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BY

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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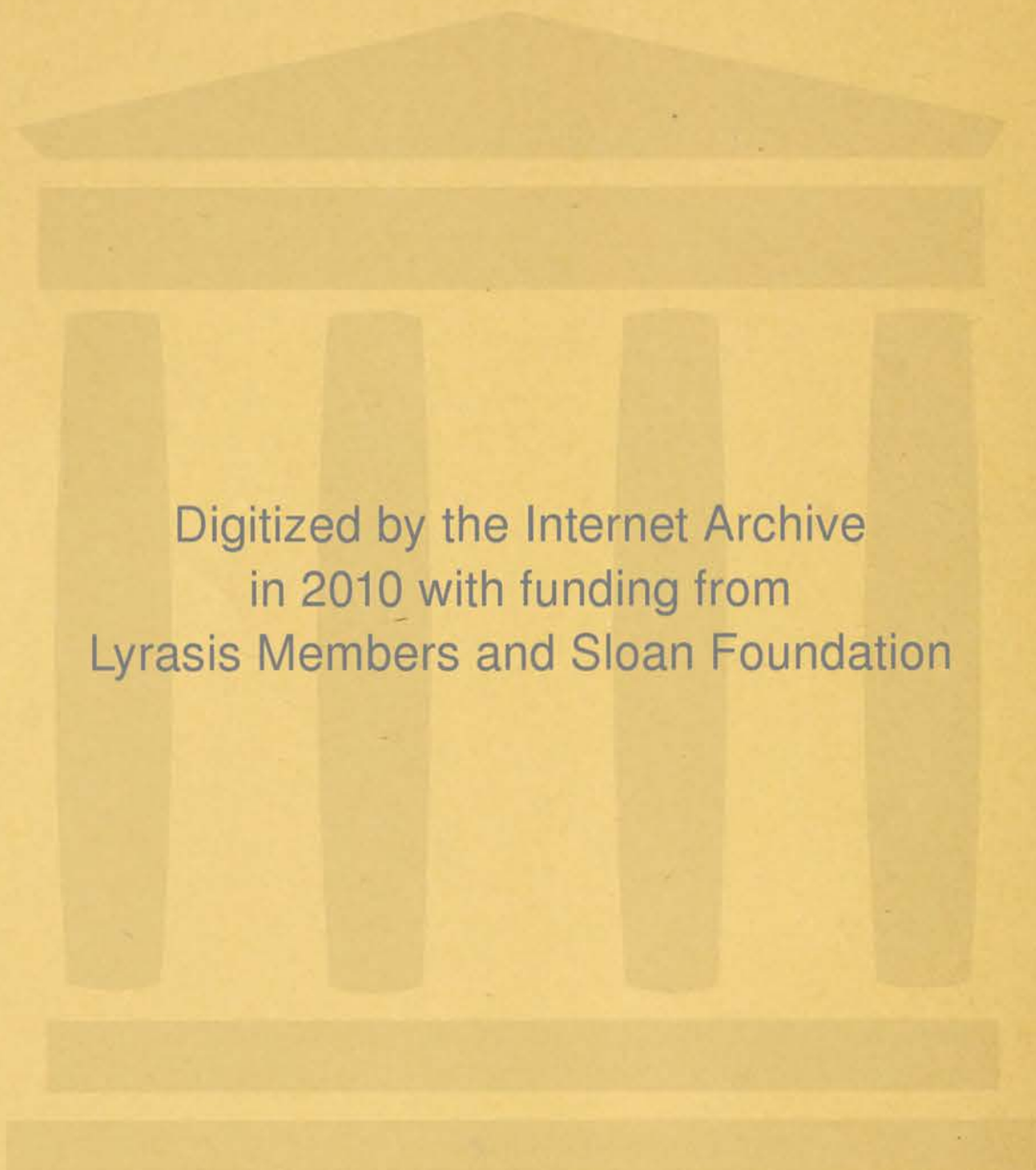

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CONTENTS

AREA SURVEYED

The Panama Canal Zone comprises a strip of country 10 miles wide and approximately 45 miles long, lengthwise through the center of which the Panama Canal has been cut. The canal, about 50 miles long from deep water to deep water, crosses the Isthmus of Panama in a southeasterly direction from the Caribbean Sea on the Atlantic side to the Gulf of Panama on the Pacific side. The original area of the zone was about 441.5 square miles, but since the acquisition of the territory by the United States Government a small area northeast of the city of Panama has been excluded and several additions have been made in accordance with the provisions of the Hay-Varilla treaty.[2] This reconnaissance area includes 855 square miles.

The latitude and longitude of the Atlantic end of the canal are 9° 23′ N. by 79° 56′ W., and of the Pacific end, 8° 54′ N. by 79° 32′ W. The Atlantic terminal of the canal is 1,974 nautical miles from New York, 1,399 from New Orleans, and 1,065 from Key West. The

[1] This survey was made by Hugh H. Bennett, of the Bureau of Soils, while working with John C. Tredwell and C. Reed Hill, representatives of the U. S. Department of Commerce on rubber investigations, during the latter part of 1923 and the early part of 1924.

[2] PANAMA CANAL. ACQUISITION OF LAND IN CANAL ZONE AND PANAMA. P. 2. 1922. (Mimeographed.)

Pacific terminal is 2,913 nautical miles from Los Angeles, 3,245 from San Francisco, and 2,616 from Valparaiso, Chile.

Transportation is provided in the Canal Zone by the Panama Canal and the Panama Railroad. A good, hard-surfaced highway has been built from Panama to Gamboa and another from Colon to Gatun. A fairly good highway extends from Empire southwest to La Chorrera and thence to Puerto de La Chorrera on the Gulf of Panama; and a road from Panama to Chepo is used for automobile travel during the dry season. Trails, passable for foot and horse travel only, extend in many directions through the Canal Zone and contiguous territory. Some of these trails are so muddy during the wet seasons that they can be traveled only on foot.

Schools and churches are located in towns and villages within the Canal Zone and also beyond its limits. Healthful living conditions in the towns are generally assured by efficient sanitary measures. No mosquitoes were seen in Ancon, Balboa, or the city of Panama during the survey period. Disease-carrying mosquitoes, ticks, and other insects abound, however, in districts not protected by sanitary measures.

CLIMATE

The climate of the Canal Zone and contiguous territory is humid-tropical, with a rainy season of eight months duration (May to December, inclusive) and a markedly dry season of about four months (January to April, inclusive). March and April are the driest and October and November the wettest months. The rainfall is heaviest on the Atlantic side of the area. The dry season there is characterized by more frequent showers than on the Pacific side, and the soil usually retains an ample supply of moisture for the maintenance of green foliage in the virgin forests. On the Pacific side of the zone most of the upland soils dry and crack in the dry season, the native grasses wither in most places, and a large proportion of the forest trees shed their leaves. Some of the deeper soils, however, conserve enough moisture to maintain a luxuriant growth of vegetation, manifested in continued greenness of the forests throughout the dry season; other soils, such as the shallow limestone clay and savanna clay, become exceedingly dry, vegetable growth is checked, and the forests assume a desertlike aspect by the middle of February. At the close of one of the longest rainless periods ever experienced in this area the deeper and more friable red clay was still moist at the surface in virgin forests and at a depth of 1 or 2 inches below the surface in cleared areas. At the same time there were very few other upland areas on the Pacific side in which the surface soil was not dry to a depth varying from 4 to 6 inches and comparatively dry to a depth varying from 8 to 12 inches, depending on the character of the soil. Vegetation on the alluvial soils is practically always green.

On the Atlantic side of the zone most forested areas remain green throughout the dry season, even on the shallower uplands.

The vegetation of second-growth forest (restrojo) appears to suffer from drought even more than that of the virgin forest. Second-growth vegetation on the Atlantic side of the area shows the

effects of the dry season much more than the virgin forest, but not to so great a degree as the corresponding growth on the Pacific side.

The dry season (verano) (*9*)[3] is the winter season in the sense that it is the time of the year that plants shed their leaves. On the other hand, it is summer time in that it is the flowering and fruiting season for the majority of the plants indigenous to this region. Many plants of the Canal Zone and contiguous territory put forth blossoms and develop their fruit after their leaves have fallen. In the year of this survey the dry season began a month earlier than usual, and by the last of March the brown fleecy fibers of silk cotton (kapok) were floating through the air from the bursting pods of many of the ceibas.

After the first month of dry weather, much of the grass and bush growth in the southern part of the Canal Zone, except that in the stream bottoms and on the deep, friable clay soils, becomes so dry that fires are of frequent occurrence. These are most common in the restrojo and grasslands.

The dry season is the season of strong winds. During this period, trade winds blow from the north and northeast 90 per cent of the time and have an average velocity of 15 miles an hour. Other dry-season winds, locally called "northers," frequently disturb the waters on the Atlantic coast and occasionally wreck small boats. They average 30 miles an hour and have attained a maximum velocity of 59 miles. During the rainy season, winds blow from the south and southeast, particularly on the Atlantic side of the zone.

The rainy season is winter (invierno) in Central America. Short dry seasons, coming at regular intervals within the limits of the long rainy season, are referred to as little summer (veranillo) and locally as San Juan summer. In some parts of Latin America veranillo de San Martine refers to what is known in the United States as Indian summer. Undoubtedly the same term is used for the little-summer season, as explained above, by some of the inhabitants of the more humid-tropical regions.

Table 1 shows the monthly rainfall during 1922 for a number of stations in the Pacific-island, Pacific, central, and Atlantic sections of the isthmus. At many of the stations the rainfall for that year was below normal. However, the records convey a general idea of the character and distribution of rainfall in this region.[4]

TABLE 1.—*Monthly rainfall, 1922, from Pacific side to Atlantic side of the Canal Zone*

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Pacific-island section:	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
Taboga	1.24	0.47	0.03	0.17	4.54	9.72	1.72	6.77	10.77	8.18	9.38	3.83
Pacific section:												
Balboa	2.49	1.64	1.19	.14	8.58	7.65	6.47	1.29	7.87	9.45	8.22	5.61
Balboa Heights	1.73	2.03	1.02	.16	9.88	7.92	5.08	1.46	8.18	9.03	8.44	3.82
Miraflores	2.00	.62	1.71	.51	12.00	8.27	8.67	3.41	7.15	14.76	14.11	9.15
Pedro Miguel	2.67	.51	3.44	1.19	13.16	10.32	7.09	7.60	5.64	9.64	14.61	8.06
Central section:												
Culebra	4.59	1.46	.35	.33	9.14	9.06	7.16	6.00	6.15	10.49	14.91	6.45
Empire	3.58	.89	.26	.00	10.99	8.70	6.53	4.90	6.28	11.55	11.33	4.31
Gamboa	8.11	1.42	.09	.24	15.04	9.09	6.12	7.20	8.74	11.82	6.58	6.65
Juan Mina	4.69	.65	.96	.05	9.42	13.63	6.46	9.20	8.78	15.79	12.00	6.35

[3] Reference is made by italic numbers in parentheses to literature cited, p. 45.

[4] Panama Canal, Department of Operation and Maintenance, Records of the Office of the Chief Hydrographer. [Unpublished data.]

TABLE 1.—*Monthly rainfall, 1922*—Continued

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Central section—Contd.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
Alhajuela	3.95	0.16	0.00	0.17	12.52	13.85	7.59	9.92	8.31	16.74	11.15	4.38
Trinidad	4.81	.94	.07	1.64	15.71	8.00	3.62	13.29	10.37	16.01	16.79	11.04
Monte Lirio	6.69	1.35	.21	1.41	12.29	9.98	5.66	6.95	13.78	16.57	10.80	5.74
Atlantic section:												
Gatun	9.48	1.29	1.13	2.35	12.71	12.54	5.26	7.24	11.98	17.81	17.50	8.04
Brazos Brook	10.31	1.28	.70	1.98	7.62	7.86	5.46	6.29	12.50	9.71	15.44	4.99
Colon	6.85	.71	.92	2.11	8.88	8.30	4.40	14.53	12.73	13.87	15.63	7.20
Porto Bello	11.26	3.36	3.23	4.13	25.48	10.84	11.53	13.25	22.94	14.44	22.50	13.45
Bocas del Toro	24.25	14.91	8.04	13.98	7.93	12.57	24.29	9.14	5.37	8.46	9.57	18.01

The average rainfall for the Pacific-island, Pacific, Central, and Atlantic sections is given in Table 2, together with the number of years of record, number of rainy days, and period maximum of rainfall:

TABLE 2.—*Average annual precipitation in the four sections of the Canal Zone, number of rainy days in 1922, and maximum precipitation during 10 minutes, 1 hour, and 24 hours*

Station	Average annual rainfall	Years of record	Rainy days, 1922	Maximum precipitation in 10 minutes	Maximum precipitation in 1 hour	Maximum precipitation in 24 hours
Pacific-island section:	*Inches*	*Number*	*Number*	*Inches*	*Inches*	*Inches*
Taboga	52.29	8	102	----------	----------	5.90
Pacific section:						
Balboa	67.67	24	181	1.68	5.86	7.57
Balboa Heights	68.96	25	168	1.20	3.98	7.23
Miraflores	78.83	14	169	.97	4.09	4.75
Pedro Miguel	79.63	15	198	1.10	3.46	5.45
Central section:						
Culebra	86.50	32	210	1.05	3.69	5.55
Empire	80.30	18	215	1.10	4.19	6.15
Gamboa	90.56	40	227	1.17	3.32	6.56
Juan Mina	93.50	12	----------	----------	----------	4.10
Alhajuela	99.96	23	228	1.20	4.19	8.19
Trinidad	103.34	15	----------	.96	3.20	6.00
Monte Lirio	117.03	15	232	----------	----------	7.60
Atlantic section:						
Gatun	119.27	18	258	1.16	4.72	10.48
Brazos Brook	126.47	16	232	----------	----------	8.96
Colon	127.25	52	238	1.20	4.90	8.53
Porto Bello	159.76	11	314	2.56	4.53	10.86
Bocas del Toro	115.82	14	249	----------	----------	7.88

It will be seen from these records that there is a gradual increase in precipitation through the Canal Zone from the Pacific to the Atlantic side. This increase in rainfall is accompanied by a corresponding increase in the number of rainy days.

Table 3 gives the mean, maximum, and minimum temperatures; greatest daily range in temperature; mean relative humidity; total evaporation; and percentage of sunshiny days at Balboa Heights and at Colon:

TABLE 3.—*Climatic data for Balboa Heights on the Pacific side and for Colon on the Atlantic side of the Canal Zone*

	Balboa Heights	Colon
Mean temperature, ° F	80.2	80.1
Absolute maximum temperature, ° F	[1] 97	[3] 93
Absolute minimum temperature, ° F	[2] 63	[4] 66
Greatest daily range in temperature, ° F	27	20
Mean relative humidity, per cent	83	83.7
Total evaporation, inches	53.7	52.8
Percentage of sunshiny days	48	54

[1] Apr. 7, 1912. [2] Jan. 27, 1910. [3] Apr. 12, 1920. [4] Dec. 3, 1909.

Table 4 indicates far more equable temperatures in the Canal Zone than in the United States.

TABLE 4.—*Comparative temperatures, relative humidities, and mean annual rainfalls at various points in the United States and in the Canal Zone*

Station	Mean July temperature	Record temperatures		Mean annual relative humidity	Mean annual rainfall
		Highest	Lowest		
	° *F.*	° *F.*	° *F.*	*Per cent*	*Inches*
Mobile, Ala	81.4	102	−1	74	62.04
Denver, Colo	72.2	105	−29	52	14.02
Washington, D. C	76.8	106	−15	72	43.50
Key West, Fla	83.5	100	41	77	38.66
Chicago, Ill	73.9	103	−23	74	33.28
New York, N. Y	73.8	102	−13	71	44.63
New Orleans, La	82.4	102	7	78	57.42
St. Louis, Mo	78.7	107	−22	70	37.20
Oklahoma City, Okla	80.6	108	−17	70	31.70
Charleston, S. C	81.4	104	7	78	52.07
Galveston, Tex	83.4	99	8	77	47.06
Colon, Republic of Panama	80.0	93	66	84	127.25
Balboa Heights, Canal Zone	80.0	97	63	83	68.96

SURFACE FEATURES

The main axial range of the Isthmus of Panama runs northeast and southwest across the Canal Zone, the crest lying several miles south of the geographical axis of the Isthmus and within 10 miles of the coast at Panama. It is crossed by the canal at Culebra. The slope to the Pacific is comparatively steep. On the Atlantic side the slope is comparatively steep to an extremely hilly lowland belt formerly drained by Chagres River east of the canal and by a number of small tributaries of Chagres River west of the canal. These are now flooded throughout most of their extent by the waters of Gatun Lake. The following description of the southern part of the Canal Zone, including the longitudinal interior lowland just referred to and the axial range south of it, shows some of its characteristics in detail:

It would be difficult to imagine a region more hilly than the southern portion of the Canal Zone. The entire country is so broken by one hill after another that well-defined, continuous ridges are almost entirely lacking. There are, however, roughly developed drainage divides which, viewed in places from the main valley slope, sometimes appear as unbroken ridges flanked by rounded lateral hills, as is well illustrated in the valley to the west of Em-

pire. But closer view of these divides reveals a most uneven surface configuration. The valleys between the numerous hills here are extremely variable in depth, so that there are many minor high valleys lying above the deeper major stream depressions through the divide regions. This entire southern region is ramified by an intricate drainage system which favors the rapid run-off of rain water. Along their lower courses, where the fall is less, the streams are usually bordered with narrow fringes of flat bottom land. Many of the smaller tributaries descending rapidly to the larger streams are merely wet-weather drainage ways of short length and without alluvial bottoms.

North of this hilly interior lowland which seems to occupy the geographical axis of the Isthmus from the Canal Zone eastward and southward many miles, is another ill-defined mountain ridge which lies between the interior axial lowland and the Caribbean coast of the Canal Zone. It does not extend across the canal, however, or if so is represented only by a series of low hills lying along both sides of Chagres River northwest of Gatun Dam. This ridge culminates a short distance east and southeast of Colon in the Sierra Santa Rita.

The savannas [5] include the smoothest upland areas. Those extending from the vicinity of Panama to Chepo and those occurring in the La Chorrera section are characteristically gently undulating or gently rolling, with prevailingly long, gentle slopes, broken here and there by rough gullied lands. The stream bottoms are fairly broad in the savanna districts. Savanna land is amply level for easy cultivation, but unfortunately most of the soil of the larger areas examined (the red savanna soil about la Chorrera and east of Panama) is unfavorable for growing anything except grass.

Although the Canal Zone has the lowest elevation on the Isthmus of Panama, it is one of the most hilly parts of Central America. (Pl. 1, A.) With the exception of the low swamps around Colon and between Pedro Miguel and the Pacific Ocean and the narrow strips along many of the stream bottoms, there is no flat land in the Canal Zone. Hills are numerous and range in height from less than 50 feet above sea level near Gatun and Colon to 700 feet in the southern part of the Canal Zone. The highest elevation, 1,223 feet above sea level, is reached on the hill known as Cerro de Galera (fig. 1), near the boundary southwest from Balboa. Other hilltop elevations range from about 500 feet to more than 1,000 feet above sea level.

The highest elevations, as a rule, are back from the canal, near and along the boundaries of the Republic of Panama. The lower elevations occur north of Gatun, on the east side of the canal.

Some of the slopes are too steep for easy cultivation, and, if cleared and plowed, would wash severely, unless terraced, or would develop gullies similar to those in the pastures near Darien, where the land has never been plowed. The deep-red clay, the prevailing soil of the Canal Zone, shows remarkable resistance to erosion. Few gullies, even in the initial stage, are seen on these soils along old trails or even in cleared pasture land. Areas most favorable for cultivation are along the streams and on the less rolling country adjacent to them, especially along the lower courses of Rio Cocoli and Rio Puente.

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[5] Savanna, in this region, refers to grass-covered areas where the soils are principally residual. In United States savanna is sometimes used in referring to the sparsely timbered areas of the low coastal-plain region, mainly in the Carolinas, where the soils have been developed from sedimentary material.

The lower hills have comparatively gentle slopes and are fairly well suited to agriculture. An extensive area on the Empire-La Chorrera road, beginning near the Canal Zone boundary and extending southwest almost to Caimite River and to the vicinity of Arraiján, is comparatively smooth, the difference between minimum and maximum elevations being less than that characterizing the average hill land of the region. The soil here is deeper and therefore better than that of the higher hill country.

Most of the streams are bordered by narrow strips of alluvial soil which, as a rule, are not continuous but occur in patches on both sides, the broader bottom lands occurring in the bends of the streams. Few of the strips of bottom land exceed one-eighth mile in width, and most of them vary in width from about 100 to 400 feet. Exceptionally broad stretches of alluvial lands lie along Chagres and

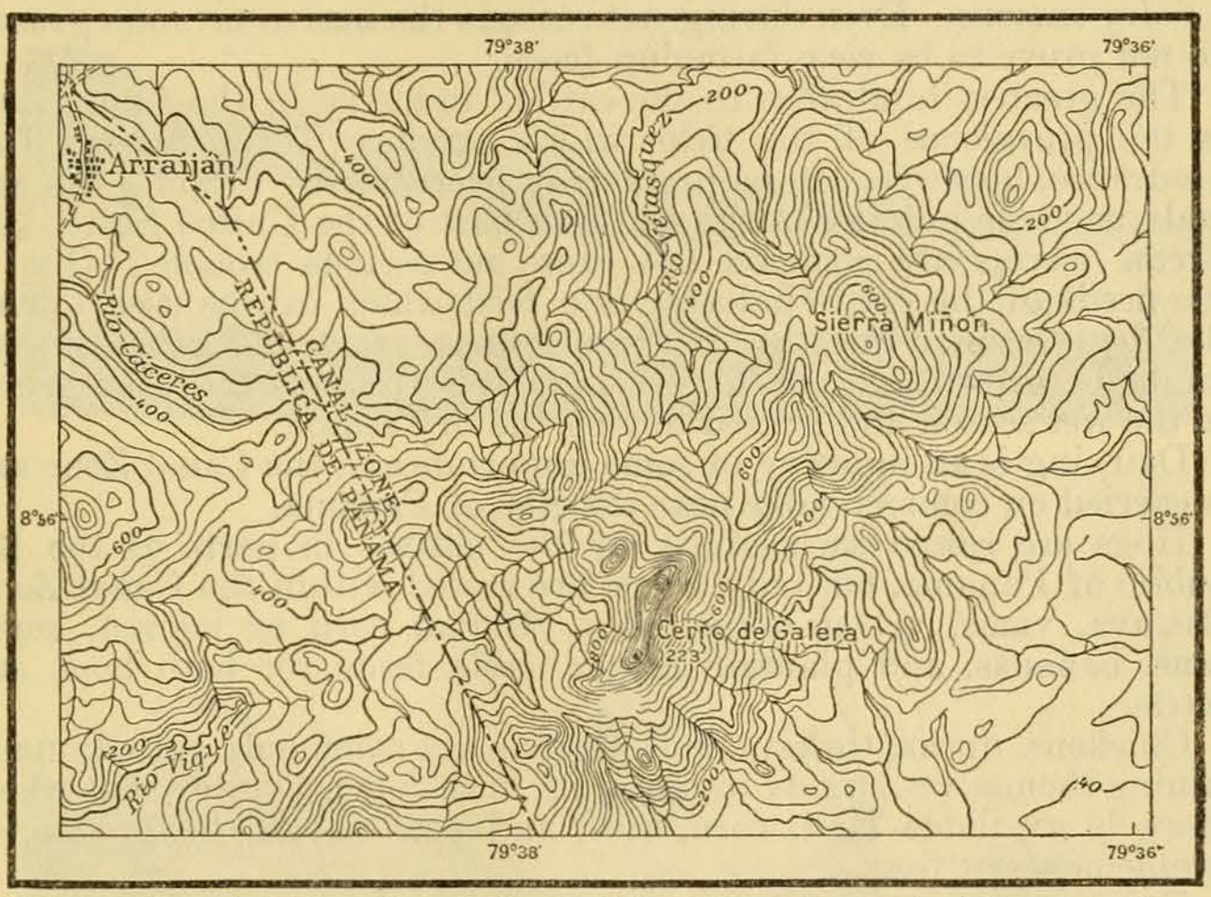


FIG. 1.—Characteristic surface features of the hilly region west of Panama. Here the principal soils are Arraiján clay and the San Jose phase of Arraiján clay

Pequeni Rivers. In places, gently sloping lands adjacent to the bottom lands along the streams have deep soils.

Many ravines (quebradas) carry water following heavy rains only, and some of the hill streams practically cease flowing toward the end of the dry season. Most of the streams, especially the smaller ones, are actively cutting their channels deeper. Some of the larger ones, however, have practically reached base level.

AGRICULTURE[6]

No full discussion of agriculture and its possibilities in the Canal Zone will be undertaken in this report, but references to some of

[6] The data in this report relating to crops and farm methods are based on (1) The agricultural possibilities of the Canal Zone; (2) the work of the plant-introduction garden of the Panama Canal; (3) the supply department of the Panama Canal; and (4) the experiences of farmers and personal observations.

the outstanding features will be made. The principal farm industries of the Canal Zone and contiguous territory at the present time consist of growing bananas and raising livestock.

Some years ago a large area in the Canal Zone was cleared and set to guinea grass (*Panicum maximum*) (pl. 1, B.), which was used for fattening cattle for the Panama Canal Commission. At one time 15,000 head of cattle were maintained on these pastures. Napier grass is also a promising grass for the clay uplands, and Rhodes grass has grown well at the plant-introduction garden. Bermuda grass and some of the native species of Paspalum thrive and remain fairly green during the dry season. Elephant grass has done well in other places and is highly valued as feed for livestock. Pastures of guinea grass or Para grass will support about one animal to the hectare (2.47 acres). New savannas will afford about the same amount of pasturage during the rainy seasons but very little during the dry seasons. Even during wet seasons the native savanna grasses do not prove to be very fattening feeds.

The greatest hindrance to the cattle[7] industry in the Canal Zone is the prevalence of the ticks which produce Texas fever. This hindrance, however, can be practically overcome by dipping the animals, as is the practice in the southern part of the United States (*6*). Screw worms are common but cause no serious trouble. One of the needs of the cattle industry is a feed which can be used during the dry season. For this purpose guinea grass and other grasses might be grown and cut for hay, and velvet beans could be grown in the wet season and grazed during the dry season.

Dairying is an industry of some importance in the Canal Zone and is carried on commercially near the city of Panama.

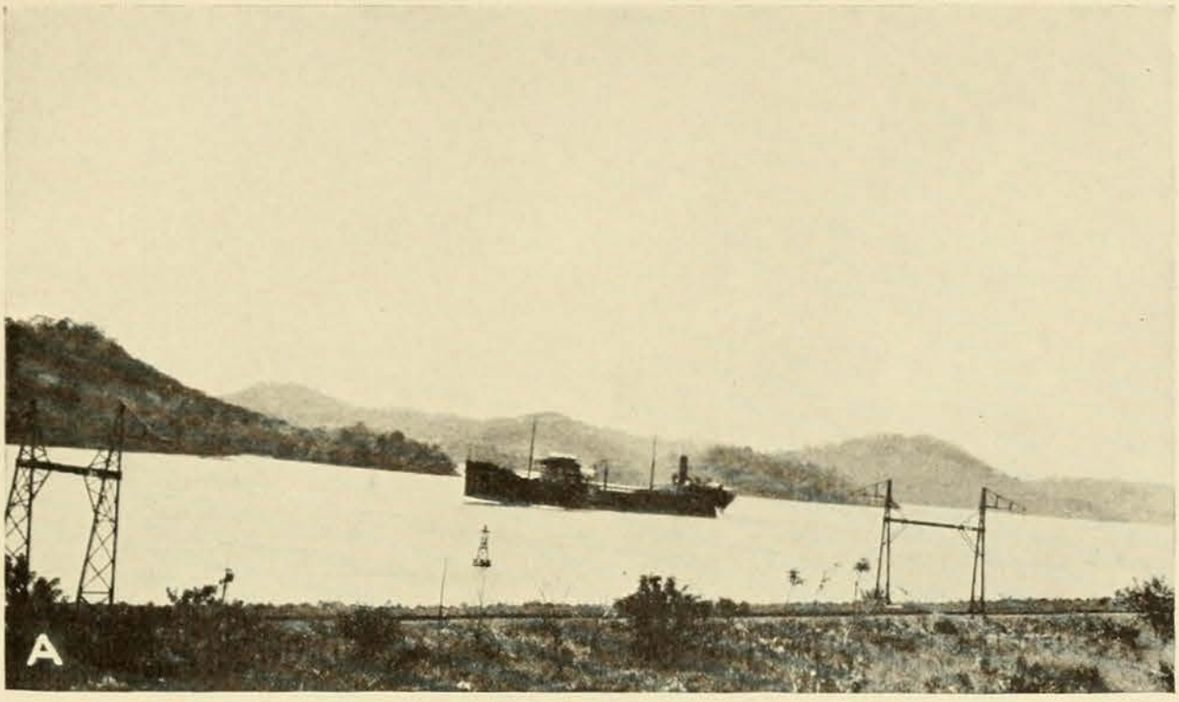
Hogs are raised successfully by the natives in parts of the Republic of Panama, but only a few are raised within the Canal Zone. Cassava, yams, velvet beans, corn (Indian corn or maize), sugar cane, bananas, and plantain are valuable feeds for both hogs and cattle.

Chickens, ducks, turkeys, and pigeons are commonly raised, maintaining themselves largely by foraging in the open country; but where there is available land, corn, rice, and peas should be grown for supplementary feed.

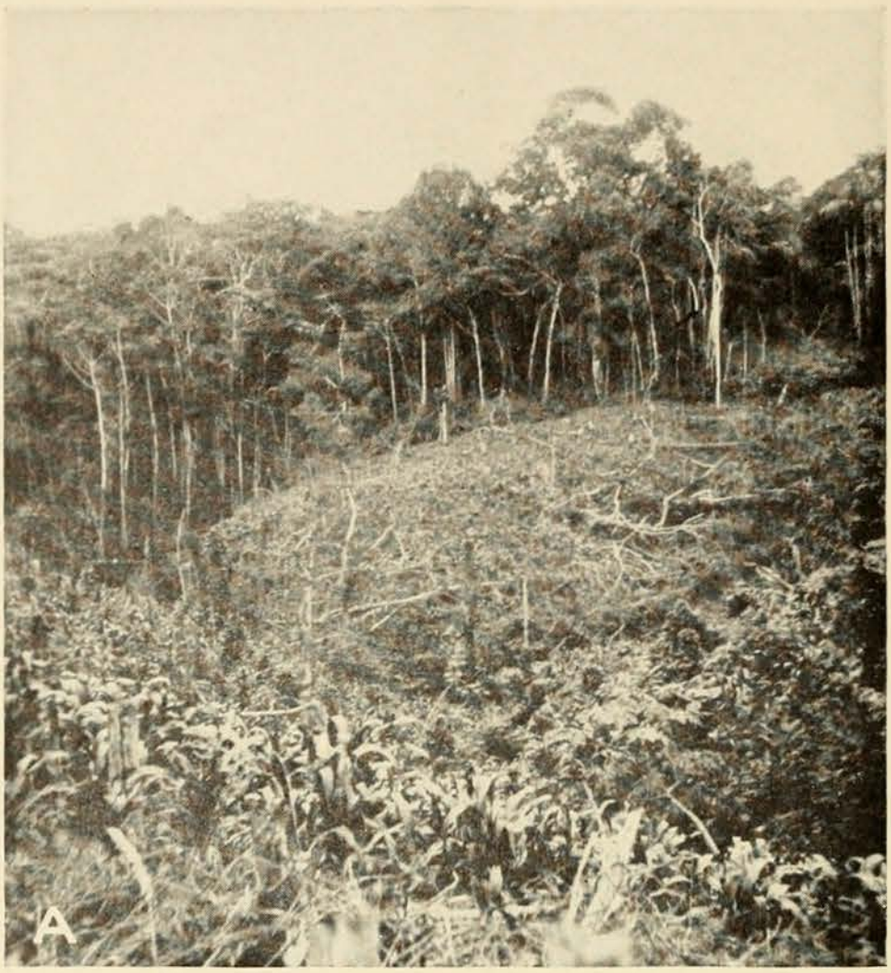
Bananas (*1*) are grown in many parts of the Canal Zone and near-by regions. Under the impetus of good prices there has recently been a very considerable increase in banana production both within the Canal Zone and in the Republic of Panama. This fruit gives best results on the deeper soils of the Atlantic side of the zone, where the moisture is sufficient to carry the crop through the dry season. In the southern part of the zone the fruit suffers severely through the drying out of the soil. The plants seldom die, but many of the leaves turn yellow and parch, and the plants cease to grow and produce little fruit, except on the more moist, deeper soil.

Selection of the proper soil is necessary for the successful growing of bananas. Best results are obtained on well-drained alluvial soils

[7] Beef cattle of the Canal Zone consist largely of Herefords crossed with native stock and the half and three-quarter grades again crossed with a grade Brahman, the purpose being to develop a type of desirable size and also immune from Texas fever. For dairy cattle, Holsteins have been introduced and crossed with native Colombian cows which are nearly immune to Texas fever and are good milk producers.



A.—Hills bordering an arm of Gatun Lake along Panama Canal
B.—Planted guinea grass on red clay (Gatun clay) near Cuipo



A.—Small clearing of a native (milpa) farmer
B.—Mixed plantings made by a milpa farmer

or on friable, deep, red clay upland soils, such as Frijoles clay and Gatun clay. Bananas do not thrive on soils with plastic, impervious clay subsoils, especially if the soils are wet and soggy. Wherever mottled bluish, rust-brown, and yellow stiff clay or hardpan layers are present within 2 or 3 feet of the surface, the plants do not, as a rule, produce good marketable fruit, and failures are common. Some conspicuous failures were observed on the west side of Chagres River above Gamboa in the Canal Zone. In selecting land for planting bananas, it has been the practice to examine the surface soil only. In the growing of bananas and most other crops, subsoil conditions are of as much or even more importance than conditions of the surface soil.

The Panama disease, produced by a Fusarium fungus, is so prevalent in this region that all banana growers expect their plantings to be attacked sooner or later but hope to obtain from three to five crops, or even more, before the plants are ruined. In some cases, bananas planted on neutral and slightly alkaline soils have been more resistant to this disease than those planted on acid soils. However, badly diseased plants on neutral and alkaline soils were seen in the Talamanca Valley of Costa Rica, and on the other hand some excellent fruit has been produced on acid soils.

Market gardening is carried on in small plots, chiefly by Chinese and negro farmers. The products are either sold in the local markets or are peddled from house to house. Small-sized tomatoes, a loose-leaf variety of lettuce, okra, small onions, cucumbers, sweet potatoes, peppers, cowpeas, chayotes (*10*), and a variety of tropical vegetables are grown in these little gardens. During the dry months, the gardens are either irrigated or watered by hand. Some vegetables which do not do well during the wet season produce fairly well in the dry season. Tomatoes, cabbage, carrots, and certain other vegetables are sometimes injured during periods of rainy weather. The dasheen (*20*) (tanier) flourishes, and the tropical yam is easily and widely grown.

Corn and rice are the most important subsistence crops grown by the natives. These are grown in patches on both upland and bottomland soils, better yields being obtained on the latter. Some actual clearing of the land is done where rice is to be sown, but corn is planted by putting the seed into the ground with a sharpened stick, then chopping down the bushes and trees. Usually no cultivation is given corn or other crops by native farmers. The only farm implements are the machete, used in felling trees and slashing weeds, and a sharpened stick used to make a hole in the ground for planting seeds. In many places yams, sugar cane, cassava, papayas, chayotes, taniers or taros, and other crops are grown indiscriminately, jumbled together on the same small plot of ground.

Plots of ground near the houses of some of the natives are farmed for six or seven years, but as a rule fresh land is sought after two or three crops have been grown, the old land being considered undesirable for use. This is known as the milpa system of farming (*5*). (Pl. 2).

As the native farmer does not plow or otherwise cultivate the ground before planting a crop, very little erosion occurs during the brief period of its use. Although grass and weed invasion is un-

doubtedly one cause for a change of ground for planting, it has been noticed that the native farmer sometimes changes ground even where the grass growth has not become troublesome. As the yields decrease, probably on account of constant cropping without cultivation, fertilization, or rotation, new ground is sought. Second-growth vegetation is cleared and recleared repeatedly, and the land is successively cropped, indicating that the soil itself has not become exhausted but that aeration and oxidation through proper cultivation are necessary to maintain it in a productive condition. The growing of legumes, particularly velvet beans, jack beans or sword beans, and probably crotalaria, would aid in lengthening the period of soil productivity. However, as the native farmer has, in most cases, plenty of available land for his few wants, he is not easily induced to change his farming methods. He seems content to dwell in his palm-thatched shack made of poles, and to live in his primitive way.

Most of the common tropical fruits may be grown in this locality. Mangoes, avocados, plantains, papayas, oranges, pineapples, limes, breadfruit, coconuts, sapotes, Annonas, star apples, and other fruits are successfully grown; and litchis, mangosteens, and others are being tried experimentally. Some very sweet, juicy, thin-skinned oranges were growing on a strip of well-drained alluvial soil at Juan Mina, on Chagres River. The less common tropical fruits that thrive in the Canal Zone are the guava, Surinam cherry, soursop, granadilla, and tamarind. Almonds are grown principally as ornamental trees. A great variety of native fruits and vegetables are seen in the native beach markets to which boats from up and down the coast come, loaded with these products.

In the Canal Zone Plant Introduction Garden at Summit the introduction of new and improved varieties of fruit and the determination of the varieties of fruit, velvet beans, and other crops best suited to the soils, climate, and other conditions of the region is being actively carried on.

The velvet bean seems destined to play an important part in tropical agriculture as a soil improver and as a valuable source of livestock feed. Pigeon peas, certain varieties of cowpeas, and other legumes produce well, but the velvet bean seems very promising. The jack bean (*16*) (*Canavalia ensiformis*) has been successfully grown, and where it grows the sword bean (*C. gladiata*) no doubt will thrive.

The native farmers grow a little tobacco. The crude product, where examined, had a good flavor. Very little data regarding yields or quality of the crop, however, are available. The sandy, alluvial lands, it is believed, would produce a smoking tobacco of the Cuban cigar type, tobacco of this kind being grown on similar soils in the San Carlos River valley in northern Costa Rica.

Rubber trees are grown in many parts of the Canal Zone (*7*, *17*, *18*, *19*). Some wild Castilla trees were seen in the forest on the northwest side of Gatun Lake, near Cuipo, and nispero (balata) trees are reported as growing on the northeast side of Gatun Lake, in the vicinity of Porto Bello, along Gatuncillo and Pequeni Rivers, and elsewhere. A beautiful grove of large Castillas was seen on stony red clay soil (Arraiján clay) at Arraiján, just outside the Canal Zone. The trees are very large, tall, erect, and clean and

produce latex freely. Trees of *Castilla panamensis* abound throughout the grounds of Ancon Hospital on the slope of Ancon Hill. Some of these are more than two feet in diameter and have a healthy appearance. Two *Hevea brasiliensis* trees are growing near the foot of Ancon Hill. These trees are believed to have been set out about 1907 and are now approximately 18 inches in diameter at breast height. Although the soil is well drained, it is not the most favorable soil for this tree, a fact evidenced by the growth of some of the main roots along the surface of the ground. Roots of trees seen in other places, where soil conditions are more favorable, are well below the surface of the soil. That soils suitable for the growing of rubber trees occur in the Canal Zone and contiguous territory is shown by the existence of trees of both the Castilla and Hevea species in several places. The land, however, except in some localities, is more hilly than might be desired for these trees, and many of the steeper slopes, if brought under cultivation, would require terracing to prevent erosion.

The most suitable land for Para (Hevea) rubber trees includes the smoother areas of the Frijoles and Gatun clays, which are the red clays in the northern part of the Canal Zone, and the less rugged phase of Arraiján clay, occurring in the southern part of the zone. The distribution of these soils is indicated on the accompanying reconnaissance soil map, and their characteristics are given later in this report under sections describing the different soil types. Alluvial soils having yellow, reddish, and brownish unmottled subsoils are suitable for rubber trees. Both the Hevea and Castilla species grow on such soils near Almirante, Republic of Panama.

Without irrigation or abundant watering during the dry seasons, vegetables commonly grown in the Canal Zone either cease to grow or make very slow growth, and in many places, particularly on the heavier soils on the Pacific side, completely dry up. Corn planted in the wet season usually matures by the latter part of February, sometimes earlier. Guinea grass ceases to grow during the dry season and, on the Pacific side of the zone, parches considerably. Rice ripens soon after the rains cease. Bananas wilt and stop growing, except on the deeper, more friable soils. Even cassava and yams make very little growth in March and April, and Pará grass parches except on moist lands. Certain tropical vegetables and fruits are only slightly retarded during the dry season. The mango, for instance, fruits most heavily at this time, and the chayote generally survives where the soil on which it is planted is not too shallow.

On the Atlantic side of the isthmus the more frequent showers which fall during the dry season help to maintain the moisture supply, and the foliage of forest trees is predominantly green. Some trees, such as ceibas and guayacan, shed their leaves all at once, but these trees are so scattered that their barrenness is not very noticeable in the prevailing greenness of the forest. The restrojo of the Atlantic side usually suffers somewhat on account of scant rainfall in the verano, or dry season, and vegetables are damaged in many localities. With the coming of the rainy season, the forest and pastures throughout the region turn green as if by magic, and from this time to the next dry season they flourish.

Land may be leased or bought outright from the Republic of Panama and concessions may be obtained through the proper Government officials of that country (*13*, *14*). Virgin land may be had for about $10 an acre. The annual tax rates on agricultural lands in the Republic of Panama in effect June, 1922, were as shown in Table 5.

TABLE 5.—*Annual tax rates on agricultural land in the Republic of Panama*

Kind of land	Rate per hectare (U. S. gold)	Equivalent rate per acre (U. S. gold)
Cultivated land	$0.144	$0.0583
Natural pasture	.096	.0348
Other than above	.06	.0243

Insect pests are numerous. The leaf-cutting ant (*Atta cephalotes*) often strips a fruit tree of its leaves within a day or two. These insects can be killed by pouring carbon bisulphide down each ground nest hole and closing the hole with dirt. Other remedies, such as pouring scalding water into the holes at intervals, driving in sulphur fumes with a bellows, and using sodium cyanide, calcium cyanide, and paradichlorobenzene, have been used with varying degrees of success. Termites, or wood ants, are destructive to woodwork of all kinds, except a few very hard woods. Scale insects and white flies are a menace to many kinds of trees, and coconut trees are damaged by beetles. Mosquitoes and other insects are at times a serious pest. Nematodes are in many places abundant in the soils, and tomatoes, eggplants, certain varieties of cowpeas, and some other plants are seriously affected by them. Insects and various plant diseases (*3*, *8*) are at present doing considerable damage to fruit trees, but could be controlled to some degree at least, by the use of fungicides and insecticides, especially if applied in the form of sprays.

Although the clays of the Panama Canal Zone are somewhat sticky at the surface when wet, it is claimed that they generally can be plowed soon after heavy rains without clodding or hardening. Erosion is not rapid, and plowed slopes are less susceptible to damage than are similar slopes in the United States. The nature of the clay, or of the colloids contained in the soil, undoubtedly has much to do with the unusual resistance to erosion. In some of the soils the colloids seem to exist in a flocculent condition conducive to friability and high absorptive or percolative capacity, and in other soils, the more erosive type, they seem to clog the pore space effectively. The less friable clays are more subject to erosion than those of greater permeability. Resistance to erosion may be due in some measure to the low content of sand and to the fact that these soils are never loosened by freezing and thawing.

At the plant-introduction garden at Summit a heavy yellow clay was being plowed fairly easily with a two-horse turning plow during the dry season in March, 1924. Some large clods were turned up, but after exposure to air and sun they were easily broken up by harrowing. This ease of cultivation may be due to the tendency of the plastic clay to shrink and crack.