting to over 50 inches, or an average of about 2 inches a day. There were three main avalanches, each starting at an altitude of about 700 feet. The Ravine Poisson avalanches are described as having been "probably the most disastrous to life and property in the whole history of the British West Indies" (33). About 150 persons were killed on that day. "In the early hours of the morning the side of part of the northern ridge at Ravine Poisson gave way and buried a number of houses and their inhabitants, as well as a group of men who were at work repairing the roads from previous slides." "The undermining of the soft substratum at the base of the ridge, enhanced by the severe recent deforestation in the vicinity, coupled with the abnormally heavy rainfall, produced a veritable avalanche of soft wet clay, 15 to 20 ft. deep in places; sweeping all before it." "Such slides are similar in every respect except that of magnitude to those which occur on a small scale every year throughout the deforested areas of St. Lucia but which are virtually unknown in the forested areas of the interior, however steep the terrain" (*ibid.*).

The first major land movement at Ravine Poisson started as a *débris-slide* in a cleared belt of steep hilly land behind a strip of forest left to protect the road.\* It grew into an avalanche and tore through the belt of trees, which it carried with it down into the river valley, completely blocking the road. The second, about half-a-mile west of the first, started on the ridge of a deforested hill, swept over the river at its foot, and crossed the

valley floor, enveloping a number of small huts in its path. The third, half-a-mile west again, closely resembled the second. Before the land movements occurred the slopes of Ravine Poisson were covered with low bush and sporadic patches of sugar-cane and coconuts. Near the huts there were small areas of pasture or provision gardens. The avalanches stripped off this vegetation as if it were a carpet, leaving an orange-red clayey substratum obscuring the bed rock below.

*Other examples of débris avalanche.*—During the same period as the Ravine Poisson avalanches, the partly-cleared hillsides of the lower portions of the same (Cul-de-Sac) valley became pock-marked with minor land movements. The orange-red scars breaking the green landscape were visible for miles. Practically all of them occurred either where the slopes had previously been precipitous, as under high ridges, or where the hillsides were covered with second-growth bush, peasants' gardens or pastures. Similar observations were made also in the Soufriere district in the mid-western region, as well as at the Anse la Raye Valley and at Vanard near the Roseau Valley. Only in a few cases, however, were occurrences of avalanches or landslides noted in high forest, and then solely on steep slopes. The fact that such instances were recorded during this period supports the generalisation that man-induced erosion may be considered to be simply accelerated natural (or geological) erosion. The conformation of the ground throughout the whole of the central region of St. Lucia offers repeated evidence that a general tendency occurs there for the mature thick layer, comprising the products of profound rock weathering, to slip away periodically in patches and gradually to move downhill. As it moves, it carries along with it the cover of soil and its mantle of vegetation, the whole jumble of material eventually forming an unstable dump which later may be partly dispersed by less cataclysmic kinds of erosion. Morainic deposits of this kind, often called "erosion dumps", occur commonly in the mountainous interior of St. Lucia. The scars left by the detachment of the masses of soil material may readily be identified higher up the slopes. There the parent rock is often exposed and eventually gives rise to Lithosol. A typical example occurs in the Quillesse Nursery area, described in the Appendix Table, Sites Nos. (20) and (21). Occasionally successive land movements may cause a superimposition of small erosion dumps, resulting in a series of buried soils, and producing stratified composite soil profiles.

*Other kinds of land movement in St. Lucia.*—Among the kinds of movement other than *débris-avalanche* and *débris-slide*, less drastic flowing movements, such as *soil-creep* and *earthflow*, appear to be common in St. Lucia. These may not be of much account in virgin forest land where the soil is well protected by litter and root-mat, but in cleared hilly districts they are important

\* The authors are indebted to Mr. R. G. Fennah for the information contained in these paragraphs concerning land movements in St. Lucia.

insidious agents causing the gradual movement of fertile soil downhill.

Apart from *débris-slide*, the main slipping movements affecting soil, especially that on grassy hillsides, is *slump*. This consists of a series of backward-rotating or shearing slides that produce small parallel terraces on the steeper grassy slopes devoid of forest or bush. They are commonly known as "cat-steps" or "sheep walks". A good example occurs in Shoal Soil at Manikin Estate adjacent to the main east-coastal road north of Micaud. Further examples occur in peasants' holdings situated on hillsides in various parts of St. Lucia.

Other kinds of slipping movements not yet mentioned, namely, *débris-fall*, *rock-slide* and *rock-fall*, occur mainly in young mountainous country where exposed masses of rock outcrop on steep slopes, escarpments or cliffs. They have been observed, though rarely, in the mid-western region of St. Lucia, particularly in the Soufriere Valley at places where the valley sides are almost vertical. Here large screes made up of detached rock fragments line the edge of the river flats.

Finally, the kinds of soil erosion that have affected the land surface in the south-western region of St. Lucia where "black cloud" deposits have formed a huge fan-shaped glacis, closely resemble those that have been operative over similar terrain in Montserrat<sup>(10)</sup>. Here deep steep-sided ghauts have been carved out of the loose or partly-cemented fine-grained volcanic materials by longitudinal stream flow. The repeated caving-in of the sides of these ghauts, accompanied by landslips above, are slowly reducing the area of the land surface. Apart from this geological process, other forms of flowing movements, such as *soil-creep* and *earthflow*, together with *slope-wash* and *sheet-flow* which occur during heavy rains, are continually removing surface humic soil off the gently-sloping land surface. Little or no protection is here afforded by permanent vegetation, since the area is mostly occupied by peasants' holdings. The highly absorptive soil, which in this district is mostly loose and sandy, suffers erosion, however, only when the rainfall is sufficiently intense to exceed the rate of water infiltration and downward percolation and thus to produce surface run-off. In this event slope-wash, sheet-flow and even gullying in a minor form develop, and a considerable amount of soil is lost by erosion. Coupled with these, the constant hoeing of the cultivated peasants' plots helps to move the soil downhill where it reaches the main drainage channels and is rapidly transported to the sea by stream-flow.

## (XII)—SOIL CONSERVATION AND ANTI-EROSION MEASURES

The seriousness of the soil losses incurred through continued erosion within clearings and peasants' gardens in the forested central region of St. Lucia was early realised by the Agricultural Department; it was particularly stressed in a report

submitted in 1936 by A. Wimbush, Chief Conservator of Forests, Madras, who was appointed by the Colonial Office to investigate forestry problems in the British Antillean Islands<sup>(34)</sup>. Repeated warnings have since been periodically issued in the Annual Reports of the Agricultural Department against the indiscriminate exploitation of timber, the clear-felling of the forests, and the wanton burning of bush.

The allocation of freehold lands to peasants was accordingly drastically curtailed in 1936, and in December, 1941, such allocation was definitely stopped. The development of land settlements in an orderly manner, with adequate provision for the protection of the soil, is now receiving the attention of Government.

In 1937, efforts were made to arouse interest in anti-erosion measures by means of demonstrations laid down in the plant nurseries belonging to the Agricultural Department, as well as on various peasant holdings. The methods of soil conservation that were demonstrated mainly comprised terracing, contour-draining and contour-banking, and the ideas underlying these operations were explained to the peasantry at frequent village meetings. The catastrophic *débris avalanches* which occurred in November, 1938, described in the last section, helped somewhat to increase public interest in soil conservation. Progress in these affairs was slow, however, because of the antipathy of the peasant towards the work involved in applying anti-erosion measures. In the 1940 Annual Report of the Agricultural Department it was admitted that the response to attempts to make the peasant erosion-conscious had been disappointing, and that "apart from the efforts of a few enterprising estate owners, there is little progress worth recording, and meanwhile the effects of soil erosion are undoubtedly extending in most districts".

*Morne Giraud anti-erosion experiments.*—As a further means of overcoming the apathy of the peasants towards the need for soil conservation, a demonstration plot was laid down in June, 1940, by the Department of Agriculture on a hillside at Moulin-à-Vent Estate, Morne Giraud, in the Gros Islet district of northern St. Lucia. This experiment at first covered only one acre, but it was subsequently extended so as to take in about 35 acres of land. The average slope is about 1 in 3. The soil of the site of the experiment belongs to the *Shoal* type. Laboratory data pertaining to it are given in the Appendix Tables, Site No. (24), and its genesis and relationships are discussed in Section (X) dealing with mineralogical transformations involved in shoal soil formation.

In the area first established, the natural formation of terraces was the chief aim. Here contour drains were dug at seven-foot intervals and with a fall of 1 in 90. The dimensions of the drains were 12 inches wide at the bottom, 18 inches wide at the top, and 18 inches deep. The upper side was cut back a further 12 inches to reduce land-slip. The drain soil was thrown upslope above the drain. A row of *Khus-Khus* Grass was planted above the

drain about 3 inches from the sloped edge, that is, on the border of the excavated soil. The tufts of grass were set out 6 to 8 inches apart.

The anti-erosion measures employed at Morne Giraud at first consisted in the construction of a series of alternate contour strips of arable land and of fodder grasses. The chief grasses used were Elephant Grass, Guinea Grass, and Uba-cane, planted in contour furrows. The main crops grown were yam, sweet potato and various legumes. The permanent or semi-permanent fodder-grass strips vary in width between 25, 15 and 10 feet. It is intended to interchange the grass strips and the arable strips after a period of years. Drains were dug at 36 feet vertical intervals, with a storm drain at the top of the area.

### (XIII)—SOIL RENOVATION

The only kind of soil renovation practised in the volcanic islands of the British West Indies is the bush fallow. In St. Lucia, bush fallowing as carried out by peasants and squatters in the forested central region invariably induces the early establishment of a much poorer kind of vegetation than the original forest growths. This fact is stressed by Wardlaw in his article on the banana lands of St. Lucia<sup>(14)</sup>, in which he states that the "secondary flora flourishes because it consists of plants which are characteristic of waste places and inexacting in their requirements. The weed flora which has involved the plantations consists of species many of which are the first to populate slightly-weathered rock surfaces, landslide areas and highly eroded open hillsides. Rock faces . . . are populated mainly by species of ferns, which rank among the first colonisers of land where a true soil stratum has not been created."

"The prevalence of *Cyathea* (large tree fern) and other fern species in the abandoned banana areas in St. Lucia may be taken as an indication of the fact that most of the true soil has been either displaced or otherwise destroyed, leaving as the new surface materials not greatly removed from the underlying parent volcanic rock." Wardlaw then goes on to affirm that "the deforested land does not revert to its original state but is repopulated by a different flora". He examined the vegetation of a number of abandoned peasants' gardens, 10, 15, 25 or more years in second-growth bush. He found that, in a garden 20 years in bush, the dominant plant was the Trumpet Tree (*Cecropia*), many specimens of which were 80 feet high. Other tall trees were also present, along with clumps of Balisier or Wild Banana (*Heliconia*) and of Bamboo, and large bushes of *Miconia*, with a sparse ground vegetation of seedlings and ferns. The soil profile here showed only 5 inches of black humic topsoil instead of the usual 12 inches present in virgin forest soil, and the weathered rock was near to the surface.

These observations by Dr. C. W. Wardlaw are fully substantiated by those recorded by Dr. A. Steven Corbet in a recent book<sup>(35)</sup> describing soil

conditions in the rubber plantations of Malaya. Corbet states that "shade is a factor of vital importance in determining the subsequent history of cleared jungle areas". Where the original forest has only been partially cleared so that "sufficient numbers of large trees are left to ensure the forest floor being still heavily shaded", Ginger soon becomes the dominant plant though it gradually disappears as other plants gain access. "Where clearing has been more drastic and the forest floor is left partially exposed to sunlight, the secondary growth follows a different course"; "the ground is soon densely covered with low-growing grasses" (including the pernicious weed, Lalang Grass (*Imperata arundinacea*)), which act as an effective check to other competitors". Eventually, however, grass disappears and shrubs and trees become established. In the case of partial clearing, only a few years elapse before the area begins again to resemble the original forest, but in the case of complete clearing where grass has become fully established the predominating plants for many decades consist of species that have no place in the primary forest flora.

The chief effects of entirely removing the shade by felling the forest is to increase greatly the degree of insolation and thus immediately to raise the temperature of the surface soil and to permit rain and wind to gain access to the land and so to bring about rapid soil erosion. The critical temperature above which the rate of loss of soil organic matter and nitrogen exceeds their rate of accumulation is stated to be 25°C. or 77°F.<sup>(35)</sup> Actual measurements made in Trinidad<sup>(36)</sup> gave values for maximum temperatures within a cleared forest area, as recorded by thermometers placed 3 feet above ground level in a shaded screen, of 96°F. in the wet season and 92°F. in the dry season, as compared with 88°F. and 82°F. in the natural forest. The corresponding minimum temperatures were 66°F. and 58°F. for the clearing (wet and dry season) as against 68°F. and 67°F. for the untouched forest. At the soil surface, however, temperatures near 120°F. have been recorded in Trinidad in open exposed spots, whereas in forests and cacao plantations, surface temperatures have seldom been found to rise above 79°F. nor often to fall below 73°F., so that the rate of decay of fallen litter approximately equals the rate of accumulation of soil organic matter.

As regards the effect of clear-felling on the drying out of the soil, comparative determinations of the rate of evaporation of free water contained in the bulbs of Livingston white and black atmometers show that, in Trinidad, in natural forest and in adjacent clearings, evaporation is about 5 times as great in the clearings, and that the degree of insolation (difference between black and white bulb readings) is about 10 times as great during the wet season. It is doubtless very much greater in the dry season.

Another peasant's garden, examined by Wardlaw, which had been abandoned for 15 years and partly grazed by cattle, carried a cover of grass and herbaceous weeds with occasional clumps of

Balisier and thickets of *Miconia* and Guava, and a few specimens of Trumpet Tree and *Cyathea* tree-fern. The soils supporting grass, Balisier and *Miconia* respectively, were found to be remarkably different. The soil under grass was only 3 to 5 inches thick and comprised sticky material only slightly darkened by humus, overlying a sticky mottled yellow subsoil. That under Balisier was very much superior; it showed 4 inches of black, humic, crumbly material overlying the mottled subsoil. Unlike the last, it was full of fibrous roots and was relatively dry and friable. The soil under the *Miconia* bushes was better than that under grass but not so good as that under Balisier.

Evidently, from these observations, the rate of renovation of eroded soils depends largely on the kinds of plants that invade and colonise them, the most effective species being those that develop vigorous, strong, deeply-penetrating and widely-spreading root-systems, that draw off excess of water from the soil, and that provide abundant supplies of organic matter by the decay of their vegetable residues. As Wardlaw puts it, "in order to produce the greatest soil amelioration, a type of vegetation should be established which, under the conditions prevailing, catches and anchors the soil, achieves root-tillage and yields the best type of organic matter".

There is much need of specific investigations into the best kinds of associations of plants to grow for the purpose of rapidly renovating eroded and deteriorated tropical soils. Under the conditions obtaining in St. Lucia, at least within the areas examined by Wardlaw, natural second-growth vegetation that has once become established on abandoned and eroded lands shows only a few additions to its early assemblage of plant species, even after a lapse of 25 years. Whether new plant successions soon appear after a dense tree canopy has been formed was left undecided by Wardlaw's researches. On the other hand, J. S. Beard<sup>(2)</sup> noted that many peasants' gardens in St. Lucia had become colonised "in a most promising manner" by young timber trees of Bois d'Amande (*Hieronyma*) and Bois Blanc (*Simaruba*). He suggests that "Wardlaw was too pessimistic about the speed of reversion to forest". He does not describe nor identify the soil in the newly-colonised areas, however, so that comparison with sites examined by Wardlaw is perhaps unwarranted.

The Department of Agriculture has experimented in recent years with the reforestation of abandoned gardens at Quillesse and Barre de l'Isle, and has tried, among other species, Teak, Honduras Mahogany, certain genera and species of Lauraceae, Cypress, Brazil Nut and Sapucaia Nut. The rain forest climate proved unsuitable to Teak, and the shoot-borer (*Hypsipyla*) attacked Mahogany badly. The Lauriers and Cypress are promising; the nut-trees are really agricultural crops. Beard suggests "a trial of Blue Mountain Mahoe (*Hibiscus elata*)", which grows well in the rain forests of Jamaica.

The general problem of soil renovation by the

growing of various kinds of trees, bush or cover-crops is closely linked with the kind of soil parent material or parent rock that has become exposed over the surface of the land, in accordance with the degree of profile truncation. Where the surface humic layer has been lost, the remaining soil material will be devoid of nitrogen. It may also be deficient in available phosphate, potash, lime and magnesia, particularly if the original soil was a mature type whose parent material was already well weathered and highly leached and now consists chiefly of inert, highly acid, mineral residues, as in the case of Red Earth. In order to reinstate a humic layer, nitrogenous manures, either organic or mineral, as well as manures containing phosphate and potash, and lime to neutralise the acidity, may all be needed, at least in the early stages prior to the natural re-establishment of a suitable micro-organic flora including bacteria that can fix nitrogen from the air.

As an example of the kind of parent material that is left exposed after deep soil erosion has removed the topsoil from a forested slope, the composition of a sample of Red Earth taken from the scar left by the second Ravine Poisson avalanche may be noted. This sample was found on laboratory examination to have index of texture 36 with sand content 37 per cent., and to contain only 0.23 per cent. of organic matter with 0.01 per cent. of total nitrogen. The reaction was pH 6.1. The amounts of available phosphate and potash present were only 4 and 43 p.p.m. respectively. Such material could not be expected immediately to support plant-life; the addition of suitable manures and lime, and the deliberate planting of the right kind of renovating crop, might however expedite the processes of renovation so greatly that the land might soon become agriculturally productive, particularly if steps were also taken to reduce further loss of soil by the application of appropriate anti-erosion measures.

The extreme result of deep erosion of mature soils developed over volcanic rocks in the interior of St. Lucia is the formation of Lithosols whose soil parent materials consist of fresh unweathered minerals associated as ash, sandstones or boulders, or as lava-flows. Under a humid tropical climate such materials rapidly weather, and new fertile soil starts to be built up over them as soon as the nitrogen status has been raised sufficiently through nitrogen fixation by micro-organisms to support plant-life. Here again soil formation may be expedited by the judicious use of manures and amendments and the conscious selection and control of the vegetation. There is much scope for experimentation along these lines. In the science of soil-building, "man's real contribution is not humus but skill, intelligence and experience; . . . only these uniquely human qualities can transform a plant-dominated soil, whether forest or grass-type, into one in which all living things exist by man's favour alone" (37).

**SUMMARY.**

(1) The soils of St. Lucia are considered as natural products of the interaction of five soil-forming factors, namely, parent rock, climate, vegetation, topography and time. These factors as expressed in St. Lucia are described in turn.

(2) The parent rocks (as in other West Indian volcanic islands) are mainly fragmental ejecta comprising agglomerates, sand and ash having a wide range of size, together with lesser amounts of intrusive and extrusive igneous rocks comprising volcanic plugs and lava-flows. The chief petrological type is andesite or its fine-grained equivalent, basalt. The commonest kind is quartz-andesite (dacite). Other forms rich in labradorite (bandaite) and in mica (diorite) also occur.

(3) These rocks have suffered varying degrees of weathering depending on their length of time of exposure or geological age. They have successively produced three kinds of soil parent material under free drainage; these have provisionally been named *Brown Earth*, *Yellow Earth*, and *Red Earth*, and two other kinds, namely, *Terras* and *Shoal*, developed under impeded drainage either through the generation within the profile of new clay minerals forming claypan (Pedological Shoal), or by decomposition, mineral transformations and induration beneath the sea prior to their final emergence (Geological Shoal).

(4) The *climate* over most of the island is continuously wet or continuously moist, having no distinct dry season. The corresponding mean annual total rainfall is 160 to 70 inches. The zones of increasing rainfall are concentrically arranged around the central highlands. There is also a coastal zone having a weak to marked dry season and mean annual rainfall 70 to 50 inches; this zone is narrow except at the north and south ends of the island, where the land is low-lying.

(5) The *vegetation* mainly consists of second growths following the clearing for agricultural purposes of the original mountain rain forest and evergreen and semi-evergreen seasonal forests. The dry coastal belt and terminal lowlands are occupied by thorn woodland or cactus scrub.

(6) The topography of St. Lucia is closely related to the geology. Three distinct regions are recognisable:

(i) *The Central Region*, comprising the main ridge and its offshoots having altitude between 2,000 and 3,000 feet in the middle of the island and below 400 feet in the north and south. This region consists of old basement Miocene or Pliocene fragmental and massive igneous rocks which have been deeply weathered into residual Red Earth. It includes three large broad valleys containing Red Earth alluvium. Its land-forms are mature, subdued and rounded.

(ii) *The Mid-Western Region*, comprising several isolated conical peaks or pitons (including the Gros and Petit Pitons) of height between

2,500 and 3,000 feet, which may represent the plugs of volcanoes. The slopes are steep and consist of bouldery fragmental rocks with occasional lava flows; the valleys are deep and narrow.

(iii) *The South-Western Region* (Choiseuil-Vieux Fort), comprising a large fan-shaped glacis made up of "black cloud" volcanic deposits sloping gently from its source at 2,000 feet to the coast and enveloping several small hills or islands at its southern extremity which has been slightly elevated to form a raised beach now occupied by an aerodrome. The glacis is dissected longitudinally by deep ravines or "ghauts".

(7) The chief soil-types of St. Lucia have been provisionally named after their parent materials. The Zonal type of the area (*Red Earth Soil*) is developed in the Central Region over old residual materials occupying hilly and undulating country, and over clayey alluvium occurring in the three northern valleys. The Intrazonal types are *Brown Earth Soil* and *Yellow Earth Soil* (Calcimorphic) and *Terras Soil* and *Shoal Soil* (Hydromorphic). These are developed over less-weathered agglomerates and ash in the Mid-Western and South-Western Regions. The Azonal types are *Lithosol* occurring in the central highlands where erosion of Red Earth has exposed the parent rock, and *Alluvial and Colluvial Soils* occupying the flats and slopes of the younger valleys in the Mid-Western Region.

(8) These different soil-types are described as they occur in the three main topographical regions. The deterioration of Red Earth Soil in the Central Region, brought about by the erosion following forest felling for banana and provision growing, is described from the observations recorded by previous investigators and from the information obtained by our own field and laboratory studies. The Red Earth-Brown Earth-Lithosol complex, as expressed in the Central Region, is described and its distribution indicated.

(9) Data obtained by the examination of numerous profile and surface soil samples representative of these different soil-types, by routine laboratory methods outlined at the end of this report, are tabulated in the Appendix. They are discussed in the text under the crops which they chiefly support, namely, sugar-cane, cacao and limes, and peasants' provision crops.

(i) *The sugar-cane soils* of the northern valleys comprise highly acid silty-loams, deficient (by arbitrary standards) in organic matter and nitrogen, and in available potash, but most deficient in available phosphate. Those of the Vieux Fort district comprise nearly neutral sands containing medium amounts of organic matter and nitrogen and available potash but deficient in available phosphate. Common salt occurs in nearly harmful quantities in some of them. Manurial experiments so far have been mainly devised to test nitrogen and potash requirements; it

is suggested that the effects of heavy dressings of soluble phosphatic manure used in conjunction with mineral nitrogenous manure (which have given promising preliminary results) be especially investigated.

- (ii) The *cacao and citrus soils* of the Soufriere district comprise slightly acid sands containing medium-low amounts of organic matter and nitrogen and variable amounts of available phosphate and potash. Manuring and liming problems of cacao and limes are discussed. The special significance of lime and of soil organic matter in the nutrition and root development of citrus is stressed.
- (iii) Some *peasants' holdings'* soils that were examined comprise highly acid Red Earth generally deficient in organic matter, nitrogen and available potash and very deficient in available phosphate.

(10) The mineralogical transformations involved in the development of (i) Geological Shoal Soil at Morne Giraud, and of (ii) raised-beach Alluvial Soil at Vieux Fort are traced from the results of bulk chemical analyses of their clay fractions, checked in the first instance by means of dehydration curves. Beidellite was found to be the charac-

teristic clay mineral in each case. Determinations of exchangeable bases proved that this mineral comprises the sand fraction of the Shoal Soil. The practical significance of this discovery is discussed.

(11) *Soil erosion* in St. Lucia is described and its effects assessed. The most widespread kind is *débris avalanche* which chiefly affects Red Earth Soil in the Central Region. This usually starts as *débris-slide* caused by heavy continuous rainfall aided by forest felling. The catastrophic *débris avalanches* that occurred in the Ravine Poisson area in November, 1938, are described. Additional examples of this and of other kinds of soil erosion are mentioned and their effects on the distribution of soil-types are stated.

(12) *Soil conservation* is discussed and its urgent need in St. Lucia is stressed. The Morne Giraud anti-erosion experiment is described.

(13) The principles of *soil renovation* are outlined and the disadvantages of shifting cultivation as a means of renovation are stated. The influence of the kind of soil parent material on the renovation of eroded soils by means of rotation-crops and cover-crops, and the proper use of fertilisers (especially phosphate) and lime in agricultural systems of soil renovation are critically considered.

## REFERENCES

- (1) A report on some cultivated St. Lucia soils. H. H. Croucher, 11 pp. Castries, 1930.
- (2) Forestry in the Windward Islands, J. S. Beard, Bul. No. 11, *Col. Devel. and Welfare in West Indies*, 1944.
- (3) Agriculture in the West Indies. Col. No. 182, *Col. Devel. and Welfare in West Indies*, 1942.
- (4) Reports, Department of Agriculture, St. Lucia, 1943, p. 7.
- (5) Peasant agriculture in the Leeward and Windward Islands. C. Y. Shephard, 1945, mimeographed.
- (6) Geology of St. Lucia. K. W. Earle in "The St. Lucia Handbook for 1924," W. V. Palmer, 1924, pp. 78-86.
- (7) The Lesser Antilles, W. M. Davis. *Amer. Geog. Soc. Publ. No. 2*, New York, 1926.
- (8) The volcanic history and petrology of Montserrat (Royal Soc. Exped. to Montserrat). A. G. MacGregor, 1938.
- (9) Soil genesis from andesite in Grenada, British West Indies. F. Hardy and G. Rodrigues. *Soil Sci.*, 1939. XLVIII, pp. 361-384.
- (10) Studies in West Indian Soils (XI). The agricultural soils of Montserrat. F. Hardy, G. Rodrigues and W. R. E. Nanton, *I.C.T.A.*, 1947.
- (11) St. Lucia's banana industry. E. A. Walters. *Tropical Agric., Trin.*, 1928, V, pp. 247-249; pp. 284-286.
- (12) St. Lucia banana lands. E. A. Walters. *Tropical Agric., Trin.*, 1929, VI, pp. 69-73.
- (13) Virgin soil deterioration. C. W. Wardlaw. *Tropical Agric., Trin.*, 1929, VI, pp. 243-249.
- (14) Soils and flora; notes on a botanical and soil inspection of the St. Lucia banana and forest lands. C. W. Wardlaw. *Tropical Agric., Trin.*, 1929, VI, pp. 304-309.
- (15) Observations on the dominance of Pteridophytes in some St. Lucia soils. C. W. Wardlaw. *Journ. Ecol.*, 1931, XIX, pp. 60-63.
- (16) The significance of carbon-nitrogen ratio in soils growing cotton: (III) Nitrate fluctuations in relation to planting date and soil manurial requirements in the British West Indies. F. Hardy. *Tropical Agric., Trin.*, 1946, XXIII, pp. 201-21.
- (17) Effects of increasing phosphate dosages on the utilisation of nitrogen: Preliminary results of pot-tests on sugar-cane soils. F. Hardy. *Tropical Agric., Trin.*, 1947, XXIV, pp. 9-18.
- (18) Assessment of fertility of abnormal soils: (A) Rendzina. F. Hardy and A. S. Harper. *Tropical Agric., Trin.*, 1941, XVIII, pp. 214-221. (B) Ferruginous red soils. F. Hardy, A. S. Harper and E. G. Cripps. *ibid.*, pp. 238-243.
- (19) Recent investigations on sugar-cane and sugar-cane soils in Trinidad: (III) Effects of manurial treatment with ground limestone on crop quality and yield of commercial sugar. P. E. Turner. *Tropical Agric., Trin.*, 1936, XIII, pp. 299-306; 1937, XIV, pp. 63-69.
- (20) Granulated lime and manures. F. Hardy. *Tropical Agric., Trin.*, 1946, XXIII, pp. 81-84.
- (21) Reports, Department of Agriculture, St. Lucia, 1932-1938.
- (22) Studies in West Indian soils: (VII) The cacao soils of Trinidad (A) Montserrat District. J. A. McDonald, F. Hardy and G. Rodrigues, *I.C.T.A.*, 1933, 50 pp.
- (23) Studies in West Indian soils: (III) The cacao soils of Tobago. F. Hardy, C. G. Akhurst and G. Griffith. *I.C.T.A.*, 1931, 22 pp.
- (24) Studies in West Indian soils: (IV) The cacao soils of Grenada. F. Hardy, J. A. McDonald and G. Rodrigues. *I.C.T.A.*, 1932, 28 pp.
- (25) The maximum yield of cacao. F. Hardy, *Tropical Agric., Trin.*, 1939, XVI, pp. 179-191.
- (26) Leaf analysis as a means of diagnosing nutrient requirements of tropical orchard crops. F. Hardy, J. A. McDonald and G. Rodrigues, *Journ. Agric. Sci.*, 1935. XXV, pp. 610-627.
- (27) Studies in the physiology of *Theobroma cacao* with special reference to cherville wilt: (II) Growth rate and mineral intake by the pod. E. C. Humphries. *Ninth Ann. Rept. Cacao Res., I.C.T.A.*, pp. 44-47.
- (28) Marginal leaf-scorch of cacao; its relationship to soil potash deficiency. F. Hardy. *Sixth Ann. Rept. Cacao Res., I.C.T.A.*, 1936, pp. 13-24.
- (29) Studies in West Indian soils: (IX) Some soil-types of British Honduras, Central America. F. Hardy, H. P. Smart and G. Rodrigues, *I.C.T.A.*, 1935, 56 pp.
- (30) Grapefruit investigations in Trinidad. F. Hardy and G. Rodrigues, *Tropical Agric., Trin.*, 1935, XII, pp. 205-215.
- (31) Reports, Department of Agriculture, St. Lucia, 1932-38.
- (32) Landslides and related phenomena. C. F. Stewart Sharpe, Columbia Univ. Press, New York, 1938; See F. Hardy, *Tropical Agric., Trin.*, 1940, XVII, pp. 187-192.
- (33) Observations on the landslides in St. Lucia, B.W.I., in November, 1938. H. E. Box. *Emp. Forestry Journ.*, 1939, XVIII, pp. 119-121; also, The St. Lucia landslides. H. E. Box, W.I.C.C., 12 Jan., 1939, p. 3.
- (34) Report on the forestry problems of the Windward and Leeward Islands. A. Wimbush, 1936, Govt. Printer, Trinidad, 20 pp.
- (35) Biological processes in tropical soils. A. Steven Corbet, Cambridge, W. Heffer, 1935.
- (36) Soil investigations in the Arena Forest Reserve, Trinidad. D. W. Duthie, F. Hardy and G. Rodrigues. Summarised account by R. L. Brooks, *Imper. Forestry Inst.*, Paper No. 6, Oxford Univ., 1937.
- (37) Humus and the farmer. G. V. Jacks. *Journ. Roy. Soc. Arts*, 1941, LXXXIX, pp. 229-244.

## APPENDIX

## SOILS OF ST. LUCIA, B.W.I. (1941)

## Laboratory Data

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln. (p.p.m.)	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)
<b>(A) ESTATE SOILS</b>												
<b>(1) SOUFRIERE—CHOISEUIL DISTRICT</b>												
<b>(1) RUBY. <i>Gilbert Field</i></b>												
Site 1½ miles from sea coast. Seedling limes and cacao; limes mostly dead. Slope at foot of Majour Hill; possibly scree material or detritus. Very stony below top 9 ins. Boulders up to 2 ft. diameter, mostly sub-angular; arranged roughly in layers; mostly weathered and soft. Elevation 200 ft., rainfall 80 ins. Roots to 5 ft., mostly Calabash. Artificial manures applied 2 years ago. No litter; bare soil surface. Soil samples mainly picked out from between stones and boulders. <i>Brown Earth</i> soil-type. Chocolate sandy-clay to 2 ft. with many stones and boulders, but mostly boulders below. Medium-low organic matter, medium nitrogen, low C/N ratio, high available phosphate, medium-low available potash.												
LCA. 174. Chocolate brown ..	3	14	47	26	10	6.2	2.6	.16	9.4	139	49	114
175. Ditto ..	6	7	43	32	12	6.3	1.8	.13	7.9	90	19	75
176. Stony ..	9	19	47	31	13	6.2	1.5	.11	7.9	106	8	50
177. Rotten rock ..	15	16	48	34	17	6.1	1.1	.09	6.9	314	16	31
178. Rock layer ..	24	20	58	26	13	6.4	0.7	.07	6.6	70	21	43
179. Rotten rock ..	36	17	59	24	11	6.0	0.6	.05	7.0	1,104	0	60
180. Sand; rotten ..	48	3	52	25	10	6.3	0.6	.05	7.3	86	4	89
181. Ditto; bouldery ..	60	27	58	22	8	6.3	0.5	.04	7.2	94	16	99
Avail. K <sub>2</sub> O; LCA. 174, 175 (top 6 ins.); 92 p.p.m.												
<b>(2) SOUFRIERE I. <i>Susumbere Field</i></b>												
Sandy flat 300 yds. from sea; river 50 yds. to south; canal 10 yds. to north. Limes, coconuts. Water-table at 4 ft. Grassy; abundant Tephrosia. <i>Alluvial</i> (sandy) soil-type. Bright-brown, fine clayey-sand to 19½ ins. over dark sepia humic sand, 12 ins. thick, occupying spaces between large round boulders, overlying brownish-grey, coarse, loose grit, stained rusty-brown above water-level, grey below. Medium-low organic matter, medium nitrogen, low C/N ratio, medium-low available phosphate and potash.												
LCA. 182. Brown gritty ..	3	1	42	28	13	6.1	2.3	.13	10.3	102	33	101
183. Similar ..	6	0	40	32	15	6.0	1.9	.13	8.7	125	30	92
184. Paler, soft ..	9	0	50	26	11	6.1	1.2	.08	8.9	86	15	92
185. Loose ..	15	0	54	18	0	6.1	0.7	.05	8.3	94	10	100
186. Redder; speckled ..	19½	0	30	31	14	6.3	0.9	.07	7.8	79	6	108
187. Change to black ..	26	6	50	25	6	6.0	1.2	.08	8.3	104	19	109
188. Buried soil ..	32	12	58	21	5	6.3	1.2	.07	9.7	59	10	95
189. Loose, sand ..	39	3	87	7	0	5.9	0.3	.03	6.9	110	25	80
190. Rusty sand ..	47	4	87	7	0	5.9	0.2	.02	6.9	405	11	61
191. Grey; water-table ..	50	7	91	4	0	6.5	0.2	.02	6.3	78	22	45
Avail. K <sub>2</sub> O; LCA. 182, 183 (top 6 ins.); 82 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(3) MORNE LÉZARD 1. <i>Caille Bagasse Field</i>												
Site near R. Dorée on small flat or ledge, 20 ft. above river level, down at bottom of ravine. Cacao 35 years old, healthy but overshadowed. Sloping ground, 30°, 20 yds. to S. also in cacao. Old sugar factory nearby. Soil profile in two parts; (i) grey-ochre, coarse, loose river-flood sand, (ii) old buried soil, black, compact sand with clay band at 34-48 ins. <i>Alluvial</i> (sandy) soil-type. Medium-low organic matter and nitrogen, low C/N ratio, medium-high available phosphate and potash.												
LCA. 192. Sepia humic ..	3	2	77	12	0	7.0*	3.4	.17	11.9	205	295	71
193. Variegated ..	6	15	77	15	0	7.0*	1.0	.07	9.2	119	69	49
194. Ditto ..	12	18	84	10	0	7.0*	0.3	.02	9.0	60	25	27
195. Ditto ..	20	17	86	9	0	6.5*	0.2	.11	7.5	58	19	29
196. Black humic ..	23	17	70	14	0	6.6	1.1	.07	8.6	62	25	784
197. Ditto ..	27	4	69	15	1	6.7	1.1	.06	11.1	70	32	964
198. Stony layer ..	34	24	60	21	2	6.6*	0.6	.01	7.4	123	17	179
199. Tough clay ..	40	0	27	53	19	6.6*	0.8	.07	6.6	63	22	104
200. Ditto ..	48	0	31	48	20	6.4*	0.7	.07	6.6	94	17	15
201. Sandy ..	56	1	39	40	7	6.8	0.4	.05	5.5	57	16	15
202. Ditto ..	64	0	55	30	9	6.3	0.3	.03	5.3	148	5	17
203. Stony ..	72	26	63	25	6	6.4	0.2	.03	4.8	46	15	23
Avail. K <sub>2</sub> O; LCA. 192, 193 (top 6 ins.); 171 p.p.m. * pH by glass electrode.												
(4) MORNE LÉZARD 2. <i>The Flat</i>												
Level land at top of river-gorge. Cotton field, first year; previously limes and sporadic coconuts. Black humic sandy soil to 12 ins., with abundant quartz crystals, over red-brown, partly-cemented, harsh terraces. "Black cloud" deposits. Loose sand below 36 ins.; sparse stones, boring to 105 ins. <i>Terras</i> soil-type with affinities to Yellow Earth; widespread in this district. Medium-low organic matter and nitrogen, fairly high C/N ratio; low available phosphate and potash.												
LCA. 204. Made-up ..	6	—	66	16	0	5.8	3.0	.15	11.7	133	0	14
205. Black ..	12	—	65	18	0	4.8	1.7	.10	9.5	500	16	11
206. Coherent ..	18	1	45	45	18	6.1	0.8	.06	8.4	104	20	8
207. Tough ..	24	1	45	45	7	6.5	0.4	.04	6.3	73	1	8
208. Stiff, speckled ..	30	1	48	38	13	6.8	0.3	.03	6.0	68	20	7
209. Coherent ..	36	1	54	34	9	6.8	0.2	.02	4.8	58	9	4
210. Loose, ginger ..	48	2	69	18	0	6.9	0.2	.02	5.7	49	12	11
211. Ditto ..	60	4	77	13	0	6.8	0.1	.01	6.1	45	10	35
212. Variegated ..	72	2	82	0	0	6.7	0.2	.02	5.6	47	20	35
Avail. K <sub>2</sub> O; LCA. 204 (top 6 ins.); 74 p.p.m.												
(5) MORNE LÉZARD 3. <i>Cadebat Field</i>												
Alongside road to Parc. Grapefruit. Site in hollow; may once have been an "etang." Fine sand to 9 ins., over stiff olive-grey clay to 33 ins., over mottled sandy-clay to 42 ins., over rotten rock and compact hard variegated sand. Possibly <i>Terras</i> soil-type but may be partly a hydromorphic or swamp type. Contains manganese oxide concretions throughout. Medium organic matter and nitrogen; fairly high C/N ratio, medium-low available phosphate, fairly high available potash.												
LCA. 213. Loose ..	3	1	57	21	5	6.1	2.7	.14	11.7	222	47	25
214. Ditto ..	6	1	51	25	6	5.9	2.3	.12	10.8	64	16	10
215. Transition ..	9	2	65	34	2	5.9	1.4	.08	10.5	90	14	7
216. Hard, horny ..	12	7	37	56	22	5.5	1.4	.08	10.3	85	7	4
217. Waxy, olive ..	18	6	21	74	34	4.9	1.0	.06	9.3	148	0	3
218. Cracked ..	24	5	19	75	33	4.9	0.5	.04	8.2	183	38	2
219. Tough ..	33	0	17	56	33	4.9	0.4	.03	9.4	219	52	1
220. Concretionary ..	42	0	28	62	21	5.3	0.4	.03	9.3	243	48	3
221. Rotten rock ..	49	13	40	47	16	5.6	0.3	.02	7.8	258	23	1
222. Black patches ..	54	25	38	45	13	6.0	0.2	.02	6.1	225	12	1
223. Crumbly ..	66	11	44	42	14	5.4	0.2	.02	6.1	478	0	3
Avail. K <sub>2</sub> O; LCA. 213, 214 (top 6 ins.); 181 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion. (pH).	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln. (p.p.m)	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(6) SOUFRIERE 2. <i>S. side of River Valley</i>												
Gentle slope. Coconuts and limes. Humic sand to 9 ins., cemented pinkish-grey terras below, containing a layer of fresh soft stones, 12 to 36 ins., thick loose sand to bottom; boulders at base. <i>Brown Earth</i> soil-type with affinities to <i>Terras</i> . Medium-low organic matter and nitrogen; low C/N ratio; medium-low available phosphate and potash.												
LCA. 225. Sepia humic ..	3	21	50	23	4	5.9	2.4	.13	10.5	81	26	35
226. Paler ..	6	9	46	29	4	5.6	1.7	.11	9.1	98	22	17
227. Dull brown ..	9	1	46	31	3	5.8	1.5	.09	9.7	61	13	13
228. <i>Terras</i> , soft ..	12	1	38	41	6	5.8	1.3	.08	9.8	42	2	10
229. Harder ..	18	1	39	43	13	5.7	0.7	.04	8.8	47	4	8
230. Marbled ..	24	1	47	35	8	5.7	0.5	.04	8.1	64	0	1
231. Soft stones ..	36	8	55	25	3	6.2	0.1	.02	5.6	51	4	3
232. Loose sand ..	48	38	68	18	0	6.0	0.1	.01	7.0	62	0	5
233. Brown-pink ..	60	37	79	10	0	6.3	0.2	.01	9.4	35	2	1
234. Ditto ..	66	44	83	7	0	6.0	0.1	.01	7.8	139	6	2
Avail. K <sub>2</sub> O; LCA. 225, 226 (top 6 ins.); 82 p.p.m.												
(7) RABOT. <i>Agricultural Department Experiment Station</i>												
Nursery. Site at east foot of high hill, 150 yds. away. Land gently sloping to east. No manure added; land occasionally mulched. Black humic sand to 21 ins., pebble layer, 5 ins.; harsh brown coarse sand with partly rotten stones and sparse boulders below. Pebble layer may be flood or colluvial material. Clayey below to 94 ins. (boring). <i>Brown Earth</i> soil-type but probably colluvial or erosion dump from opposite hill-side. Medium-low organic matter and nitrogen; low C/N ratio; medium available phosphate, medium-high available potash.												
LCA. 237. Black, friable ..	3	11	64	19	2	5.1	1.6	.09	10.2	113	9	54
238. Yellowish ..	6	8	65	19	2	5.4	1.2	.08	9.3	98	10	29
239. Stoneless ..	12	9	65	18	2	4.9	0.8	.05	9.5	302	18	11
240. Loose grit ..	21	7	65	19	2	5.9	1.1	.07	8.5	55	10	11
241. Pebble bed ..	26	41	59	21	5	6.2	1.1	.06	9.5	50	0	9
242. Clayey ..	36	6	56	23	7	6.3	0.7	.05	8.6	51	3	8
243. Dull brown ..	48	8	58	23	8	6.0	0.5	.04	7.0	368	27	19
244. Rotten stones ..	56	8	69	23	6	6.2	0.3	.03	6.1	83	6	42
245. Coherent ..	70	14	64	21	5	6.5	0.4	.03	6.8	142	20	54
Avail. K <sub>2</sub> O; LCA. 237, 238 (top 6 ins.); 163 p.p.m.												
(8) HERMITAGE												
Site on hillside east of main road, 200 yds. Cacao. Black humic soft-sand to 6 ins. changing imperceptibly into dull brown-pink clayey-sand with rotten grey stones below and patches of soft rock throughout. Waxy clay. Quartz crystals and golden mica conspicuous below 12 ins. Rock resembles diorite or dacite. <i>Brown Earth</i> soil-type, profile possibly truncated. Medium-high organic matter and nitrogen; medium-low available phosphate, very high available potash (although leaf-scorch present); high C/N ratio.												
LCA. 246. Black, soft ..	3	26	51	27	10	6.4	4.8	.21	13.2	184	110	31
247. Black, stony ..	6	24	46	22	7	6.5	1.9	.10	10.7	115	60	14
248. Transition, ..	9	23	42	22	8	6.2	1.5	.08	10.4	83	40	11
249. Brownish clayey ..	12	14	38	26	14	5.7	1.2	.07	10.3	53	15	9
250. Paler ..	18	14	37	27	15	5.6	1.1	.05	10.8	44	7	6
251. Soft, rotten ..	24	9	40	25	13	5.5	0.6	.04	9.1	51	3	5
252. Looser ..	36	8	37	22	10	5.5	0.4	.03	8.0	40	6	9
253. Ditto ..	48	2	37	23	10	5.5	0.5	.03	9.4	133	10	8
Avail. K <sub>2</sub> O; LCA. 246, 247 (top 6 ins.); 353 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12	
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)	
(9) UNION VALE													
Road side bank section near manager's house on edge of cane-field, 400 ft. elevation. Dark brown humic sand to 12 ins., merging imperceptibly below into brown-pink hard, compact, partly-cemented <i>terras</i> . Sparse grey stones. Edge of "black cloud" deposits. <i>Terras</i> soil-type. Medium organic matter; medium low nitrogen; low available phosphate; medium-low available potash.													
LCA. 255.	Brown, humic ..	3	31	63	24	8	5.5	3.2	.13	15.0	93	22	13
256.	Hard, humic ..	6	43	55	24	9	5.8	2.2	.10	14.0	71	21	11
257.	Dull brown ..	9	22	50	24	10	6.0	1.2	.06	11.8	65	17	11
258.	Pinkish ..	12	26	58	21	6	6.0	0.7	.05	9.4	68	21	19
259.	<i>Terras</i> ..	18	34	69	Sandy	0	6.3	0.2	.02	7.6	70	2	11
260.	Harder ..	32	51	77	"	0	6.1	0.2	.02	8.2	244	14	52
261.	Softer ..	48	22	77	"	0	6.1	0.1	.01	7.2	302	7	140
262.	Ditto ..	66	18	75	"	0	6.3	0.1	.01	7.8	78	4	144
263.	Yellow grit ..	86	9	77	"	0	6.5	0.1	.01	7.8	198	7	140
Avail. K <sub>2</sub> O; LCA. 255, 256 (top 6 ins.); 101 p.p.m.													
(10) ANSE MAMIN													
Valley north of Soufriere Village; narrow flat, 2 miles long, 250 yds. wide. Site, north side of flat at foot of small hill. Coconuts, limes. Dark brown humic sand to 6 ins., paler compact sand to 13 ins., layer of charcoal residues to 19 ins., over grey sand and boulders. No water-table reached to 95 ins. River <i>Alluvial</i> (sandy) soil-type. Medium organic matter, medium-low nitrogen; very high C/N ratio (charcoal); very high available phosphate and potash, possibly from burnt wood.													
LCA. 264.	Brown, loose ..	3	23	55	21	5	6.6	3.2	.09	19.6	148	41	122
265.	Crumbly ..	6	13	52	22	7	6.2	2.5	.10	14.7	478	14	135
266.	Compact ..	13½	17	61	Sandy	3	6.5	0.7	.03	12.9	100	18	70
267.	Black band ..	19	71	70	"	0	5.6	29.5	.28	60.3	162	18	95
268.	Pink, ashy ..	30	24	59	"	0	5.4	1.2	.06	12.3	364	0	130
269.	Bouldery ..	45	37	79	"	0	6.2	0.8	.05	9.6	66	6	111
270.	Sand bed ..	54	0	87	"	0	6.3	0.3	.02	8.2	47	11	101
271.	Ashy-sand ..	66	20	88	"	0	6.6	0.2	.02	7.2	60	17	82
Avail. K <sub>2</sub> O; LCA. 264, 265 (top 6 ins.); 814 p.p.m.													
(II) VIEUX FORT DISTRICT													
(11) LA TOURNEY I													
Site in cane-field on flat near road. Swampy bush-land nearby. Hard, black, somewhat saline clay, deeply cracked. Ploughed to 9 ins.; land laid out in cane banks. Humic clay to 12 ins., merging into dull greenish-grey tough clay with glassy quartz crystals and vertical lines of black spots rich in manganese oxide, some of large size. <i>Alluvial</i> (clay) soil-type with affinity to Solonetz (White Alkali Soil). Medium-high organic matter, fairly high nitrogen; high C/N ratio; medium available phosphate and potash. Saline below 12 ins.													
LCA. 277.	Horny black clay ..	6	15	20	64	25	6.0	4.5	.22	11.6	305	25	34
278.	Ditto ..	9	5	18	64	25	6.8	3.7	.20	10.8	246	68	29
279.	Ditto ..	12	3	19	68	24	6.8	2.6	.16	9.7	246	32	25
280.	Transition ..	18	0	18	67	21	7.0	1.6	.10	9.2	533	134	15
281.	Khaki, spotted ..	24	7	20	65	21	7.3	1.1	.09	7.2	762	180	12
282.	Ditto ..	36	10	24	64	19	7.5	0.6	.04	9.5	1,454	146	12
283.	Ditto ..	42	9	22	66	21	7.6	0.5	.03	9.3	1,758	82	6
No <i>terras</i> , no stones, sand 35%													
Avail. K <sub>2</sub> O; LCA. 277 (top 6 ins.); 128 p.p.m.													

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln. (p.p.m)	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(12) LA TOURNEY 2												
Site in cane-field north-east of last, 300 yds. Sand layer, top, 10 ins., over very hard clay or <i>terras</i> . Slight hollow surrounded by low hills on three sides; land gently sloping to south-west. <i>Alluvial</i> (clay) soil-type, with affinity to <i>Terras</i> or <i>Shoal</i> . Composite profile. Medium-low organic matter, nitrogen, available phosphate and potash. Somewhat saline.												
LCA. 284. Sand; quartz ..	10	7	63	2	0	6.2	1.8	.10	10.9	117	6	27
285. Drab clay sand ..	18	4	43	43	8	6.3	0.6	.04	8.4	143	24	7
286. Soft <i>terras</i> .. Harder below No stones	24	43	60	18	0	5.8	0.3	.02	9.5	225		4
Avail. K <sub>2</sub> O; LCA. 284 (top 10 ins.); 104 p.p.m.												
(13) LA TOURNEY 3. <i>Pasture Field</i>												
Site north-east of last; no sand layer on top. Hard black clay to 12 ins. merging into brownish green (khaki) stiff clay sharply overlying ginger-brown and grey-green partly-cemented sandy <i>terras</i> or <i>shoal</i> . <i>Alluvial</i> (clay) soil-type with affinity to <i>Shoal</i> . Concretionary spots of manganese oxide. Medium-low organic matter and nitrogen; very low available phosphate and medium-low available potash. <i>Saline</i> below top 6 ins.												
LCA. 287. Black clay ..	6	14	31	57	19	5.9	2.1	.12	10.1	219	20	8
288. Black spotted ..	12	17	28	61	21	6.1	1.6	.10	9.7	302	28	8
289. Khaki; spotted black ..	18	26	28	59	18	5.9	0.4	.03	7.4	488	55	7
290. Ditto ..	24	20	31	57	17	5.3	0.3	.02	6.7	762	38	5
291. Transition ..	30	13	29	58	17	5.3	0.2	.04	3.3	942	58	7
292. Ditto ..	36	6	39	49	14	5.3	0.2	.02	6.9	1,067	77	7
293. <i>Terras</i> ; rusty No stones	40	7	71	15	1	5.9	0.1	.02	3.2	628	39	11
Avail. K <sub>2</sub> O; LCA. 287 (top 6 ins.); 85 p.p.m.												
(14) BEAUSEJOUR I. <i>James Clarke Block, A 41.</i>												
Cane-field. Small plateau or raised flat; elevation about 45 ft., near labourers' houses and U.S. military headquarters office. Beausejour Hill 300 yds. north. Stiff, cracked, very hard clay, merging imperceptibly below into ginger <i>terras</i> or <i>shoal</i> . Surface 12 ins. Soil contains hard "shot." <i>Alluvial</i> (clay) soil-type with affinity to <i>Ground Water Podzol</i> (Hydromorphic) and to <i>Terras</i> . Medium to medium-low organic matter and nitrogen; medium C/N ratio; very low available phosphate, medium available potash. <i>Saline</i> below 12 ins.												
LCA. 296. Shotty ..	9	24	42	42	12	6.3	2.5	.13	10.9	199	23	10
297. Black; horny ..	12	36	31	56	19	6.0	1.2	.09	7.6	205	39	9
298. Khaki ..	18	16	27	61	20	5.8	0.6	.05	6.9	356	49	3
299. Transition ..	23	52	31	53	19	5.4	0.6	.04	8.7	562	78	7
300. <i>Terras</i> ; rusty No stones	26	10	65	17	5	5.8	0.2	.02	8.0	427	73	1
Avail. K <sub>2</sub> O; LCA. 296 (top 9 ins.); 134 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(15) BEAUSEJOUR 2. <i>Canterbury Block</i>												
Cane-field. Site north-west of last, 250 yds., near Beausejour Hill, but slightly higher elevation. Shallow depression. Hard black clay to 12 ins., grading through brownish-green stiff clay to grey-green sandy terras. <i>Alluvial</i> (clay) soil-type with affinity to <i>Terras</i> . Medium-low organic matter and nitrogen; low available phosphate, medium-low available potash. Medium C/N ratio. Saline below 12 ins. No shot. Sparse black spots, probably manganese oxide.												
LCA. 301. Black clay .. ..	6	30	41	44	12	6.2	2.2	.13	10.0	229	12	11
302. Ditto .. ..	12	13	31	51	17	6.2	1.9	.14	7.9	200	14	11
303. Greenish .. ..	18	19	27	60	17	6.1	0.8	.07	6.8	281	5	5
304. Streaky .. ..	24	23	28	57	15	5.8	0.5	.04	6.4	377	23	5
305. Transition .. ..	28	12	31	54	14	5.7	0.4	.04	7.0	492	42	5
306. <i>Terras</i> .. ..	31	7	28	49	18	5.7	0.3	.03	5.7	534	18	5
307. Ditto .. ..	38	3	26	51	20	5.6	0.2	.02	3.8	628	39	5
308. Ditto .. ..	43	10	28	52	18	5.7	0.1	.02	1.4	712	33	1
No stones												
Avail. K <sub>2</sub> O; LCA. 301 (top 6 ins.); 103 p.p.m.												
(16) BLACK BAY. <i>Mamdolly Field No. 1</i>												
Site on small plateau; approach to hog's back ridge. Black stiff shallow clay; rusty specks and rotten rock below, merging into grey terras or shoal. Shotty manganiferous concretions in top 6 ins., denoting impeded drainage. Soil probably derived from old residual volcanic rocks comprising Miocene Basement and not from "black cloud" deposits. <i>Shoal</i> soil-type. Markedly to highly acid. Medium-low organic matter, medium nitrogen; low C/N ratio; very low available phosphate, fairly-high available potash. Not saline.												
LCA. 309. Shotty; black ..	6	51	51	34	10	5.8	2.3	.15	9.3	76	20	8
310. Red-brown clay ..	12	32	31	59	24	5.4	1.2	.09	8.0	116	18	8
311. Ditto .. ..	16	39	24	69	30	4.9	1.0	.06	8.6	137	14	9
312. Rusty cobbles; cemented; rotten	20	73	36	51	23	4.9	0.9	.05	10.4	172	11	9
Avail. K <sub>2</sub> O; LCA. 309 (top 6 ins.); 64 p.p.m.												
(17) LA RETRAITE. <i>Pack Buef Field</i>												
Cane-field. Site on undulating land between small hills or knolls. Beausejour Hill, the nearest large hill, seems to consist of basaltic lava, onion-weathered, which presumably therefore comprises most of the Vieux-Fort hills, around which the "black cloud" deposits wrap. Heavy black clay to 18 ins.; sparse stones; some shot in top 12 ins. Dull green clay below with patches of yellow sand. Quartz crystals and golden mica at 48 ins. Terras below 58 ins. Occasional small boulders. Much may be hill-wash. <i>Terras</i> soil-type; "black cloud" deposits. Medium organic matter and nitrogen; fairly high C/N ratio; medium-low available phosphate, low available potash. Not particularly saline.												
LCA. 313. Shotty; dark- brown clay ..	6	30	50	33	10	5.5	2.7	.13	11.8	150	19	29
314. and stones ..	12	28	42	39	11	6.3	1.4	.09	9.8	92	31	26
315. Streaky black ..	18	45	38	50	15	6.7	0.9	.06	8.8	134	37	11
316. Transition ..	24	26	36	56	20	7.0	0.4	.03	8.1	194	50	10
317. Khaki clay ..	36	27	25	66	26	6.4	0.4	.02	9.1	368	37	7
318. Transition ..	40	34	32	56	18	6.0	0.3	.02	7.6	416	23	5
319. Ditto sandy ..	48	10	38	48	15	6.1	0.2	.02	5.9	356	17	5
320. Ditto .. ..	58	13	39	44	16	6.1	0.1	.02	4.7	320	17	5
321. Terras; yellow ..	72	21	70	16	0	6.7	0.1	.01	5.5	205	20	49
Stones sparse; some boulders												
Avail. K <sub>2</sub> O; LCA. 313 (top 6 ins.); 66 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion. (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-8</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(18) ST. URBAIN 1. <i>Field No. 1</i>												
Cane-field. Site enclosed by low hills on three sides; land nearly flat; mangrove patch to north-east. Very poor cane crops; previously, logwood scrub. Jet-black spongy clay, 4 ins. thick, full of quartz crystals, sharply overlying green-grey stiff clay, over partially-cemented sand at 46 ins., indurated below. No stones. <i>Alluvial</i> (clay) soil-type with affinity to <i>Terras</i> . May be composite profile; 46 ins. clay-over-sand, cemented terras below. High organic matter and nitrogen; high C/N ratio; low available phosphate, medium-high available potash. Very saline below top 4 ins.												
LCA. 326. Jet black .. ..	4	0	21	65	33	6.2	6.0	.29	12.1	244	195	19
327. Smear'd .. ..	10	0	18	75	31	5.7	1.7	.10	9.8	451	42	15
328. Speckled .. ..	18	2	16	79	33	5.2	1.0	.08	7.6	800	43	13
329. Green-grey .. ..	24	1	12	83	33	4.8	1.1	.07	8.9	1,333	0	9
330. Ditto .. ..	36	2	19	75	27	4.6	0.3	.02	7.1	1,600	0	8
331. Transition .. ..	46	0	17	75	28	4.7	0.2	.02	6.7	1,759	125	9
332. Sand .. ..	58	20	57	27	9	6.2	0.1	.01	2.7	800	0	13
333. Ditto, soft terras.. No stones	70	11	74	14	2	7.0	—	.01	—	372	61	87

Avail. K<sub>2</sub>O; LCA. 326 (top 4 ins.); 155 p.p.m.; (10 ins.) 75 p.p.m.(19) ST. URBAIN 2. *Syton Field*Cane-field. Site due west of last, 600 yds., in small hollow; same broad flat surrounded by low hills on north and north-west, near St. Urbain old factory. Black clay to 6 ins., green-grey clay to 30 ins., over tawny partly-cemented terras. *Alluvial* (clay) soil-type with affinity to *Terras*. Medium organic matter, medium-high nitrogen; low C/N ratio; medium-low available phosphate, medium available potash. Saline below 12 ins.

LCA. 334. Black clay .. ..	6	18	17	72	31	6.2	3.2	.19	9.8	148	26	17
335. Piped, speckled .. ..	12	—	12	81	39	5.5	1.3	.10	7.1	405	11	13
336. Transition .. ..	18	2	12	82	37	5.7	0.9	.07	7.5	348	28	7
337. Khaki clay .. ..	24	5	12	83	37	5.0	0.6	.05	7.1	493	69	7
338. Ditto .. ..	30	24	17	74	34	4.9	0.6	.04	8.4	593	47	8
339. Sand .. ..	38	24	39	40	17	5.2	0.2	.02	8.0	451	34	7
Not quite terras No stones												

Avail. K<sub>2</sub>O; LCA. 334 (top 6 ins.); 122 p.p.m.

## (III) CENTRAL MOUNTAIN DISTRICT

(20) QUILLESSE 1. *Agricultural Experiment Station*Nursery. Site actually on erosion dump or avalanche debris from hill-slope to south. Mostly raw subsoil material of *Red Earth* relationship. Buried soil at 57 ins. Variable profile. Red-brown, rusty, fawn, grey, drab-brown orange. Conspicuous sepia spots in upper 24 ins. layer; possibly manganese oxide. Mostly free from stones, except between 36 and 57 ins. Medium high organic matter and nitrogen; high C/N ratio; high available phosphate, very high available potash, probably from fertilisers.

LCA. 340. Crumbly .. ..	6	23	19	54	30	6.1	4.2	.20	12.4	291	99	78
341. Grey, bleached .. ..	12	3	13	59	32	5.0	1.9	.11	10.2	77	8	13
342. Sepia, spotted .. ..	18	5	20	49	26	5.1	0.7	.05	8.1	74	4	4
343. Spotted .. ..	24	5	34	40	21	5.1	0.5	.03	8.5	70	7	8
344. Rusty fawn .. ..	36	6	41	35	18	5.4	0.5	.03	9.1	64	8	13
345. Pale grey .. ..	44	9	38	36	17	5.7	0.5	.03	8.9	62	7	11
346. Stony .. ..	57	11	42	33	18	5.6	0.4	.03	9.1	65	7	12
347. <i>Old soil</i> .. ..	60	8	27	45	25	5.8	0.7	.05	8.1	54	5	8
348. Dull grey .. ..	65	26	26	49	26	5.8	0.6	.05	7.7	46	8	9
349. Rusty .. ..	72	9	20	60	35	5.7	0.6	.05	8.3	46	3	11

Avail. K<sub>2</sub>O; LCA. 340 (top 6 ins.); 636 p.p.m.

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos $\times 10^{-6}$ )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m)
(21) QUILESSE 2												
Site in hillslope opposite last (nursery) site, just above Teak plot. Hollow caused by great land-slide or débris avalanche that produced erosion dump occupying nursery area. Slope, 35°. Very bouldery surface; shallow soil. Black sand to 3 ins., then ochre-brown clay, then a buried soil at 24 ins., then boulders and stones to 60 ins. <i>Red Earth</i> soil-type; composite; eroded or truncated, so that it now comprises <i>Lithosol</i> . Very high organic matter and nitrogen; high C/N ratio but only in top 3 ins. layer; low available phosphate, very high available potash.												
LCA. 350. Black .. ..	3	58	57	16	—	5.9	11.6	.47	14.4	221	224	24
351. Ochre-brown .. ..	6	53	26	50	—	5.8	4.3	.22	11.5	87	42	8
352. Bouldery .. ..	12	36	23	52	29	5.5	2.6	.15	10.0	42	17	3
353. Interstitial .. ..	24	33	28	48	28	5.3	2.0	.13	8.8	36	9	3
354. Black .. ..	34	87	46	31	0	5.4	6.7	.33	11.7	57	20	7
355. Yellowish .. ..	48	87	22	51	32	5.7	4.6	.30	9.0	67	10	9
boulders below												
Avail. K <sub>2</sub> O; LCA. 350, 351 (top 6 ins.); 811 p.p.m.												
(IV) NORTHERN DISTRICT												
(22) 'TI ROCHER District												
Road-side bank, near Guesneau, showing Red Earth overlying andesite. Second growth bush. Sepia-humic gravelly sandy-clay with quartz crystals and small black stones to 6 ins., over brownish-red friable clay becoming bright orange-red at 12 ins., flaky, friable clay. Pink Earth comes in below at 36 ins.; transition, variegated red, orange, pink, grey to base of bank at 120 ins. <i>Red Earth</i> soil-type ("Red Lateritic Soil"). Fairly high organic matter and nitrogen, high C/N ratio; low available phosphate, high available potash.												
LCA. 363. Sepia .. ..	6	67	48	33	14	6.3	4.4	.20	12.9	150	96	13
364. Red-brown .. ..	12	54	25	62	31	6.1	1.8	.11	10.1	73	10	7
365. Terra cotta .. ..	24	4	8	78	47	5.5	1.2	.07	9.6	68	3	3
366. Transition to pink earth	36	0	8	76	46	5.0	0.6	.04	8.0	58	0	5
Avail. K <sub>2</sub> O; LCA. 363 (top 6 ins.); 223 p.p.m.												
(23) UNION. Government Experiment Station.												
Site of flat, Section 8, nearly at sea-level, west of river. Seldom flooded. Dark chocolate-red hard humic loamy-clay with incipient hard-pan between 36 and 48 ins., dull neutral grey clay below, rusty speckled, to 66 ins. (base). Water-table probably around 48 ins. depth in wet season. <i>Alluvial</i> (clay) soil-type. Medium-low organic matter, medium nitrogen, low C/N ratio; medium-low available phosphate, very low available potash. Not saline. Possibly limed.												
LCA. 368. Chocolate .. ..	6	3	13	58	37	6.1	2.3	.14	9.9	128	55	22
369. Ditto .. ..	12	3	13	58	38	6.5	1.8	.12	9.1	121	78	17
370. Ditto .. ..	18	2	13	59	39	6.3	1.7	.11	9.3	57	24	8
371. Yellower .. ..	24	2	11	60	39	6.1	1.4	.09	8.6	43	8	7
372. Yellowish .. ..	36	1	7	68	43	6.1	1.0	.08	8.0	47	13	5
373. Spotted .. ..	48	3	14	66	41	6.4	0.7	.06	7.7	48	12	13
374. Grey, mottled .. ..	54	0	3	83	46	6.4	0.7	.06	6.9	51	9	12
375. Ditto .. ..	66	2	3	74	45	6.0	0.5	.04	7.5	48	4	13
Avail. K <sub>2</sub> O; LCA. 368 (top 6 ins.); 45 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> ).	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)
(24) MORNE GIRAUD. <i>Soil Conservation Experimental Area, Moulin-a-Vent Estate</i>												
Site about 50 yds. east of experimental area on same gentle hill-slope. Cossie bush, grass, logwood scrub. Remnants of contour banks. Black gravelly clay to 12 ins., hard horny clay, chocolate-pink colour, to 20 ins., merging into grey cemented shoal, very hard and compact. Parent rock, grey igneous rock, probably lava, but much weathered and rusty at depths observed. <i>Shoal</i> soil-type, probably "Geological Shoal." Fairly high organic matter, fairly high to high nitrogen, high C/N ratio; medium-low to low available phosphate, low available potash.												
LCA. 376. Gravelly .. ..	6	45	31	37	26	6.1	5.0	.24	12.0	118	29	16
377. Stony .. ..	12	80	29	30	20	6.2	2.3	.15	9.0	87	39	8
378. Horny .. ..	16	22	5	45	43	5.6	1.3	.10	7.5	218	18	5
379. Ditto .. ..	20	0	4	45	43	5.1	0.9	.07	7.2	273	16	4
380. Transition .. ..	22	35	21	35	28	5.2	0.5	.05	6.3	239	19	5
381. <i>Shoal</i> .. ..	28	43	65	Sandy	0	5.4	—	—	—	162	18	5
382. Ditto .. ..	38	78	72	„	0	5.7	—	—	—	210	20	8
Avail. K <sub>2</sub> O; LCA. 376 (top 6 ins.); 78 p.p.m.												
(25) CAP. <i>Open Pasture</i>												
Site on very gentle slope down to sea-beach; elevation about 50 ft., Cossie scrub. Land surface cut up by grazing sheep and surface erosion. No boulders, no stones. May be a raised beach. Hard dull chocolate uniform clay to 30 ins., over hard, compact, cemented speckled terras, deeply cracked. Probably igneous rock below old Miocene Basement. (Not much agglomerate seen near sea-coast in Cap district and Gros Islet). Gives rich umber-brown soil, probably derived from calcareous parent material (black sand). <i>Shoal</i> soil-type; calcareous below (coral sand); probably saline. May be Coastal Alluvial. Medium organic matter and nitrogen; low C/N ratio; medium available phosphate, medium-low available potash.												
LCA. 383. Chocolate .. ..	6	3	7	46	43	6.3	2.8	.16	9.9	178	65	35
384. Ditto, very tough..	12	3	6	43	40	7.0	1.9	.11	9.6	198	50	32
385. Ditto, pinkish ..	18	4	7	42	39	7.2	1.2	.09	8.0	281	129	30
386. Ditto, spotted ..	24	2	7	43	39	7.4	0.9	.06	8.7	485	180	25
387. Ditto, speckled ..	29	6	10	40	36	7.4	0.7	.05	9.0	605	176	25
388. <i>Shoal</i> ; soft ..	34	4	41	28	15	7.7	0.3	.02	9.7	427	135	25
389. Ditto, very hard ..	39	33	70	27	10	7.8	0.1	.01	5.8	330	103	47
No stones												
Avail. K <sub>2</sub> O; LCA. 383 (top 6 ins.); 110 p.p.m.												
(V) CUL DE SAC VALLEY												
(26) CUL DE SAC I. <i>Field 2; Incommode East</i>												
Cane-field; site 1 mile from sea, north side of river, near valley centre. Land forked to 7 or 9 ins.; pen manured; limed; some ammonium sulphate, a little superphosphate and potassium chloride. Yield, 35-40 tons acre. Orange-tawny clay-loam, markedly sepia-spotted between 18 and 48 ins.; indications of "gley" below. Impeded drainage. River <i>Alluvial</i> clay-soil type. Medium to medium-high organic matter, medium nitrogen; high C/N ratio; low to medium-low available phosphate, medium-low available potash. Not saline.												
LCA. 390. Yellow-brown ..	3	0	9	39	30	5.8	3.6	.17	12.5	221	20	19
391. Forking .. ..	6	0	9	38	29	5.9	3.1	.14	12.5	188	60	14
392. Paler, compact ..	9	1	6	38	29	5.7	2.6	.14	11.4	82	29	12
393. Orange .. ..	12	1	15	39	29	5.4	2.4	.13	10.9	68	19	7
394. Tawny .. ..	18	1	11	38	29	5.8	1.4	.08	10.3	67	10	3
395. Spotty .. ..	24	2	11	38	29	5.9	1.1	.07	9.7	73	11	1
396. Ditto .. ..	36	3	9	38	31	6.1	0.9	.05	9.8	65	4	3
397. Very spotty .. ..	48	4	9	39	32	6.7	0.7	.05	8.2	74	10	4
398. Mottled .. ..	60	1	12	35	26	6.3	0.5	.04	8.2	62	8	3
399. Grey, ochre .. ..	72	0	27	31	20	6.2	0.4	.03	8.5	54	6	11
Avail. K <sub>2</sub> O; LCA. 390, 391 (top 6 ins.); 89 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay. (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)
(27) CUL DE SAC 2. <i>Ferrands Field No. 3</i>												
Cane-field. Site at east end of alluvial flat, 1½ miles from last site. Tractor-ploughed, 12 ins. deep. High water-table. Yields, 35-40 tons ac. Dull ochre-brown humic clay to 18 ins.; humic pipes below in old drains, over orange-mottled, pale-grey compact clay, coarsely-mottled below to 67 ins., over nearly pure white clay. River <i>Alluvial</i> clay soil-type. Medium organic matter, medium to medium-high nitrogen; fairly high C/N ratio; very low available phosphate, medium-low to medium available potash.												
LCA. 400. Surface soil ..	6	0	5	43	35	5.5	3.1	.16	11.2	199	49	7
401. Dull ochre ..	9	1	8	44	37	5.1	2.8	.15	10.9	90	0	7
402. Paler ..	12	2	6	45	37	5.0	2.4	.16	8.7	74	11	8
403. Transition ..	18	0	5	46	39	4.8	2.0	.13	8.8	70	5	5
404. Orange-grey ..	24	0	4	44	40	4.9	1.1	.08	7.8	71	10	7
405. Mottled ..	36	0	6	45	41	5.2	0.8	.06	8.9	80	15	9
406. Mostly grey ..	45	0	2	45	43	5.0	0.7	.06	7.4	62	8	9
407. Marbled ..	60	0	6	51	47	5.0	0.8	.05	8.7	67	10	13
408. Grey ..	67	0	2	41	38	5.4	0.5	.04	8.3	58	11	7
409. White ..	72	0	2	41	40	5.4	0.5	.06	4.8	63	10	11
Avail. K <sub>2</sub> O; LCA. 400 (top 6 ins.); 115 p.p.m.												
(28) CUL DE SAC 3. <i>Field 10, Soucis</i>												
Cane-field; site south of No. (26), across river, 250 yds. Field not ploughed for 6 years. Yields, 40 to 45 tons ac. plants. Forked to 7 or 9 ins. Humic dull orange clay to 16 ins., changing gradually to greyish orange-mottled and sparsely sepia-spotted, hard, horny, glazed clay; no white clay at base. River <i>Alluvial</i> soil-type, showing impeded drainage. Fairly high to high organic matter, medium-high to fairly-high nitrogen; high C/N ratio; medium-low available phosphate, low available potash. Not saline.												
LCA. 410. Dull orange ..	6	0	6	50	43	4.8	5.5	.20	15.8	157	121	23
411. Dull brown ..	12	0	5	45	38	5.1	2.9	.17	9.8	100	29	17
412. Transition ..	16	0	5	46	40	5.4	2.1	.14	9.0	58	15	15
413. Grey-fawn ..	24	0	4	44	40	5.5	1.0	.07	8.6	66	11	9
414. Mottled ..	36	0	4	41	36	6.1	0.7	.06	6.7	78	16	12
415. Ditto ..	48	0	3	41	37	6.2	0.5	.04	6.9	62	8	13
416. Greyer ..	60	0	2	41	37	6.3	0.6	.05	6.4	46	7	17
417. Spotted ..	72	0	3	46	41	6.2	0.5	.04	7.6	45	6	18
Avail. K <sub>2</sub> O; LCA. 410 (top 6 ins.); 70 p.p.m.												
(VI) ROSEAU VALLEY												
(29) ROSEAU I. <i>Field William, South</i>												
Cane-field; site near southern hillslope, 1½ miles from sea-coast. Ploughed 12 ins. deep. Yield, 54 tons ac. plants. Six ratoons taken. Pen manure applied to plants; also ammonium sulphate, 3 cwt. ac. Water-table, 30 ins. in wet season; water in hole to 66 ins. (dry season). Sepia humic soil to 12 ins., increasingly mottled and spotted orange, with sepia (manganiferous?) spots to 48 ins., over sandier, greyish, broadly orange-mottled, clay becoming greyer below until greenish-grey, slightly speckled clay, at base. River <i>Alluvial</i> soil-type. Medium to medium-high organic matter, medium high nitrogen; high C/N ratio; medium-low available phosphate and potash. Not saline.												
LCA. 419. Sepia ..	6	0	12	41	33	5.2	3.4	.17	11.3	84	18	24
420. Ditto ..	9	0	13	40	32	5.4	2.7	.17	9.1	78	17	21
421. Transition ..	12	0	10	40	32	5.8	2.1	.12	10.1	59	22	12
422. Mottled ..	18	0	9	39	33	5.9	1.2	.08	8.3	79	14	5
423. Spotted ..	24	0	8	38	32	6.4	1.1	.07	8.5	95	18	11
424. Spotted ..	36	3	9	36	31	6.5	0.7	.05	8.2	74	17	28
425. Ditto ..	48	2	17	32	28	6.5	0.5	.03	8.5	71	17	31
426. Grey ..	60	2	42	31	18	6.6	0.4	.03	8.4	62	9	37
427. Variegated ..	66	4	40	30	18	6.8	0.3	.03	6.2	74	0	38
428. Green-grey ..	72	3	23	34	25	6.9	0.6	.04	9.2	59	5	37
Avail. K <sub>2</sub> O; LCA. 419 (top 6 ins.); 91 p.p.m.												

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12	
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln. (p.p.m.)	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	
(30) ROSEAU 2. <i>Bernard Field</i>													
Cane-field; site east end and middle of valley, 13½ miles from factory, near bend in river. Usual cultivations and manuring. Composite profile, flood-silt deposited in layers. One rich buried soil and traces of two others. Yellow-brown uniform soft loam, variably coloured in humic parts. No stones. Mostly rich yellow-brown with slight mottling rusty-red, 12 to 18 ins., and 42 to 54 ins. River <i>Alluvial</i> soil-type. Medium organic matter, medium-low nitrogen; very high C/N ratio; medium available phosphate, fairly high available potash. Not saline.													
LCA. 429.	Fawn brown	5	0	31	37	34	6.4	3.0	.10	18.3	212	48	32
430.	Ditto	12	0	22	36	24	7.2	2.1	.11	11.0	265	180	30
431.	Mottled	18	0	18	35	24	6.6	1.8	.09	11.8	86	17	17
432.	Buried soil	22	0	23	34	24	6.1	1.5	.10	9.6	59	21	17
433.	Sand	30	0	52	29	15	6.1	0.7	.04	10.5	54	9	7
434.	Buried soil	36	0	15	37	27	6.1	2.0	.11	10.0	70	16	5
435.	Paler	42	0	16	36	27	6.1	1.2	.09	8.5	77	9	6
436.	Ditto	54	0	13	31	22	6.1	1.0	.07	8.6	85	3	10
437.	Ditto	66	0	16	30	20	6.4	0.8	.05	9.0	71	8	14
438.	Ginger	75	0	35	25	12	6.4	0.5	.04	8.7	69	9	16
Avail. K <sub>2</sub> O; LCA. 429 (top 5 ins.); 175 p.p.m.													
(31) ROSEAU 3. <i>MacCafe Field</i>													
Cane-field; site at extreme east end of valley, 2½ miles from factory, near foot of small hill. Yields, 40-50 tons ac. plants. Lime and ammonium sulphate applied. Land drained. <i>Peaty profile</i> ; buried forest, said to have been a swamp 60 years ago. Sandy, loose black soil to 6 ins. ginger sand to 10 ins., then thick mass of black structureless peat with soft bright-brown altered wood still showing structure. Soft, spongy, fibrant. <i>Bog</i> soil-type (Hydromorphic). White clay band, 43-44 ins. Water seeping in at 58 ins. Very high organic matter, high nitrogen; very high C/N ratio; medium-low available phosphate, fairly high available potash. High salt content.													
LCA. 439.	Humic sand	6	6	28	39	28	7.4	9.5	.29	19.2	665	200	28
440.	Ginger	10	0	39	32	19	7.6	5.7	.21	15.7	405	188	29
441.	Black peat	18	1	7	51	45	7.3	19.6	.68	16.9	696	408	32
442.	Ditto	24	3	22	68	61	6.7	34.1	1.01	19.6	1,600	425	38
443.	Red wood	43	2	32	Peat	0	5.7	48.7	1.27	22.4	2,162	60	12
444.	Clay	44	0	8	Clay	0	5.3	3.6	1.13	18.2	1,032	72	335
445.	Peat	54	7	20	Peat	0	4.2	79.5	1.65	28.1	7,620	0	9
446.	Ditto	66	—	28	„	0	5.2	76.4	1.33	33.3	6,160	0	26
Avail. K <sub>2</sub> O; LCA. 439 (top 6 ins.); 184 p.p.m.													
(VII) MABOUYA VALLEY													
(32) DENNERY. <i>Field No. 5. La Caye</i>													
Cane-field; site in centre of Mabouya Valley, 1 mile from sea-coast. Yields, 16-30 tons acre. Pen manure, 10 tons acre, ammonium sulphate, 3 cwt. acre, potassium chloride, ½ cwt. acre, ground limestone, 1 ton acre. Brown loam, paler and yellower below; signs of buried soil at 36 ins. River <i>Alluvial</i> soil-type. Uniform, speckled below 48 ins. Medium organic matter and nitrogen, medium C/N ratio; low to medium-low available phosphate, low available potash. Not saline. Highly acid.													
LCA. 456.	Brown	3	0	10	36	29	5.3	2.7	.16	10.0	99	8	17
457.	Darker	6	0	12	37	29	5.0	2.7	.15	10.4	76	10	17
458.	Paler	9	1	9	37	30	4.6	2.2	.14	9.6	62	7	14
459.	Ditto	12	1	10	35	28	4.6	2.0	.12	9.9	48	4	8
460.	Ditto	21	0	13	37	28	4.7	1.7	.10	9.9	53	5	8
461.	Yellowish	27	0	38	27	14	5.1	1.0	.06	9.0	39	5	5
462.	Ditto	36	0	45	28	14	5.6	0.7	.04	9.7	43	12	5
463.	Buried soil	48	0	31	26	14	5.7	0.7	.04	9.8	38	3	9
464.	Pale brown	60	0	50	26	12	5.8	0.5	.03	9.4	40	6	11
465.	Speckled	72	0	51	27	13	6.1	0.4	.03	7.3	47	8	13
Avail. K <sub>2</sub> O; LCA. 456 (top 6 ins.); 69 p.p.m.													

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11	12
	Dpth. (ins.)	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)
(33) DENNERY 2. <i>Field Block 6, Resource</i>												
Cane-field; site 1½ miles west of last. Cultivations, manuring, yields, similar to last. Deep water-table; not reached. Black to dark-grey humic loam to 12 ins., mottled to 24 ins., transition to weathered rock with small rotten stones, overlying granular stiff clay, slightly mottled, becoming bluer at base. River <i>Alluvial</i> soil-type. Fairly high organic matter and nitrogen; high C/N ratio; very high available phosphate, medium-low available potash. Not saline. Highly acid in top 6 ins.												
LCA. 466. Black .. ..	3	28	18	39	32	4.9	5.4	.23	13.8	254	0	135
467. Grey .. ..	6	15	14	37	30	5.8	4.0	.20	11.9	181	23	155
468. Grey brown .. ..	9	13	14	36	30	6.3	3.5	.18	11.5	222	67	185
469. Grey .. ..	12	1	14	36	29	6.7	2.1	.13	9.3	182	39	90
470. Mottled .. ..	24	1	4	40	38	6.6	1.1	.08	7.5	122	43	19
471. Transition .. ..	30	6	24	33	26	6.4	0.5	.04	7.1	98	33	13
472. Granular .. ..	40	13	34	31	23	6.4	0.4	.03	9.3	97	21	11
473. Stiff .. ..	48	0	8	39	35	6.2	0.5	.03	9.3	110	11	5
474. Mottled .. ..	60	0	24	34	25	6.2	0.4	.03	8.5	112	8	9
475. Blue, red .. ..	72	0	17	36	29	6.4	0.4	.03	9.7	119	10	17
Avail. K <sub>2</sub> O; LCA. 466, 467 (top 6 ins.); 98 p.p.m.												

(34) DENNERY 3. *Field 38/39; Richfond*

Cane-field; site still further up valley, ¾ mile south-west of last. Cultivations, etc., as last. Yield, 28 tons/acre plants. Yellow soil, becoming browner and redder below. No water-table reached. River *Alluvial* soil-type. Medium-low organic matter, medium nitrogen; medium C/N ratio; low available phosphate and potash. Highly acid to 6 ins.; markedly acid to 24 ins. Not saline.

LCA. 476. Yellow .. ..	3	0	23	32	24	5.0	2.4	.14	10.1	80	12	10
477. Darker .. ..	6	1	21	36	29	5.1	1.9	.12	9.6	74	8	8
478. Darker .. ..	9	1	17	39	32	5.4	1.8	.10	10.8	77	12	4
479. Ditto .. ..	12	1	21	35	28	5.8	1.4	.07	10.9	72	9	4
480. Yellow-brown .. ..	24	0	23	35	28	6.0	0.9	.05	10.4	71	11	7
481. Ditto .. ..	38	1	10	39	34	6.2	0.7	.04	9.4	57	2	17
482. Red-brown .. ..	47	1	25	31	24	6.2	0.4	.03	8.0	50	4	7
483. Mottled .. ..	60	0	8	39	34	6.0	0.4	.03	7.3	61	2	5
484. Red .. ..	72	0	17	35	30	5.9	0.3	.03	8.0	58	7	4

Avail. K<sub>2</sub>O; LCA. 476, 477 (top 6 ins.); 60 p.p.m.

## (B) PEASANTS' HOLDINGS SOILS

(Surface 6 ins. soil samples)

	Gravel (%)	Coarse Sand (%)	Silt and Clay (%)	I.T.	Re- action (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O
RED EARTH soil-type												
(i) Morne Fortune .. ..	0	52	30	18	4.9	2.3	.12	11.0	65	8	8	103
(ii) " " .. ..	0	24	51	26	4.6	2.7	.17	9.1	58	4	5	100
(iii) " " .. ..	43	28	53	30	5.3	4.0	.23	10.1	116	1	17	143
(iv) " " .. ..	0	17	58	33	5.5	3.8	.21	10.5	99	0	14	178
(vii) Grande Riviere .. ..	0	32	52	28	5.2	3.8	.22	10.2	106	26	9	82
(viii) Postlethwaite .. ..	41	32	52	27	4.7	3.5	.20	9.3	85	17	5	70
(ix) " " .. ..	20	29	50	31	4.9	3.8	.22	10.0	96	15	9	115
<b>Means</b> .. ..	<b>27</b>	<b>20</b>	<b>53</b>	<b>29</b>	<b>5.0</b>	<b>3.4</b>	<b>.20</b>	<b>10.0</b>	<b>89</b>	<b>10</b>	<b>10</b>	<b>113</b>
SHOAL soil-type												
(v) Choc .. ..	0	23	58	37	5.9	4.0	.22	10.4	138	14	12	101
(vi) Corinth .. ..	0	34	49	41	5.3	3.7	.22	9.9	103	3	8	206

## APPENDIX—Continued

	1	2	3	4	5	6	7	8	9	10	11				
	Dpth. (ins.)	Sand (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O (p.p.m.)				
<b>(C) PROPOSED FOREST SETTLEMENT: MURRAY ROAD</b>															
(Soil samples collected, Sept. 1936, by E. A. Walters, Superintendent of Agriculture, St. Lucia)															
<b>(I) TANNIA GARDEN</b>															
High forest, cleared 2 years, not burnt. Below clay ridges on slope to streamlet; not wet. Rocky and stony. <i>Soil; Type I</i> ; 0-2 ins., leaf mulch; 2-8 ins. blackish humic soil; 8-24 ins. brown-grey gravelly soil. Surface layer to 2 ins. removed before sampling. Andesite stones.															
LCA. 115.	Brown	..	..	..	6	34	41	5.8	7.6	.39	11.3	186	151	47	373
117.	Yellow-brown	..	..	..	12	49	19	6.4	1.2	.07	9.7	37	5	20	—
116.	Rock specimens	..	..	..	—	—	—	—	—	—	—	—	—	—	—
<b>(II) BROW FLAT</b>															
High forest, cleared 2 years, recently cut over. <i>Soil; Type I</i> . Litter and fibrous roots, 0-2 ins. dark fibrous friable loam, 2-8 ins., dark-brown, dry friable loam, 8-14 ins. Surface layer to 2 ins. removed before sampling.															
LCA. 118.	Black	..	..	..	6	13	72	5.2	27.0	.77	20.4	295	0	10	181
119.	Brown	..	..	..	12	36	43	5.8	8.9	.43	12.0	264	132	57	—
<b>(III) BROW SLOPE</b>															
High forest, etc., as last. <i>Soil; Type I</i> . Sparse litter; 1-7 ins. firm loam; 7-24 ins. firm loam, stony, no change, few rocks; crystalline, quartzose? (Soil sparkles with small glassy quartz crystals.)															
LCA. 120.	Black	..	..	..	6	32	51	5.6	12.9	.59	12.7	135	28	8	120
121.	Brown	..	..	..	12	54	34	6.1	6.7	.29	13.4	83	13	6	—
<b>(IV) CUT SLOPE</b>															
Clearing near and below Piton Cochon ridge, near "bath brick" grits; quartz wash on surface. <i>Soil; Type II</i> ; 0-6 ins. dark, red-brown loam, sparse iron concretions; 6-12 ins. medium-brown moist, sandy quartzose grit, very crystalline, containing also chloritic mica.															
LCA. 122.	Dark	..	..	..	6	55	33	6.2	2.6	.24	6.2	56	6	8	128
123.	Brown grit	..	..	..	12	70	22	5.8	4.1	.21	11.6	117	28	14	—
<b>(V) FLATS, RIVER TROUMASSEE</b>															
South-east by east of river. Forest, cut over and regrown. Abundant litter. <i>Soil; Type II</i> . 0-11 ins. dark-red. loamy river alluvium, changing below to bright-coloured loam. 12-15 ins. clay loam.															
LCA. 124.	Mid-brown	..	..	..	6	29	46	4.6	8.5	.37	13.2	137	0	20	193
125.	Brighter	..	..	..	12	55	17	5.5	0.9	.05	10.1	62	4	7	—
<b>(VI) SLOPE ABOVE RIVER TROUMASSEE</b>															
Forest cleared and regrown. Not yet planted. <i>Soil; Type I</i> . 0-1½ ins. litter, 6 ins. of dark sticky loamy-clay containing quartz-wash below; 6-12 ins. greyish-brown very gritty clay, becoming brighter brown below and wetter. Contains quartz crystals.															
LCA. 126.	Dark	..	..	..	6	67	20	6.2	5.9	.29	11.9	181	23	18	1,140
127.	Grey-brown	..	..	..	12	32	36	4.6	2.0	.13	8.9	48	1	10	—
<b>(VII) SLOPE ABOVE FERGUSON; facing north</b>															
High forest, very large old trees. Thick forest litter and fibrous humus. <i>Soil; Type III</i> . 0-6 ins. dark brown, smooth, friable loam, changing gradually to paler open loam below. Full of glassy gritty quartz crystals.															
LCA. 128.	Dark brown	..	..	..	6	36	41	5.2	11.0	.56	11.4	115	13	9	106
129.	Paler	..	..	..	12	54	18	5.7	1.4	.10	8.2	40	2	10	—

## APPENDIX—continued

	1	2	3	4	5	6	7	8	9	10	11
	Dpth (ins.)	Sand (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O (p.p.m.)
(VIII) FLATS OF RIVER TROUMASSEE											
Open forest, heavy canopy, few palms, old Ficus trees; <i>Soil; Type III.</i> 0-3 ins. humus; 3-9 ins. fibrous dark brown loam; 9-15 ins. yellow-brown friable loam, containing quartz crystals.											
LCA. 130. Brown	6	14	—	5.2	18.0	—	—	—	—	11	190
131. Yellow-brown	12	46	33	6.0	5.6	.34	9.6	53	8	6	—
(IX) ROAD CUTTING; LA FALAGE											
Yellow clay-loam underlying crystalline deposits, 9-12 ins. Top soil, dark red-brown humic clay containing abundant glassy quartz crystals, pale yellow-brown lumpy clay below (type not given).											
LCA. 132. Cryst.	6	52	36	5.4	10.6	.47	13.0	144	51	10	171
133. Yellow	12	52	25	5.8	3.4	.18	10.6	41	12	20	—
(X) NURSERY											
Forest cleared April, 1934, but not burnt nor forked. Planted and drained. Surface rich in humus and incorporated banana mulch. Gravelly, dark-coloured loam. <i>Soil; Type II.</i>											
LCA. 134. Black	6	51	40	5.6	10.0	.43	13.5	132	34	32	553
135. Brown	12	41	28	6.0	2.7	.15	10.3	51	36	12	—
(XI) NURSERY											
See last. Site near wet patch; clear weeded, but not planted. Dark-coloured loam, slightly gravelly below. <i>Soil; Type II.</i> (Sample 137 mainly stones).											
LCA. 136. Dark	6	48	28	6.0	4.2	.22	11.3	83	106	17	140
137. Gravelly	12	54	—	6.3	—	—	—	82	41	10	—
(XII) APPROACH TO NEW CLEARING											
Dark-coloured humic soil to 8 ins. then gravelly, sandy, yellow loam below. <i>Type II.</i>											
LCA. 138.	6	48	29	6.5	1.5	.09	9.1	44	26	11	84
139.	12	68	15	6.6	1.4	.07	10.6	46	26	38	—
(XIII) RAVINE END OF NEW CLEARING											
In cultivation. Loose brown friable loam, clayey below 8 inch depth, and somewhat stony. <i>Soil; Type II.</i>											
LCA. 140. Brown	6	47	45	5.7	11.1	.48	13.6	189	111	49	395
141. Clay	12	50	34	6.3	4.0	.23	10.2	83	74	20	—
142. Stony	—	60	19	6.3	2.2	.12	10.0	33	11	16	—
(XIV) NEW CLEARING											
Rocky brow. Cleared, Sept. 1935. Soil contains some large gravel stones and abundant roots. <i>Type II.</i> Dark red loam changing to greyish below. Gritty; probably derived from "tiff" ("Roche Varess"; terras.)											
LCA. 143. Dark	6	32	45	5.9	5.6	.27	11.9	153	154	40	931
144. Grey	12	60	24	6.6	2.4	.10	13.6	65	80	26	—

## APPENDIX—continued

	1	2	3	4	5	6	7	8	9	10	11
	Dpth (ins.)	Sand (%)	I.T.	Reac- tion (pH)	O.M. (%)	N (%)	C/N Ratio	Avail. Nutr. (mhos × 10 <sup>-6</sup> )	Rate of Soln.	Avail. P <sub>2</sub> O <sub>5</sub> (p.p.m.)	Avail. K <sub>2</sub> O
(XV) FLAT. NEW CLEARING											
High forest, with palms; Soil; Type II. 0-3 ins. litter and humus; 3-9 ins. dark-coloured loam, 9-15 ins. yellowish-grey grit.											
LCA. 145. Dark	6	51	33	6.7	3.5	—	—	113	101	26	565
146. Yellow, grey	12	25	35	5.6	1.5	.08	11.4	99	6	4	—
(XVI) NEW EXTENSION FOR EAST SIDE											
Sloping, somewhat rocky ground; thin litter. Soil; Type III, dark-brown loam, containing finely-divided quartz; paler below 6 ins. friable and clayey at 2 feet depth. (Samples of stones in 148; very fine-grained blue-green, slightly rusty rock, perhaps andesite, slightly lateritised; contains gold-like specks of mica.)											
LCA. 147. Dark brown	6	36	41	5.8	5.8	.33	10.2	297	11	5	72
148. Grey white	12	stones	—	—	0.1	—	—	—	—	12	—
(XVII) MURRAY ROAD SETTLEMENT; GARDEN SLOPES											
Composite soil from 5 spots; few stones, fairly humic, clay and "tiffy" and moist below. Soil; Type I. (Subsoil contains much glassy quartz grit.)											
LCA. 149. Humic	6	44	42	6.2	11.9	.57	12.1	206	56	14	239
150. Clayey	12	52	27	6.5	4.1	.27	9.1	64	14	10	—
(XVIII) MURRAY ROAD SETTLEMENT; UNCULTIVATED SLOPE											
Composite soil from 5 spots. Fairly humic, dry silty-clay. Type II. (Dark red-brown almost black topsoil, red-brown subsoil, containing numerous white stones, looking like terras.)											
LCA. 151. Humic	6	34	46	6.0	11.6	.51	13.2	156	31	6	498
152. Silty	12	53	36	6.4	3.9	.26	8.9	64	16	5	—
(XIX) MURRAY ROAD SETTLEMENT; GARDEN SLOPES											
Composite from 2 spots. Not very humic; contains some clay and alluvium. Soil; Type II. (Yellow-brown stony topsoil, paler stony subsoil.)											
LCA. 153. Not humic	6	48	30	6.4	3.0	.13	13.5	74	49	22	319
154. Alluvial	12	31	34	6.2	1.9	.11	10.2	49	12	21	—
(XX) MURRAY ROAD SETTLEMENT; GARDEN SLOPES											
Composite from 2 spots. Somewhat humic sandy-loam; dry. Type II. (Dark red-brown, almost black humic topsoil, pale yellow-brown, lumpy, stony subsoil.)											
LCA. 155. Humic	6	36	49	5.1	8.4	.42	11.5	96	0	23	202
156. Sandy	12	30	43	5.3	3.2	.18	10.3	39	4	9	—
(XXI) MURRAY ROAD SETTLEMENT; FOREST SLOPES											
Composite from 2 spots. Humic soil, containing crystals, clayey below. Type III.											
LCA. 157.	6	34	54	5.2	11.8	.51	13.5	169	55	31	—
158.	12	27	45	5.5	2.8	.16	10.2	36	7	9	124
159.	18	46	32	6.0	5.5	.28	10.3	58	6	12	—

**(D) FOREST PROFILE SITES**

(Inspected and described by J. S. Beard, June, August, 1945; no soil samples collected)

(F1) GRAND MAGAZIN: Summit of peak, 2,000 ft., gentle slope, north aspect; very exposed; free drainage, permanently wet. Rainfall, 200 ins., no effective dry season. Rain Forest (*Micropholis-Licquia*); TERRAS (or Yellow Earth) soil-type; "Black cloud" deposits, probably near their source of origin.

- |   |     |     |     |   |
|---|-----|-----|-----|---|
| 1. Dark brown stoneless clay; crumb structure, porous, tenacious        | ... | ... | ... | 8 |
| 2. Pale yellow-brown stoneless loam; granular structure, porous, mellow | ... | ... | ... | — |

(F2) DONIOL: 400 ft., steep slope, west aspect, sheltered. Partially-impeded drainage; seasonally wet. Rainfall, 150 ins., no effective dry season. Rain Forest (*Dacryodes-Slonea*). BROWN EARTH soil-type, over basic igneous rock.

- |   |     |     |     |    |
|---|-----|-----|-----|----|
| 1. Pale-brown uniform stoneless clay, cloddy structure, porous, mellow  | ... | ... | ... | 4  |
| 2. Yellow-brown speckled dark brown and orange gritty-clay; sparse small rotten stones; cloddy to granular structure, porous, tenacious | ... | ... | ... | 24 |
| 3. Ditto, mostly rotten rock; granular structure, hard  | ... | ... | ... | —  |

(F3) CASTRIES WATER - WORKS FOREST RESERVE: Track from dam, 1 mile, north-west of Piton Flore, 600 ft. Moderate slope, south-west aspect, sheltered. Partially-impeded drainage. Rainfall, 100 ins., no effective dry season. Rain Forest (*Manilkara*). RED EARTH soil-type.

- |  |     |     |     |   |
|--|-----|-----|-----|---|
| 1. Pale yellow-brown, uniform, stoneless, silty-clay. Porous, crumb structure, compact     | ... | ... | ... | 4 |
| 2. Red and yellow-brown streaked loam; pieces of soft rotten rock. Compact crumb structure | ... | ... | ... | — |
| 3. Red, sepia, brown, yellow, sandy rotten rock, grey-streaked, granular, hard             | ... | ... | ... | — |

(F4) CASTRIES WATER - WORKS FOREST RESERVE: 1 mile north of Piton Flore. 800 ft., gentle slope, north aspect, exposed. Partially-impeded drainage. Rainfall, 100 ins., no effective dry season. Rain Forest (*Dacryodes-Slonea*): RED EARTH soil-type.

- |  |     |     |     |    |
|--|-----|-----|-----|----|
| 1. Brown, uniform, stoneless clay, crumb structure, porous, tenacious                            | ... | ... | ... | 6  |
| 2. Orange stoneless clay, slightly mottled red and grey; cloddy structure, non-porous, tenacious | ... | ... | ... | 18 |
| 3. Mottled orange and white stoneless clay, as last  | ... | ... | ... | —  |

(F5) BARRE DE L'ILE: Top,  $\frac{1}{4}$  mile north of Plateau Souffre, 1,100 ft., moderate slope, east aspect, very exposed; partially-impeded drainage; permanently wet. Rainfall, 150 ins., no effective dry season. Rain Forest (*Manilkara*). RED EARTH soil-type over basic igneous rock.

- |  |     |     |     |    |
|--|-----|-----|-----|----|
| 1. Thick humic layer, abundant litter, turfy   | ... | ... | ... | —  |
| 2. Dark brown, uniform stoneless clay, crumb structure, spongy, loose                  | ... | ... | ... | 10 |
| 3. Pale yellow-brown stoneless clay; cloddy structure, tenacious                       | ... | ... | ... | 20 |
| 4. Orange clay; sparse, large, round, soft, rotten stones; cloddy structure, tenacious | ... | ... | ... | —  |

(F6) PRASLIN: Coastal road, 200 ft., moderate slope, north aspect, fairly sheltered; partially-impeded drainage, seasonally dry. Rainfall, 60 ins., marked dry season, 5 months. Secondary xerophytic woodland. SHOAL soil-type.

- |   |     |     |     |    |
|---|-----|-----|-----|----|
| 1. Dark brown, uniform, gritty clay; sparse large angular stones; cloddy structure, porous, compact | ... | ... | ... | 6  |
| 2. Speckled red, yellow, grey clay; sparse decayed large stones; cloddy structure; porous; compact  | ... | ... | ... | 24 |
| 3. Grey rotten rock, speckled orange, granular structure; hard                                      | ... | ... | ... | —  |

**LABORATORY METHODS OF SOIL ANALYSIS**

The following determinations were made on the air-dried soil samples after pulverising and passing through a sieve having round holes 2 mm. in diameter.

**(1) Gravel, Coarse Sand, Silt and Clay**

*Gravel*; particle diameter above 2.0 mm.; expressed as weight percentage on air-dry soil.  
*Coarse sand*; particle diameter 2.0-0.2 mm.; wet sieving through 0.2 mm. sieve.  
*Silt and Clay*; particle diameter below 0.02 mm.; not settling in water through 11.8 cm. depth in 4 min. 48 sec., at 27°C.

**(2) Index of Texture (I.T.)**

Derived from values determined for sticky point moisture content (P) and coarse and fine sand content (S) by the formula  $I.T. = P - S/5$ . The index assesses the degree of clayiness or sandiness as a single value. The following arbitrary scheme is employed:—

Index of Texture	Texture
60-55	Heavy clay
55-40	Clay
40-30	Silt
30-20	Loam
20-10	Sand
10-0	Light sand

(Reference: F. Hardy, *Journ. Agric. Sci.*, 1928, XVIII, pp. 252-256)

**(3) Reaction (pH)**

Quinhydrone electrode method, checked by glass

electrode method applied to suspensions of one part soil to 2.5 parts water.

<i>pH</i> value	Reaction
8.0-7.5	Highly alkaline
7.5-7.0	Alkaline
7.0	Neutral
7.0-6.5	Slightly acid
6.5-6.0	Acid
6.0-5.5	Markedly acid
5.5-5.0	Highly acid

(4) *Organic matter* (O.M.)

Watts' wet combustion method; 0.5 to 2.0 g. soil oxidised by 3 g. chromic acid and 10 cc. conc. sulphuric acid; carbon-dioxide measured over mercury in nitrometer. Result (carbon content) multiplied by 1.724 to bring to approximate O.M. content and then by correcting-factor 1.33, experimentally determined.

(Reference: F. Hardy; *Journ. Agric. Sci.*, 1929, XIX, pp. 727-733)

(Sands and Loams)

O.M. per cent.

(corrected values)	Organic status
8.0-6.5	Very high
6.5-5.5	High
5.5-4.5	Fairly high
4.5-3.5	Medium-high
3.5-2.5	Medium
2.5-1.5	Medium-low
1.5-0.5	Low
0.5-0.0	Very low

(5) *Total Nitrogen* (N)

Kjeldahl's standard method

(Sands and Loams)

N per cent.	Nitrogen status
0.45-0.35	Very high
0.35-0.30	High
0.30-0.25	Fairly-high
0.25-0.20	Medium-high
0.20-0.15	Medium
0.15-0.10	Medium-low
0.10-0.05	Low
0.05-0.00	Very low

(6) *Carbon-Nitrogen Ratio* (C/N)

Calculated from carbon (corrected) and nitrogen contents. The magnitude of this ratio provides a rough index of the degree of decomposition and humification of soil organic matter, low values being associated with high degree of breakdown.

(7) *Available Nutrients*

Estimated by measuring the electrical conductivity of a water suspension of the soil, 50 cc. distilled water, 10 g. air-dry soil, in contact for 21 hours, by the Kohlrausch-Wheatstone Bridge method. Easily-soluble salts (nitrates and bicarbonates chiefly) are extracted. Values are  $\text{mhos} \times 10^{-6}$ . When above 200, they may denote presence of abnormal salts (saline, alkaline, calcareous, gypseous soils).

(Reference: W. R. G. Atkins, *Journ. Agric. Sci.*, 1924, XIV, pp. 198-203)

Avail. nutr. ( $\text{mhos} \times 10^{-6}$ )	Very high
Over 200	High
200-150	Fairly high
150-125	Medium-high
125-100	Medium
100-75	Medium-low
75-50	Low
50-20	Very low
20-0	

(8) *Rate of Solution* (potential nutrients)

Estimated by measuring electrical conductivity as above but after 7 days' standing and subtracting value for Available Nutrients. Slowly soluble salts (such as gypsum) and soluble products of mineral hydrolysis and oxidation are extracted. Values are  $\text{mhos} \times 10^{-6}$ .

(Reference: as last)

Rate of solution ( $\text{mhos} \times 10^{-6}$ )	Very high
Over 85	High
85-65	Fairly high
65-50	Medium-high
50-40	Medium
40-35	Medium-low
35-30	Low
30-20	Very low
20-0	

(9) *Available Phosphate* (Avail.  $\text{P}_2\text{O}_5$ )

Truog's coeruleo-molybdate colorimetric method applied to extracts obtained by shaking for 30 minutes 2 g. soil with 400 cc. of a 0.01 per cent. solution of sulphuric acid buffered at pH 3 with ammonium sulphate. Results are expressed as parts  $\text{P}_2\text{O}_5$  per million of air-dry soil.

(Reference: E. Truog, *Journ. Amer. Soc. Agron.*, 1930, XXII, pp. 874-882)

$\text{P}_2\text{O}_5$ p.p.m.	Available phosphate status
120-95	Very high
95-75	High
75-60	Fairly high
60-45	Medium-high
45-30	Medium
30-15	Medium-low
15-5	Low
5-0	Very low

(10) *Available Potash* (Avail.  $\text{K}_2\text{O}$ )

Cobalti-nitrite volumetric method applied to extracts obtained by leaching 25 g. soil with 1 litre of 3 per cent. acetic acid. Results are expressed as parts  $\text{K}_2\text{O}$  per million of air-dry soil.

(Reference: G. Milne, *Journ. Agric. Sci.*, 1929, XIX, pp. 541-552)

$\text{K}_2\text{O}$ p.p.m.	Very high
350-250	High
250-200	Fairly high
200-175	Medium-high
175-150	Medium
150-125	Medium-low
125-75	Low
75-25	Very low
25-0	

**PROVISIONAL LIMITS OF ADEQUACY***Three chief nutrients for the main crops grown in St. Lucia*

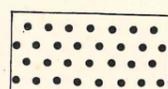
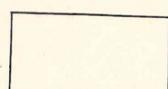
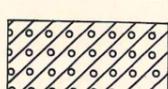
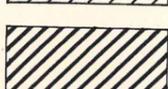
(SURFACE 6-INCH LAYER OF SOIL)

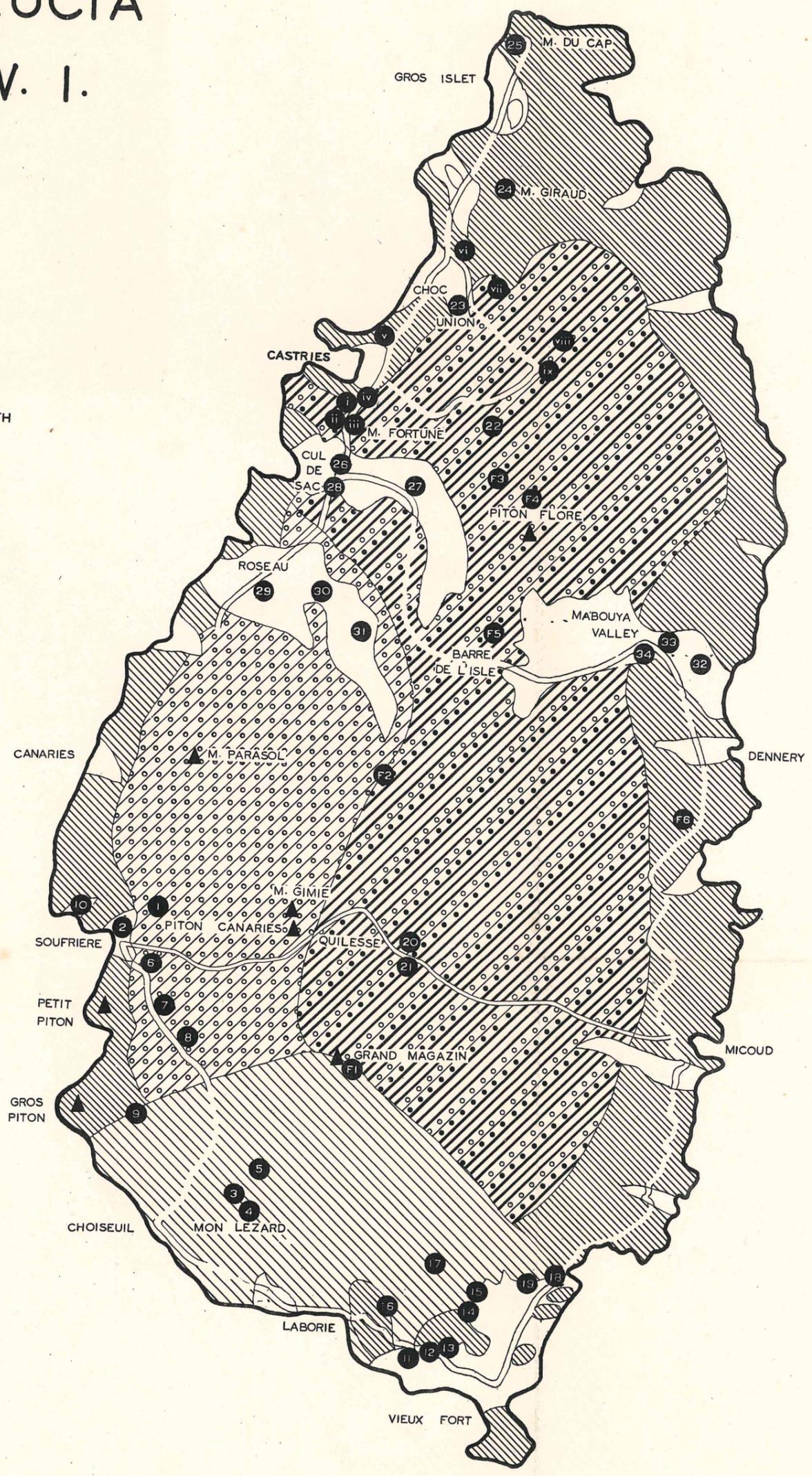
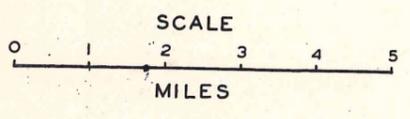
Crop	Sands and Loams (I.T., 0-30)			Silts and Clays (I.T., 30-60)		
	Total nitrogen %	Avail. phosphate p.p.m.	Avail. potash p.p.m.	Total nitrogen %	Avail. phosphate p.p.m.	Avail. potash p.p.m.
Cacao .. .. .	0.15	30	100	0.20	50	160
Limes .. .. .	0.10	50	200	0.12	85	320
Sugar-cane .. .. .	0.15	25	120	0.20	35	180

# PROVISIONAL GENERAL SOIL MAP

## ST. LUCIA

### B. W. I.

-  LITHOSOL
-  ALLUVIUM
-  BROWN EARTH
-  RED EARTH
-  TERRAS
-  SHOAL



# EFFECTIVE RAINFALL MAP (MOHR)

## ST. LUCIA

INCHES

150  
120  
100  
80  
70  
60  
50



CONTINUOUSLY  
WET

CONTINUOUSLY  
MOIST

WEAK DRY SEASON

MARKED DRY SEASON

