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Ecology of Rancho Grande, a Subtropical Cloud Forest in Northern Venezuela.[1]

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(Plates I-V; Text-figures 1-10).

CONTENTS.

I. INTRODUCTION.

Rancho Grande, the center of the research area described in this paper, is in the National Park of Aragua, in north central Venezuela, at 10° 21′ North Latitude, 67° 41′ West Longitude. It lies in a subtropical cloud forest on the coastal range of the Andes, at an altitude of 1,097 meters (3,600 feet). It is 80 kilometers west of Caracas, and midway between Lake Valencia and Ocumare de la Costa on the Caribbean Sea.

This area was headquarters for the forty-fifth and forty-sixth expeditions of the Department of Tropical Research of the New York Zoological Society. These were made possible by the kindness of the Venezuelan government, in putting the facilities of the National Park at our disposal, and through the generosity of the Creole Petroleum Corporation in financing and otherwise aiding the undertaking. A well-equipped laboratory and comfortable living quarters were established in the building known as Rancho Grande, and occupied for five months in 1945 and six and a half months in 1946. Here we carried on intensive observation and field study of the fauna and general ecological conditions, in an area of an approximate circle two kilometers in diameter.

The following pages deal briefly with the zones adjacent to Rancho Grande and with the various ecological aspects of the cloud forest itself, including the geography, meteorology, botany and zoology. The purpose of the paper is two-fold, first to give a bird's-eye view of the subtropical cloud forest from the viewpoint of the field zoologist, and, second, to lay a general foundation for the series of papers on the various faunal groups and problems studied during the course of the two expeditions. These publications will succeed the present paper, and appear from time to time.

The expeditions were carried out under the direction of William Beebe, with Jocelyn Crane as Research Zoologist, Henry Fleming, Entomologist, and George Swanson, Artist. For part of 1946 Kenneth Gosner served as field artist and Mrs. Mary Fleming as field assistant. We were fortunate in our local helpers, Manuel Vegas, Pedro Infante and Eduardo Echenagueio performing their various duties thoroughly and efficiently, while Octavio Chellé, the general caretaker lent by the Creole Corporation, added much to the success of the expeditions.

We wish to express our appreciation to the innumerable individuals in Venezuela, not directly connected with our expeditions, who gave their constant friendly cooperation. Within the national government itself, we are grateful particularly to the officials of the *Ministerio de Agricultura y Cria*, within the jurisdiction of which now fall both the National Park and the building of Rancho Grande, and to those of the *Ministerio de Obras Publicas;* their endless help included everything from the maintenance of our water supply to the furnishing of maps and rainfall records, and to the prompt identification of ecologically significant plants.

Particular thanks go also to the officials of the State of Aragua, to all the officers of the Creole Petroleum Corporation and to many other friends, both North American and Venezuelan, in Caracas and Maracay. In addition, we want to mention the following individuals here, since the help they furnished, in the form of special data and loans of instruments and collections, was of a specifically scientific nature; in alphabetical order they are: Sr. Victor Badillo, Dr. Charles Ballou, Sr. Fulvio Benedette, Dr. Esteban Delgado, Sr. Walter Dupouy, Dr. Arnoldo Gabaldón, Rvdo. Hermano Ginés, Dr. Derald Langham, Dr. Tobias Lasser, Sr. René Lichy, Dr. Victor M. López, Sr. Rodolfo Luzardo, Sr. Roberto Perez, Mr. William H. Phelps, Mr. William H. Phelps, Jr., Dr. Henri Pittier, Dr. Eduardo Röhl, Dr. L. Schnee, Dr.

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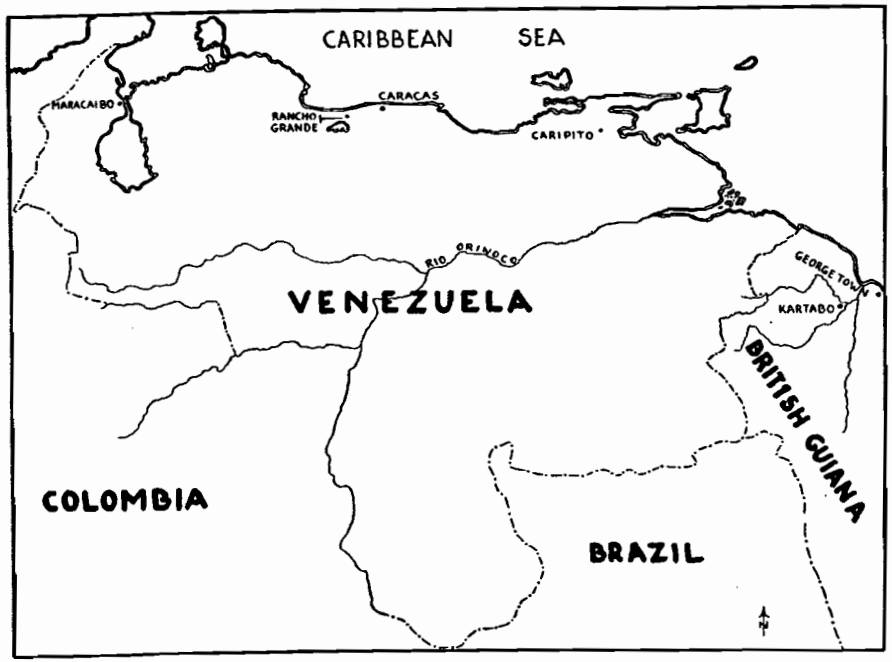


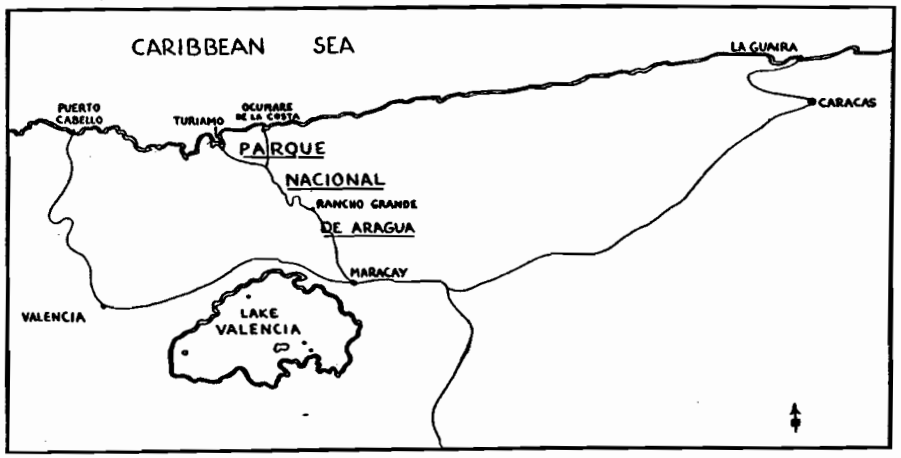
TEXT-FIG. 1. Map showing location of three field laboratories of the New York Zoological Society in northern South America: Kartabo, British Guiana (1916-1924); Caripito, Venezuela (1942); and Rancho Grande, Venezuela (1945-1946).

Robert H. Tschudy, Dr. Luis Felipe Vegas and Dr. Guillermo Zuloaga.

The history of Rancho Grande and the National Park seem worth recording here. In this area near the pass called *Portachuelo* there existed for many years a little road-house or caravanserai which provided food and shelter for the burro trains carrying loads over the ancient trail from Maracay to Ocumare de la Costa. In 1915 good bridges were built across the gorges, and the road widened to accommodate carts. A final, complete change turned the winding track into an excellent cement automobile road, this transformation being brought about by the energetic dictator, Juan Vicente Gómez, during the years 1930 to 1933. In the latter year, the small road-house was torn down and in its place Gómez began the erection of a stately steel and concrete building of some 120 rooms which was to serve as an official hotel. In December, 1935, the dictator, who had reigned for three decades, died, and all work on the half-finished building ceased, leaving the new Rancho Grande in the general condition of a castle of the Middle Ages.

In February, 1937, 80,000 to 90,000 hectares (about 350 square miles) of the surrounding mountains and coastal lands were set aside by government decree as the National Park of Aragua. Except for a few long-cultivated areas in the lowlands near Ocumare, some secondary savanna on the burned-over foothills of the Maracay slopes, and several cottages along the highway, the preserve is in its original state, the principal zones of vegetation including thorn woodland, seasonal forest and above all, a magnificent unbroken expanse of montane cloud forest.

The results of this ten-year protection of the forest and its wildlife are already apparent from the most cursory comparison with many recently similar areas in the tropics. Here in the Reserve, the usual tragic sequence of unplanned deforestation, erosion and desiccation has been halted, and with it the extinction of countless useful, attractive or scientifically interesting forms of animal life. The appreciation of all conservationists is due the officials of the Venezuelan government in general and Dr. Henri Pittier in particular for their foresight and energy in establishing this Park. Its present maintenance, when the urgent need for such reserves is scarcely realized by the public, will for years be an example and stimulus in other parts of the hemisphere.



TEXT-FIG. 2. Location of Rancho Grande in north central Venezuela. Scale: 1 cm = 11 km.

II. THE FOURTEEN ZONES ADJACENT TO RANCHO GRANDE

[Note: The terminology of Dr. John Beard, as given in his definitive paper, "Climax Vegetation in Tropical America" (1944), is followed below in the discussion of the various terrestrial zones. The term "Montane Cloud Forest" is used, rather than his more general "Montane Rain Forest," because, as he himself suggests (p. 145), in agreement with Pittier's earlier usage, (e.g. 1939, p. 20), it is more applicable to this particular location.]

Our special area of study, as has been said, is a circle two kilometers in diameter with Rancho Grande at the center. In Nature, however, there are no hard and fast lines and every day there were found living creatures, causes and effects, which could not be accounted for or explained by one zone alone. With Rancho Grande as the hub, if the perimeter of our circle be enlarged to a radius of twenty-five kilometers, there will be found within its borders fourteen territories, to each of which, without impropriety, may be applied the term zone. (Text-figs. 5, 6).

Their influence on our central one is indirect, but it may be worth while briefly to visualize these zones. Ten kilometers off shore from Ocumare or Turiamo we float over a half mile of water, a depth sufficient to bring the Abyssal Zone of life within a comparatively short distance. This is probably the least known, yet at the same time the least varying of all the fourteen. Without use of net or bathysphere we could, with sufficient accuracy, from our previous experience elsewhere, enumerate the dominant forms of life—strange fish, crustacea, mollusks and coelenterata – which inhabit and often illumine the deeper portions of this sunless, bitterly cold world with its terrible watery pressure.

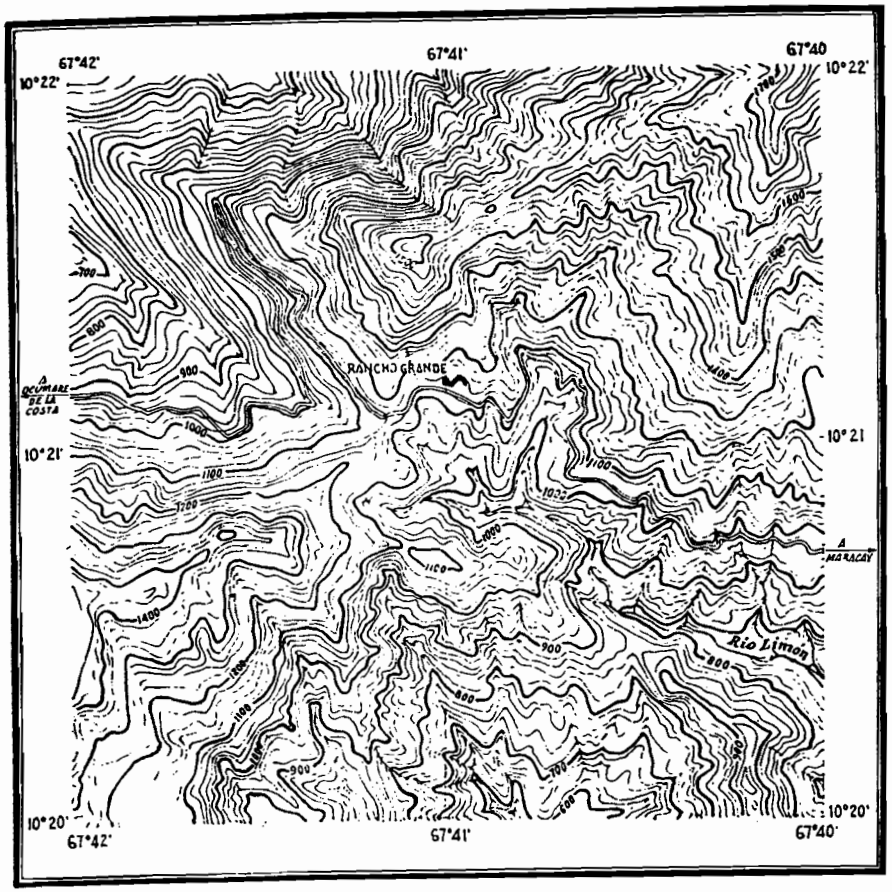
On the surface of this off-shore area, is Zone Two, the Pelagic, intense blue over the deep water. As typical surface, aquatic and aerial forms of life, we may expect to find blackfish whales, petrels, tropicbirds, shearwaters, flyingfish and Portuguese-men-o-war.

Zone Three, the Shore Water and Reefs, is still marine, the water changing to turquoise over the shallows. Here are found shore fish, sharks and such birds as ospreys, gannets, frigatebirds, terns and pelicans. At Turiamo is a typical coral reef, the great flat fronds sheltering a host of beautiful creatures, brightly colored fish and equally colorful shelled and naked mollusks, crabs and anemones.

The Sandy and Rocky Littoral, Zone Four, exists wherever sea and land meet, alternately covered and exposed by the tide. Sand-burrowing, rock-clinging and crevice-loving creatures call this home. These are chiefly crustacea, snails and worms, having as dominant predators the many long-legged waders, such as sandpipers.

Zone Five comprises the Mangroves, a limited zone, bordering the bays, occupying a muddy, inter-tidal area, the home especially of herons and fiddler crabs.

The Fresh-water or Zone Six is almost synonymous with Lake Valencia. This is a large, slowly drying body of water, supporting many fish, especially characins and catfish, as well as crocodiles and reed-haunting birds. This zone enters our territory by way of rushing mountain streams which rise near Rancho Grande.



TEXT-FIG. 3. Contour map of the Rancho Grande area, from an official aeronautical survey. Courtesy of the *Ministerio de Obras Publicas de Venezuela.*

The Llanos or great, grassy rolling plains which comprise so large a part of Venezuela can barely be considered our Zone Seven, for typical llanos are found farther away than any of the other zones, well to the south of Lake Valencia. Their fauna is peculiar and controlled by the dominant grass vegetation and the extremes of wet and dry seasons.

Savanna, the Eighth Zone, bounds us to the south, over the lower slopes towards Maracay and Lake Valencia. It shows a monotonous expanse of grass, sparsely dotted with chaparral. Here are lizards, large and small, and covies of crested quail, while gray and white mockingbirds perch among the leathery leaves. This local savanna is not a climax formation but rather is a result of the early denudation of the seasonal forest combined with almost annual burning during the dry season.

Cactus Scrub, our Ninth Zone, is found chiefly on the slopes immediately above the littoral and is typical of many Caribbean shores, including the one under discussion. It is a shock to the newcomer to the tropics to have as his first view, instead of lush jungle, great stretches of barren rock and gravelly slopes covered with sparse growths of agave, acacias and candelabra cactus, all bristling with an armor of thorns. Ground doves and equally dust-colored lizards scurry over the dry ground, and now and then a blazing vermillion flycatcher rises singing into the sky.

Merging almost imperceptibly with the coastal scrub on one side and the deciduous seasonal forest on the other, is found a sort of Thorn Woodland, the Tenth Zone. It differs from Beard's general description in having a number of the dominant acacias deciduous, but otherwise agrees well with his diagnosis of "a scrubby type, varying from fairly open to more or less closed, with hard-leaved, microphyllous, evergreen spiny trees, 3 to 10 meters high . . . The soil is not grassed, ground vegetation being practically absent, save for rare bromeliads and succulents. Most of the thorn trees belong to the Mimosaceae and Caesalpiniaceae." (1944, p. 140). Examples are found chiefly on the Caribbean slope, and are distinguished from the cactus scrub by the almost total absence of cactus and by the higher, denser growth of the thorny thickets. Like the vegetation, the fauna is intermediate between that of the scrub and the seasonal forests.

Above the Savanna on the south, and in the foothills beyond the Cactus Scrub and Thorn Woodland on the Caribbean side, lies the Eleventh Zone, the Deciduous Seasonal Forest. This area contrasts in the most interesting manner with the Montane Cloud Forest so close above it. It agrees well with Beard's definition of the zone, the dominants being more than ten meters in height with two strata, the upper open, consisting of widely scattered trees of which more than two-thirds of the species are deciduous. In complete contrast to conditions in the Montane Cloud Forest, the tree trunks are almost always bare, except for a few common deciduous lianas, including a characteristic "monkey ladder" (*Bauhinia* sp.); arboreal epiphytes are practically absent; palms are rare, apparently confined to occasional examples of the *corozo* palm (*Acrocomia sclerocarpa*); heliconias, arums, ferns and mosses do not occur at all (except in stream bed intrusions, which, of course, do not properly belong in the zone).

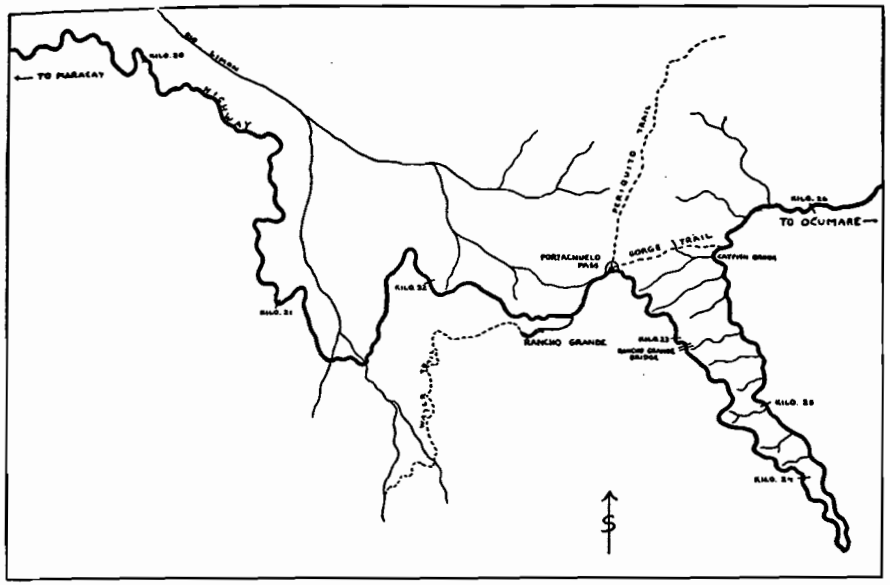
Among the most conspicuous dominants of this zone on both sides of the mountains are the following, none of which occurs in the Cloud Forest: Various *Erythrina*, locally called *bucare* and famous here as throughout the Caribbean area for spectacular, flame-colored blossoms during the dry season; *Tecoma chrysantha*, the yellow-flowered *araguanay; Ceiba pentandra*, the giant silk cotton; *Burura simaruba*, the *pelo de indio* with the smooth reddish trunk; and *Hura crepitans*, the spiny-trunked *habillo*. The lower layer of the forest, though much more nearly closed than the upper, is ragged because of the steep slopes, and formed of mixed evergreen and deciduous species. The shrub layer, growing to a height of three or four meters, is composed of evergreens. During the dry season their thin leaves are drooping and paper dry. Vines, both leaved and leafless, some of them spiny, spring from isolated spots in the ground and creep toward the nearest saplings which they cover in tangled mats; because of them, a machete is almost essential for progress. A trailing bamboo is locally abundant and even diagnostic on the Valencia side of the ranges. From February until the coming of the rains two or more months later, these deciduous forests appear utterly desiccated, the infrequent brooks are dry, the ground is slippery and crackling with dead leaves, and animal life is at its lowest ebb.

The fauna is of a wholly tropical character, rather than montane subtropical; for example, butterflies, including morphos, are abundant during the rains; termite nests are common; heat-loving *Cnemidophorus* and *Ameiva* lizards, both completely absent in the Cloud Forest, are plentiful; the birds are all lowland forms.

The Deciduous Seasonal Forest begins abruptly on the south at about the level of Guamitas, which lies at 737 meters, and extends to about 900 meters, where it merges imperceptibly with the next zone. On the Caribbean side, it extends, very roughly, from 100 to 500 meters.

Merging insensibly with the upper edges of the Deciduous Seasonal Forest and the lower margin of the Montane Cloud Forest is the narrow, rather anomalous Twelfth Zone, which in Beard's classification, corresponds more closely to his Semi-evergreen Deciduous Forest than to any of the others. This type of forest, in his analytical key, differs from the Deciduous Seasonal in having the upper story closed and only one-third to two-thirds of the individuals in the story deciduous. In the Rancho Grande area the upper story, even allowing for the steep slopes, is not noticeably closed, yet the zone fits this group much better than that of Lower Montane Rain Forest, which could more logically be expected here. Its character has doubtless been somewhat modified from the climax type by the deforestation of the adjacent lowlands, particularly on the Valencia side.

Its most diagnostic tree is *Bactris* sp., a spiny palm that occurs abundantly in this zone, but is absent from the Deciduous Forest, and uncommon in the cloud forest above. Both flora and fauna are decidedly transitional in character. Arboreal epiphites are present in very limited numbers. The first *Monstera* appears in this zone, but the species is *pertusa* rather than any of the various forms appearing in the higher, more humid regions; also heliconias, several ferns and even a small tree-fern appear close to the stream beds. *Cnemidophorus* and *Ameiva* are absent, and typically subtropical birds begin to appear. On the southern, Valencia side, it extend from about 900 to 1,000 meters; on the Caribbean side from 500 to 800 meters. Part of the southern portion of this zone is included within the two-kilometer circle of concentrated work (Text-fig. 4).



TEXT-FIG. 4. Area of concentrated work at Rancho Grande.

The Thirteenth Zone is the Montane Cloud Forest, on the lower edge of which is situated Rancho Grande. The succeeding section of this paper is devoted to its characteristics; here it will be said only that it is cooler and damper than any of the preceding zones; the forest is completely evergreen with mosses, ferns and epiphytes of many sorts at their optimum; tree-ferns are diagnostic; and in both botanical and zoological characteristics the zone is subtropical. It extends from about 1,000 meters upward on the Valencia side, and from around 700 or 800 meters upward on the Caribbean slopes.

It may be said here that each zone on a mountain side has intrusions in its valleys representing the next higher zone. For example, in the gorges of the Semi-evergreen Seasonal Forest are good examples of Cloud Forest flora, complete with hydrophilous arums and even tree-ferns, while near the riverbeds of the Savanna grow typical gallery forests of the seasonal type.

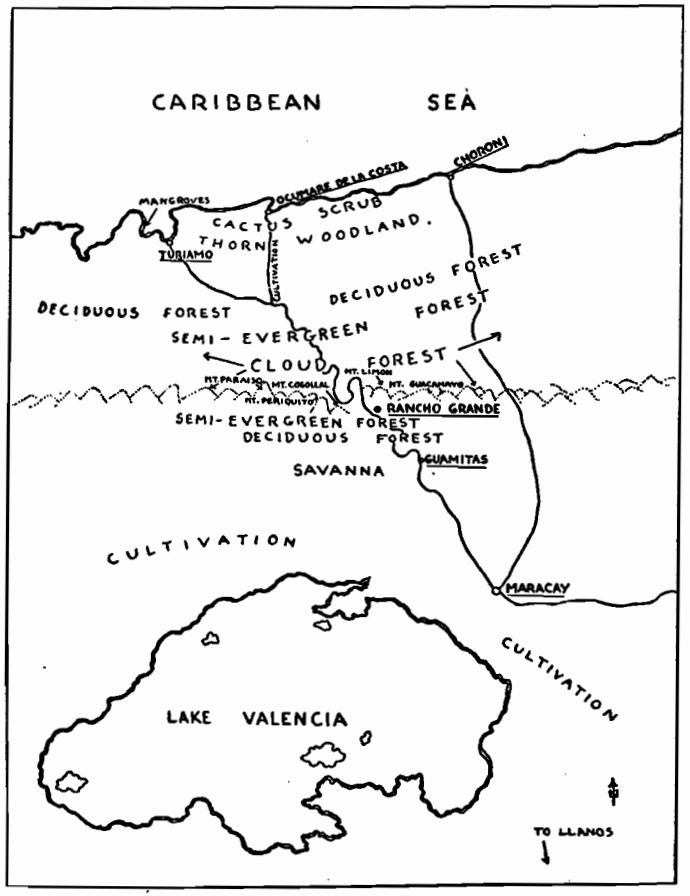
The fourteenth or Aerial Zone is the last of our subdivisions and was added to the list as an afterthought. Its authenticity was in considerable question in our minds, and we were fully resigned to elimination if in reality it proved too ethereal and indefinite. Surprisingly, it turned out to be one of the most distinct and sharply delimited of all the zones, and yielded an amazing amount of new and interesting facts and material. In brief, it was concerned chiefly with the migration of birds and insects wholly alien to the Cloud Forest, through the narrow bottle-neck that formed the sharp divide of the Pass of Portachuelo, only a few hundred yards from Rancho Grande.

III. Physical and Biological Characteristics of the Rancho Grande Cloud Forest.

A. Geography.

The outstanding geographical factors of the Rancho Grande area which influence its biology are the following: its location in the neotropics; its situation in the steep, narrow coastal range; its nearness to the ocean; the relatively low altitude, promoting subtropical rather than alpine conditions; the restricted size of the cloud forest, now extending in an unbroken strip for less than 100 kilometers along the ridges; the relative poverty of the soil; the presence of Portachuelo Pass; the nearness of Lake Valencia; and, finally, the nearness of deforested and settled areas.

Rancho Grande's exact geographical location is given in the first paragraph of this paper, p. 43. The following list of altitudes, in meters, will help orient the forest vertically: Rancho Grande, 1,097, Portachuelo Pass, 1,136, Maracay, 435, Mt. Guacamayo, to the east, 1,900, Mt. Periquito and Mt. Paraiso, both to the west, 1,525 and 1,814, respectively. The highest neighborhood peak, which lies to the south and east of Guacamayo, is La Mesa, reaching 2,240 meters.



TEXT-FIG. 5. General location of the principal ecological zones near Rancho Grande. Only the highest ridge of the coastal mountain range is indicated; actually the entire region, with the exception of the plain around Lake Valencia, is mountainous.
Scale:
1 cm. = 4.7 km.

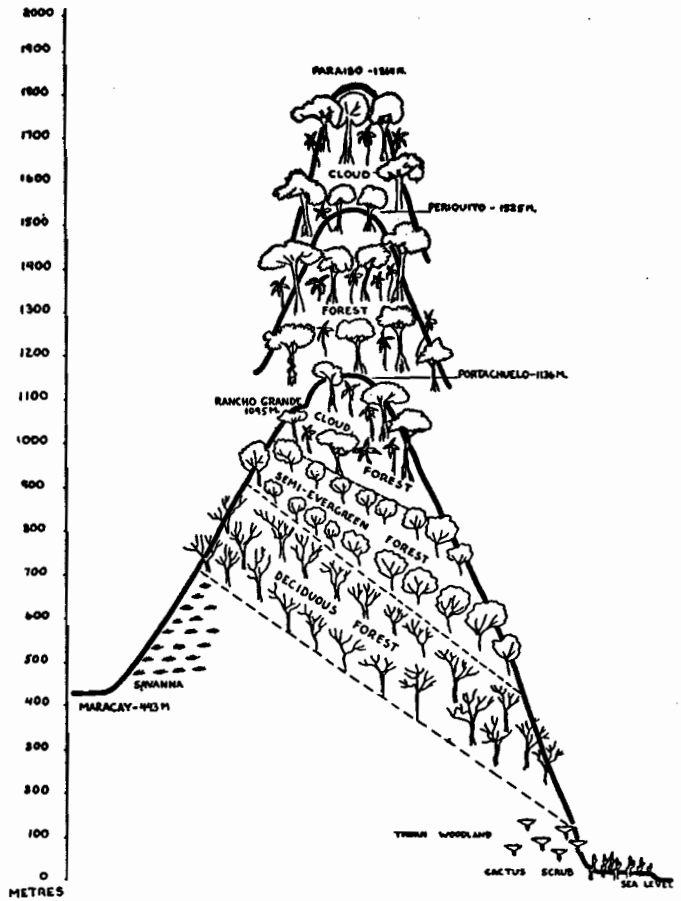
B. Meteorology.

[Note: In the following discussion, the phrase "enveloping cloud" is used to indicate the inside of the mountain cloudcap, called *neblina* in Venezuela; "overcast," on the other hand, indicates cloudiness in the sense of high clouds blotting out the sky and sun.]

1. General Weather Conditions.

Because of its contrast to the better-known, desiccated lowlands, the weather at Rancho Grande is one of its most striking characteristics. Its uniform dampness and coolness are typical of tropical montane conditions. The rainfall is twice as high as in nearby Maracay, which lies seven direct miles to the south and less than 700 meters lower. This Rancho Grande average is, however, only 175.3 cm. (68.8 in.) annually over a five-year period, a figure not excessive for the tropics. To the mountain cloud cap, therefore, must go most of the credit for the extreme lushness of the vegetation, since to its prevalence is due the high average humidity of 92.4% and the absence of great daily or seasonal extremes. From the plain below, or from the seacoast on the opposite side of the range, the local ridges appear buried in the clouds during most of the daylight hours, particularly in the afternoon, even when the lowlands are baking in full sunlight. The temperature during the period recorded, which includes the warmest months, is also distinctly subtropical, averaging 18.9° C. (66° F.) between March and August inclusive, 1946.

Although the mountain weather is very local in extent, it does reflect in general the seasonal characteristics of the lowlands. The temperature is lower around the winter solstice, and the rainfall and humidity are both



TEXT-FIG. 6. Diagram of altitudinal succession of ecological zones in Rancho Grande area.

less during the height of the country's dry season in February and March. The extreme of heat and drought, with the accompying decrease in animal activity, are greatly reduced, however. Compared to the periodic desiccation found in the adjacent lowland seasonal forests, coastal scrub, savannas and llanos, the Rancho Grande dry season is not strongly marked; although there may be scarcely any precipitation during February and March, the cloud still keeps foliage and ground relatively damp.

The general meteorological character of a given year is also reflected faintly in the local weather of Rancho Grande. For example, prolonged, widespread spells of bad weather are experienced there in common with the lowlands. The rainy season of 1946 started somewhat early, in both the Maracay region and at Rancho Grande, with repeated downpours occuring in early April, while the months of June and July were abnormally cool and dry, and August remarkably wet. Finally, in March, a three-day savanna fire on the lowest slopes of the range toward Maracay had a pronounced effect on both the humidity and temperature five hundred meters higher at Rancho Grande; the hottest, least humid days of the record occurred at this time.

An interesting observation was that the effect of the lunar phases on the weather was much more pronounced than in the adjacent lowlands. The least overcast periods of the month usually fell toward the middle and end of the second and fourth quarters, while the days of continuous enveloping cloud, drizzle and heavily overcast skies almost always occurred just after the new moon, and, to a lesser extent, following the full moon. This tendency is indicated in the following figures: In the second and fourth quarters combined, as opposed to the first and third, occured 60% of the hours of sunlight, 59% of the days (observed from 6 AM to 10 PM) totally without enveloping cloud, only 41% of the total number of hours of enveloping cloud, and only 26% of the completely sunless days. Short visits to Rancho Grande which involve general collecting or photography, should, therefore, be planned for the second or fourth quarter, unless the chief interest is in the collection of night-flying insects at the electric lights.These exceptions reached their maximum abundance in wet weather in the dark of the moon.

TABLE I.

RANCHO GRANDE WEATHER: MARCH-AUGUST, 1946.

	Mar.	*Apr.*	*May*	*June*	*July*	*Aug.*
Average Temperature, C.	18.6	19.8	19.4	18.9	18.5	18.3
Average Humidity, %	88.3	94.8	94.0	92.6	92.7	92.3
Rainfall, mm.	16	363	330	132	179	511
Approx. no. of hrs. of enveloping cloud*	194	274	194	134	120	84
No. of days without enveloping cloud	6	1	3	11	14	12
No. of sunless days	2	12	5	3	4	4
Approx. no. of hrs. of sunshine	102	47	82	96	109	103

*Observed 6 a.m.–10 p.m. only.

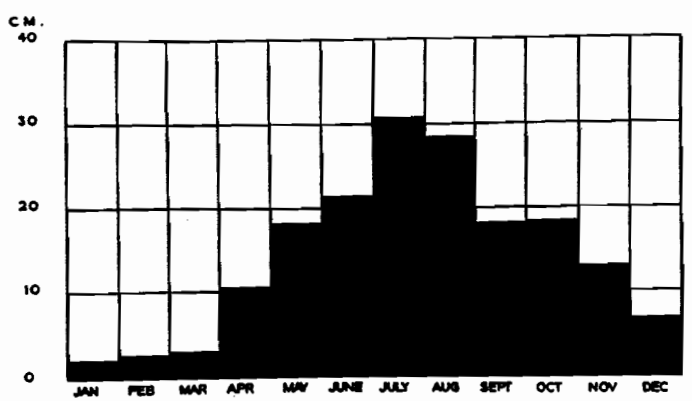
Although individual days vary radically, a typical daily weather pattern is apparent. This occurs frequently in both dry and wet seasons and includes a clear early morning; partial or complete overcast after eight o'clock; brief, partly sunny periods around noon; increasing overcast and enveloping cloud in the early afternoon; enveloping cloud, with or without showers, from around four to six or seven o'clock; and more or less complete clearing during the evening. Individual days, however, run the gamut from the very rare altogether clear exceptions to the much more frequent intervals consisting entirely of rain and enveloping cloud. Enveloping cloud after midnight is frequent.

The components of the weather are discussed below in more detail and summarized in Table I.

Although the actual rainfall was distinctly moderate, the figures give no idea of the all-pervading dampness, since the mountain cloudcap rarely precipitated as drizzle strong enough to be recorded on the rainfall instrument. Comparison of the April and August data in Table I shows how little can be judged of actual weather by the amount of rainfall. April was not only very rainy but had sunshine reduced to a minimum while the hours of enveloping cloud reached their peak. August, on the other hand, though the rainfall was much greater, was notably a month of "good weather" from a human standpoint, the high rainfall being due largely to concentrated downpours.

It must be kept constantly in mind that the data given are for Rancho Grande itself, unless otherwise stated. Since the building is located on the lower southern edge of the cloud forest, that is, of the subtropical zone, the records of sunshine, humidity and temperature would have differed noticeably in opposite directions had the observations been made a mere hundred yards further up or down the mountain, or even at the same altitude in the lee of the range instead of close to Portachuelo Pass.

Dr. Röhl's monograph, *Climatologia de Venezuela* (1946), has arrived just as this paper is going to press. Thanks to his work, there are now available for comparison with the present Rancho Grande data extensive records of temperature, rainfall and extremes of humidity in many localities, including a few montane stations such as Colonia Tovar.



TEXT-FIG. 7. Average monthly rainfall at Rancho Grande, 1941-1945, inclusive. (The months of August and September are based only on 1941-1944 inclusive).

TABLE II.

RAINFALL.

(From Government records, Rancho Grande Station).

	1941		1942		1943		1944		1945		1946	
	mm.	(inches)	mm.	(inches)	mm.	(inches)	mm.	(inches)	mm.	(inches)	mm.	(inches)
January	12	(.5)	4	(.2)	67	(2.6)	7	(.3)	11	(.4)	11	(.4)
February	0	(0)	9	(.4)	81	(3.2)	15	(.6)	21	(.8)	21	(.8)
March	10	(.4)	35	(1.4)	69	(2.7)	4	(.2)	46	(1.8)	16	(.6)
April	48	(1.9)	118	(4.6)	149	(5.9)	36	(1.4)	150	(5.9)	363	(14.3)
May	165	(6.5)	143	(5.6)	164	(6.5)	287	(11.3)	180	(7.1)	330	(13.0)
June	201	(7.9)	198	(7.8)	217	(8.5)	244	(9.6)	218	(8.6)	132	(5.2)
July	257	(10.1)	333	(13.1)	220	(8.7)	241	(9.5)	452	(17.8)	179	(7.1)
August	361	(14.2)	158	(6.2)	300	(11.8)	326	(12.8)	612*	(24.1)*	511	(20.1)
September	141	(5.6)	248	(9.8)	116	(4.6)	234	(9.2)	193	(7.6)	182	(7.2)
October	155	(6.1)	227	(8.9)	194	(7.6)	171	(6.7)	90	(3.5)	170	(6.7)
November	136	(5.4)	133	(5.2)	92	(3.6)	224	(8.8)	18	(3.7)	110	(4.3)
December	38	(1.5)	193	(7.6)	46	(1.8)	58	(2.3)			66	(2.6)
TOTAL	1524	(60.05)	1799	(70.8)	1715	(67.5)	1847	(72.7)	1991	(78.3)	2091	(82.3)

*August and September together.

2. RAINFALL.

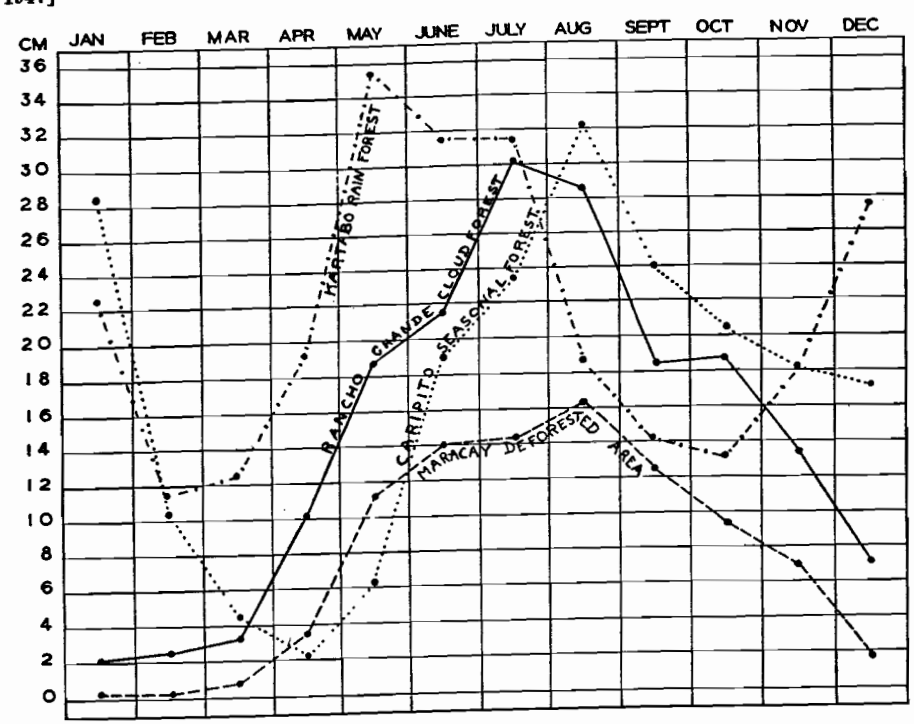
Complete rainfall records are available from the government gauge maintained in front of the Rancho Grande building for the years 1941-1945 inclusive, and it is from these that the averages given in Table III and Text-fig. 7 are derived. In addition, we include in Table II the totals for 1946, a year with abnormally high rainfall during April and August, while June and July were dry. The latter table shows the high degree of monthly variation in rainfall from year to year. Text-fig. 8 indicates the relative rainfall of four types of tropical areas: that of Kartabo, British Guiana, with an average of 254 cm. (100 in.), an example of climax rain forest; Caripito, Venezuela, average 203.2 cm. (80 in.), in a seasonal forest; Rancho Grande, average 175.3 cm. (69 in.), in montane cloud forest; and Maracay, adjacent to Rancho Grande in the Lake Valencia plain (altitude 1,400 ft.), average 91.9 cm. (36 in.), in a deforested area. The latter locality was probably originally seasonal forest and now comprises agricultural land and secondary savanna.

At Rancho Grande, as throughout the Caribbean area, there are two major seasons, dry and wet, the former extending roughly from January to April and including more or less of the latter month. In many parts of Venezuela, there is a "little dry season" in August and September, when the rainfall is somewhat diminished before rising again to a secondary, lower peak in the succeeding months. This secondary peak does not occur in the Rancho Grande curves, the rainfall usually dropping off gradually after the August heights.

Heavy showers at Rancho Grande almost always swept across the Maracay plain from the southeast, and occurred most often late in the afternoon.

3. HUMIDITY.

Of greater importance than the rainfall in maintaining the constant dampness of Rancho Grande is the high percentage of humidity even during the dry season. Table I shows the monthly averages from March through August of 1946; Table IV a comparison with 1945, and Text-fig. 9 a comparison of typical wet and dry season days with similar ones at Caripito in an area of seasonal forest. It will be remembered that the actual average precipitation at Caripito is more than 10 inches greater than at Rancho Grande (about 80 inches instead of less than 70). The average in the British Guiana rain forest is similarly high, but is due more to actual precipitation (average 100 inches), and has more low daytime extremes. The average at Rancho Grande for the six months is 92.4%, with an extreme low of 45% on



TEXT-FIG. 8. Average rainfall in four types of localities in northern South America. *Dot-dash line:* climax tropical rainforest, at Kartabo, Bartica District, British Guiana (9 year average, 1911-1920); *dotted line:* seasonal forest, Caripito, Venezuela (10 year average, 1932-1941); *solid line:* montane cloud forest, Rancho Grande, Venezuela (5 year average, 1941-1945); *dashed line,* deforested, cultivated land near Rancho Grande at Maracay, Venezuela (40 year average, 1900-1940).

June 20.[2] On only four days in the entire period did the reading drop, for a short midday period, into the fifties, and days with dips into the sixties and seventies were rare. Practically every afternoon and night the high nineties were reached. As will be seen from Table I, there was little difference in humidity between the drier and rainier months.

The basic causes of the formation of the mountain cloudcap are the same as in similar mountain ranges, since it results from the daily condensation of the rising, sun-warmed air of sea level against the cool flanks of the mountains. Complicating factors at Rancho Grande are Portachualo Pass, at Rancho Grande's gates, and Lake Valencia on the south. During the expedition, enveloping cloud occurred in the afternoon about two and a quarter times more often than during the morning; however, a common morning sight was the cloud forming in the adjacent range on the south and sweeping northward through the pass, although it infrequently enveloped the Rancho itself at this hour. During the afternoon it poured through from the opposite direction, from the sea, and descended simultaneously upon the building from the higher ridges. Afternoons of enveloping cloud were often followed by clear nights.

From March through August of 1946, between 6 AM and 10 PM daily, there were at least 1,000 out of a possible total of 3,570 hours of cloud surrounding the building itself, or more than one-quarter. A five-minute walk up or down the mountain would have given respectively, much higher or lower percentages.

The apparatus used to record temperature and humidity was the Termoigrografo, manufactured by La Filotecnica Ing. A. Salmoiraghi S.A. of Milan, and was loaned to us through the kindness of Dr. Guillermo Zuloaga of Caracas. It was stationed on the Rancho Grande verandah about eight feet above ground level, in a position of excellent air circulation.

[2]Except during the days of forest fire on the lower slopes, around March 21.

TABLE III.

RAINFALL.

From Government records, Rancho Grande Station, 1941-1945 inclusive.

	Mean		*Extreme*	
	mm.	*(inches)*	*mm.*	*(inches)*
January	20.2	(.80)	4-67	(2-2.6)
February	25.2	(.99)	0-81	(0-3.2)
March	32.8	(1.29)	4-69	(2-2.7)
April	100.2	(3.98)	36-150	(1.4-5.9)
May	187.8	(7.39)	143-287	(5.6-11.3)
June	215.6	(8.49)	198-244	(7.8-9.6)
July	300.6	(11.83)	220-452	(8.7-17.8)
August*	286.25	(11.27)	158-361	(6.2-14.2)
September*	184.75	(7.28)	116-248	(4.6-9.8)
October	188.0	(7.40)	155-227	(6.1-8.9)
November	135.0	(5.32)	90-224	(3.5-8.7)
December	70.6	(2.78)	18-193	(3.1-7.6)
TOTAL, yearly	1747.1	(68.82)	1524-1991	(60-78.4)

*Based on 4-year average (1941-1944) only.

4. SUNSHINE.

The number of hours of sunshine given in Table I were estimated only by observation, and so give only a rough idea of the small amount. Sunny afternoons were exceedingly rare.

5. TEMPERATURE.

As with all observations except rainfall, no recordings have been made except for the time of our stay, during part of the 1945 expedition and throughout that of 1946; these periods included the months of June and July in 1945, and March through August of 1946. In temperature a most interesting discrepancy occurs in the 1945 and 1946 records during the two comparable months, the 1946 monthly average being from 2° to 3° C. (4° to 5½° F.) lower than during 1945 (Table IV). This period of 1946 was markedly cooler than usual in the hot country around Maracay also, as well as a period of drought in that locality, and of less than average rainfall at Rancho Grande. Probably the 1945 temperatures were nearer to the normal. The average 1946 temperature through the six months was 18.9° C. (66° F.); year-round temperatures would doubtless lower the average appreciably, judging by reports of visitors to Rancho Grande during the cold Venezuelan months of December and January. By contrast, the monthly averages at Caripito, on the edge of lowland seasonal forest, range from a December average of 25.6° to a May average of 28.9° C. (78°-84° F.). At Kartabo, in the British Guiana tropical rain forest, the range is from a minimum average of 25.4° C. in January to 27.5° C. in October (77.8° to 81.5° F.). Depending on whether the 1945 or 1946 temperatures are nearer the true Rancho Grande average, and how low is the December-January minimum, the climate there is some 5.5° to 8° C. (10°-15° F.) cooler than at either Caripito or Kartabo.

At Rancho Grande, the extreme recorded highs were 24° C. (75.2° F.) reached half a dozen times around noon during late March and in April. This excludes the false highs of 25° and 26° C. (77° and 78.8° F.) attained during the forest fire on the lower slopes around March 21. The highest temperature for May was 22° C. (71.6° F.) while June, July and August each reached only 21° C. (69.8° F.).

The lowest recorded temperatures were 14° and 15° C. (57.2-59° F.), both reached frequently between midnight and dawn during the first ten days of March. From April through August, lows of 17° C. (62.6° F.) occurred occasionally every month.

6. WIND.

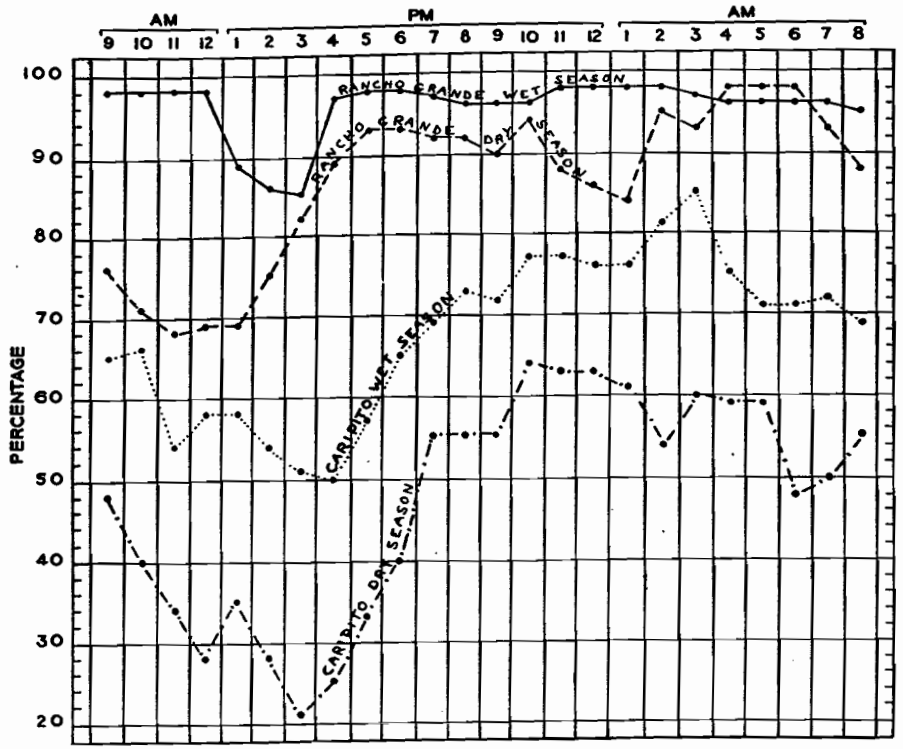
No wind records were made. As usual in the mountains, the breezes were variable. During the day the wind was often from the southeast, as in Caracas, changing during the late afternoon to northwest.

TABLE IV.

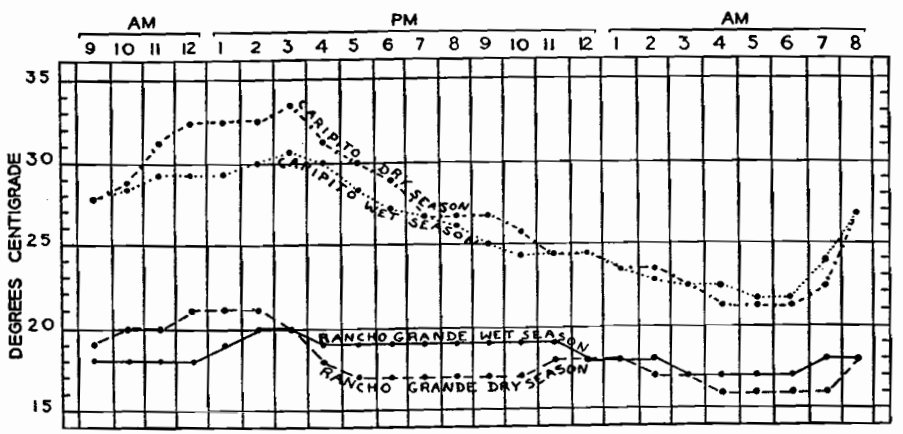
RANCHO GRANDE: HUMIDITY AND TEMPERATURE.

COMPARISONS BETWEEN 1945 AND 1946.

	Humidity		*Temperature*	
	1945	1946	1945	1946
June	93.9	92.6	20.9C. (69.6F.)	18.9C. (65.6F.)
July	93.0	92.7	21.6C. (70.9F.)	18.5C. (65.3F.)
August	92.5	92.3		



TEXT-FIG. 9. Humidity readings during typical rainy and dry season days in northern Venezuelan forests. *Solid line:* Rancho Grande montane cloud forest, rainy season day (June 26-27, 1946); *dashed line:* same, dry season day (Mar. 11-12, 1946); *dotted line:* Caripito seasonal forest, rainy season day (June 26-27, 1942); *dot-dashed line:* same, dry season day (Mar. 10-11, 1942).



TEXT-FIG. 10. Temperature readings during typical rainy and dry season days in northern Venezuelan forests. *Solid line:* Rancho Grande montane cloud forest, rainy season day (June 26-27, 1946); *dashed line:* same, dry season day (Mar. 11-12, 1946); *dotted line:* Caripito seasonal forest, rainy season day (June 26-27, 1942); *dot-dashed line:* same, dry season day (Mar. 10-11, 1942).

C. Botany.

From a general ecological viewpoint, and in comparison with the neighboring zones, the principal botanical characteristics of the Rancho Grande Cloud Forest are the following: the presence of a climax evergreen forest; a moderate abundance of gigantic dominants; an abundance of epiphytes; an abundance of terrestrial hydrophilous groups, especially tree-ferns, small palms, large-leaved arums and families more or less closely related to the arums; and, finally, the presence of a few common, typical plants which, although immigrants from neighboring zones or ecologically widely spread, are important in the life histories of insects and other animals (e. g., a spiny *Bactris* on the lower fringes of the zone, *Cecropia* spp., and *Hedychium coronarium*, the wild ginger).

The zone agrees well with Beard's general description of a montane rain or cloud forest, his diagnosis being as follows (1944, p. 145): "The forest is in two closed stories, at 20 and 10 meters (60 and 30 feet) with a shrub layer formed mainly of simple-leaved dwarf palms and tree-ferns. The trees have heavy crowns, branch low, and are loaded with moss and epiphytes. Leaves are simple, mesophyllous, and covered with epiphylls." Here at Rancho Grande the zone extends on the south from about 1,000 meters to the crests of the local ridges of Guacamayo and Paraiso, which attain 1,814 and 1,525 meters respectively, without giving way to Elfin Woodland. On the northern, littoral side of the range it begins much lower, at about 700 to 800 meters, owing to the lower boundary of the cloudcap on that side.

The Venezuelan Cloud Forest, with special emphasis on this local example, has been so well described by Dr. Pittier, that it seems well to give a translation of his most detailed account (1939, p. 20-21): "When one looks toward the mountains of the Venezuelan coast from the sea, clouds are seen to form on the flanks after the early morning hours, and to increase in size from hour to hour until they cover the highest ridges. The lower edges are straight and uniform, but the mass rises and falls with the temperature. To these strata correspond the cloud forests, enveloped during part of the day in a dense cloud which keeps them perpetually humid. They are the temperate or subtropical rain forests, whose flora in extreme variety appears to possess the greatest number of endemic forms. The plants belonging to this formation have a number of characteristics in common with those of the tropical rain forest, and are not always inferior to them in size. They are distinguished, however, by the immense variety of epiphytes and the presence of a great number of dwarf palms in addition to larger species.

"The cloud forests appear on the flanks of the Andes and of the mountains of Guiana as well as on the coast range. The most typical and best known are in the valley of Ocumare de la Costa [the Rancho Grande forest] and of Colonia Tovar. The first are of immense proportions and, because of their lower altitude (700-1,600 meters) are of a more tropical character. Here we note as dominant the *niño* or *cucharón* [or *candelo*] (*Gyranthera caribensis*), while the following also are frequent: *el vaco* or *palo de leche* (*Brosimum utile*), *el jobo* (*Spondias lutea*), *el guamo caraota* (*Inga marginata*), as well as *Fagar ocumarensis, Abarema trapezifolia, Coussapoa villosa, Hedyosmum bonplandianum* and many others no less conspicuous. Among the ferns, also numerous, *Hemitelia speciosa* is especially beautiful."

As with every ecological area with which one becomes closely acquainted, subzones early become distinguishable, due primarily to differences of soil, moisture and exposure. For example, in the immediate region of Portachuelo Pass, mosses, lichens, and tree-ferns, as well as epiphytic arums, bromeliads and orchids reach their optimum, because there the enveloping cloud is very prevalent while the temperature is still moderate compared with that of the higher ridges. Again, on the crests of the ridges, there is insufficient support for *Gyranthera*, the local tree giant, and the flora as a whole is poor; here alone is found a shrub-like species of bamboo. Finally, the saturated small gorges support a characteristic flora of their own, not particularly varied; *Dieffenbachia*, a terrestrial arum, reaches here its maximum development. As in all other mountain zones, the vegetation most typical of the Cloud Forest grows on the more moderate slopes, midway between ridge and gorge.

In spite of the constant moisture in the Cloud Forest even during the dry season, there is in many families a well-defined peak of flowering after the beginning of the rains. For example, the Melastomaceae, a family having many conspicuous representatives in this area, blooms principally in May and June; the majority of arums flower in May, June and July, each of the many species having a relatively short season; and the same is true of many bromeliads and orchids. Botanists could profitably spend years at Rancho Grande working out the life histories and ecological relationships of only the more common members of these few families.

D. Zoology.

To present even a casual view of the general fauna of Rancho Grande is difficult, yet a few paragraphs seem worth while if only to answer the numerous questions of many zoologists. A typical one is, "If I visited Rancho Grande, would I find an abundance of sphinx moths?" (Or fish or cotingas, as the case might be).

Our advice to a Protozoologist at Rancho Grande would be to concentrate on the infinite number of tiny pools among the leaves and bracts of Bromeliads and Heliconias. These natural aquaria have a range of one to fifty meters above the ground, they are overflowing throughout most of the year, and afford an unending succession of Euglenas, Amoebae, Volvox and a host of other single-celled organisms. Hydras, too, inhabit these infusions and they are also found living more precarious lives on the legs of fresh-water crabs, both in and out of the mountain streams.

As at more tropical levels, Turbellaria or land planarians are common. One giant, six to twelve inches long, lives on leaves and damp moss. It is brilliantly colored and from its size should afford excellent material for experimentation in the field. Lumbricidae or earthworms are abundant, noticeable for their great size, serpent-like activity and frequent occurrence in decayed hollows of lofty trees.

Land mollusks are uncommon, varying from the great four-inch *Dryptus marmoratus* which breeds in the moss of the jungle floor, to small slugs and minute snails in their homes in the damp terrariums of the bromeliads. A few aquatic forms such as *Pachycheilus laevissimus*, manage a successful existence in the swift water of the small mountain brooks.

In these wooded heights and steep slopes high above the sea, crustacea are naturally a subordinate group. Nevertheless, the bromeliad pools teem with copepods and ostracods, while isopods thrive on the jungle floor. Two species of medium-sized brown land crabs (*Pseudothelphusa*) are found on almost every walk, wandering through the jungle or clinging, crouched, at the bottom of the swift brooks.

Six of the ten orders of Arachnoidea are present, but in relatively few numbers compared with lower, tropical rain forest areas. Among these are spiders, scorpions, whip scorpions, chelifers, harvestmen, ticks and mites. Ticks are rare but harvest mites, or bête rouge, are moderately troublesome.

Several species of *Peripatus* inhabit the Rancho Grande zone, but their discovery is accidental as they inhabit the detritus in the lower leaves of bromeliads and hollows high up in the trees. Millipedes and centipedes are common. The largest of the former, *Polyconoceras ruberculinus*, is six inches in length, brilliant scarlet with narrow black bands, lives on the ground, low brush and tree trunks and is visible from a considerable distance.

We found every order of insects except Protura, Mecoptera and Strepsiptera. Omitting mention of the rarer orders, Orthoptera inceases from uncommon to abundant with the progression of the rains. Life histories of very many forms would be easy to work out and offer a relatively untouched field to an entomologist. Grasshoppers and crickets range from the eight-inch spread of the scarlet-winged *Tropidacris deix* to the abundant, small quadrupedal *Tridactylides*. Giant tree crickets are abundant in bromeliads. Mantids and walking sticks, both small and large, thrive at this altitude and under these untropical temperatures. Earwigs are fewer than in more tropical areas, but much more common than in our eastern United States. They share with staphylinids the carcasses used as bait in the pits, as well as the spathes of terrestrial and epiphytic arums.

Isoptera or termites are very rare. Some element in the elevated and cool environment is against them. Arboreal nests are absent, and only at rare intervals is there a flight of the winged sexes from some hidden subterranean nest. Odonata are not common and their larvae find scant shelter in the upper reaches of the streams. We especially missed the spectacular *Mecistogaster* of the deep tropical jungle. Many families of Hemiptera and Neuroptera are present but in reduced numbers due to the absence of some important ecological necessities. Homoptera are more fortunate and almost up to their tropical numbers. Fulgorids are rare but a few striking forms come to our lights.

The great order of Coleoptera presents a very irregular sequence of family representation. Cicindelidae and Gyrinidae are almost absent from lack of suitable sand and water. Considering the abundance of dead trees both standing and fallen, it is not easy to account for the relative scarcity of Elateridae, Buprestidae, and to a less noticeable extent of Cerambycidae. It is perhaps the lack of *dry* dead wood which is the deterrent to successful breeding of the larvae. Flower weevils vie with Chrysomelids in abundance. Carabidae are rare for some unknown reason, whereas staphylinids are common, at least in individuals. As in groups of wholly unrelated organisms such as Myriopoda, Turbellaria and Mollusca, certain coleopteran families may have a single species which in size and conspicuousness stands out from any of its fellows. Examples are *Acrocinus* in Cerambycidae, and *Dynastes hercules* in Dynastidae. Sudden eruptions of enormous numbers may occur, as in several species of cockchafers or "Junebugs" among the Scarabaeidae, which occasionally come to the light in tens of thousands.

Diptera, owing to inadequate collecting, must be dismissed with the generalization of being present in far fewer numbers of species and individuals than in more typically tropic places. At Maracay, for example, houseflies are most unpleasant pests, while at Rancho Grande *Musca* is a rarity in the laboratory.

Drosophila melanogaster and *D. simulans*

were abundant from June through August, but were doubtless brought up from the low country on market fruit. When mangos or bananas were exposed in the forest, no *Drosophila* were attracted, nor were they taken on wild blossoms or fruit.

Hymenoptera, as far as wasps and bees are concerned, are far from common. Army and leaf-cutting ants are present in the same relative numbers as in the hot tropics. A few very large nests of the latter are near Rancho Grande, and bivouacs of army ants occur and reoccur here and there in the forest. Ants of other groups are decidedly rare, very few on the jungle floor, and almost wholly absent in the laboratory.

We have reserved the order Lepidoptera for the last of the insects. The use of electric light for the first time in a locality such as Rancho Grande results in an effect on moths which is indescribable, and which will be considered in detail in other papers. Throughout portions of two years, on all but moonlight nights, moths, in hundreds of species and thousands of individuals, came to the great windows of the laboratory and to three white-washed walls on the roof. As one example of this abundance, a preliminary survey reveals that we have taken at least 67 species of sphinx moths at the lights. The nocturnal hosts were all the more unexpected because in the course of our diurnal walks along the trails or through underbrush we almost never saw a moth, except now and then some very small species.

A phenomenon equally interesting concerned vast numbers of butterflies. These were migrants to the ultimate count of almost one hundred species, and numbers of individuals which attained astronomical proportions. For days and sometimes weeks, these poured through the pass of Portachuelo, only a few hundred meters from Rancho Grande.

Turning to the vertebrates, the fish afford a neat, concise bit of fauna, which can be considered in a single paragraph. Within the borders of our limited ecological boundaries there are only a few small mountain brooks and only three species of fish living in them. On the Caribbean side of the divide lives a small catfish (*Pygidium banneaui*), while on the Lake Valencia slope to the south in the mountain torrents there are two species of characins (*Creagrutus beni* and *Hemibrycon dentatus metae*).

Final identification of the species of higher vertebrates of Rancho Grande is proceeding too slowly to draw upon for regional summaries in this present preliminary review. These will be included in subsequent reports.

Here it may be said only that frogs of a few species are common, particularly bromeliad tree frogs, as would be expected in this environment which combines high humidity with abundant epiphytes and absence of standing water. Of ground living forms *Atelopus cruciger* is abundant, *Gastrotheca* common, while *Pipa* does not reach this altitude. No tortoises are found.

Snakes are moderately common, but of poisonous serpents bushmasters and rattlesnakes are absent, ferdelance moderately plentiful, and coral snakes rare. The most commonly seen of the latter group is *Micrurus mipartitus*. Lizards as a whole are uncommon. Especially noticeable for their absence at this altitude are the sun-loving *Cnemidophorus* and *Ameiva*. On the other hand, geckos and skinks are present and such unusual forms as *Argalia* and *Proctoporus* are not uncommon, although these two latter genera are absent from the seasonal forest lower down.

The avifauna while rich, thanks to the preservation of the cloud forest, does not compare with that of an undisturbed tropical rain forest. Most of the forms are distinctly subtropical. This does not refer to the migrants which at times pour through Portachuelo Pass. These include local, Argentinian and North American species. Because of the extremely steep slopes and the dense underbrush, continued ornithological observation is extremely difficult.

Mammals are not abundant in this zone, but most of the major groups are represented. A mammalogist, especially if interested in comparative physiology, would doubtless find ample problems and material in the bats and small rodents, especially the spiny rats. The most conspicuous mammal is a rufous-tailed squirrel, *Sciurus griseogana meridensis*. Anteaters are absent, jaguars are rare, ocelots and tayras fairly common. The commonest diurnal, terrestrial mammal is an aguti; the rarest a small deer.

Summary and Conclusions.

The following characteristics of Rancho Grande emerge as dominant:

1. Its location in north central Venezuela (10° 21′ N. Lat., 67° 41′ W. Long.), on the Caribbean coastal range of the Andes at an altitude of 1,100 meters, in the National Park of Aragua.
2. Its situation in an undisturbed montane cloud forest.
3. Its proximity to other ecological zones on both sides of the mountain range, including seasonal forests, savanna, thorn woodland, cactus scrub, Lake Valencia, mangroves, sandy and rocky littoral, coral reefs, and pelagic and abyssal zones of the Caribbean. All of these are accessible by car over excellent roads. Alpine zones do not occur in the neighborhood.
4. The steepness of the terrain.
5. The high humidity (average 92.4% during six months of 1946) and low temperature (18.9° C. during the same period), with a slight range of both, combined with moderate average rainfall (175.3 cm. annually over a five-year period).
6. The weakly-marked seasons, because of the constant humidity, which promote moderate animal activity even during the dry season (January-April). There is, however, a decided peak in blooming and breeding during the first months of the rains.
7. The presence of a varied flora containing many endemic forms. It is especially remarkable for the profusion of epiphytes.
8. The presence of a subtropical rather than tropical fauna, which is rich in comparison with a temperate or alpine population, but poor compared with that of a tropical rain forest. It seems superior in number and variety of life forms to most types of tropical seasonal forests.

The accessibility of the National Park, near the center of the hemisphere and convenient to centers of transportation, should make it invaluable to scientists of both American continents. In addition to the more obvious problems of ecology, behavior and distribution, physiological studies of many vertebrates and invertebrates would certainly yield results in comparisons of cloud forest forms with their nearest lowland relatives. Except in the case of a few groups, such as moths, the assembling of large collections would be difficult and not very rewarding since the fauna itself, as has been said, is of only moderate richness, and the terrain is a decided physical handicap; in addition, the government quite rightly prohibits the killing of birds and game animals. The effects of this protection are even now beginning to be seen in the increased tameness of many birds and mammals which elsewhere are rare and unapproachably shy.

The present intention of the Venezuelan government is to maintain Rancho Grande as a biological field station, continuing the work inaugurated there by the New York Zoological Society through the generous cooperation of that government and of the Creole Petroleum Corporation. The Park and the building of Rancho Grande are under the jurisdiction of the *Departmento de Bosques y Aguas, Ministerio de Agricultura y Cría*, Caracas. The congratulations of all conservationists and field biologists are due the Venezuelan government for its timely action in establishing the Park and in planning for the continuation of research.

V. Bibliography.

Beard, J. S.
1944. Climax vegetation in tropical America. *Ecology*, XXV: 2, pp. 127-158.

Beebe, W.
1925. Studies of a tropical jungle; one quarter of a square mile of jungle at Kartabo, British Guiana. *Zoologica*, VI: 1, pp. 1-193.
1942. Physical factors in the ecology of Caripito, Venezuela. *Zoologica*, XXVIII: 9, pp. 53-59.

Gonzalez, E.
1941. Climatología de Venezuela. *Estados Unidos de Venezuela: Ministerio de Agricultura y Cría: Dirección de Agricultura; Servicio de Meteorologia Agricola*. Caracas.

Pittier, H.
1926. Manual de las plantas usuales de Venezuela. *Litografía del Comerico*. Caracas.
1939. Suplemento a las plantas usuales de Venezuela. *Editorial Elite*. Caracas.

Verdoorn, F. (Editor).
1945. Plants and plant science in Latin America. Chronica Botanica Co. Waltham, Mass.

Röhl, E.
1946. Climatología de Venezuela. (*Impresion ordenada por el Ministerio de la Defensa Nacional*). *Tipografia Americana*. Caracas.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Looking east toward Rancho Grande from Mt. Cogollal, showing surrounding montane cloud forest. The cloud cap, which often covers the entire area, is seen in the upper edge of the picture, hanging over Mt. Guacamayo.

Fig. 2. Looking toward Rancho Grande from the Valencia plain. In the foreground is pasture; beyond is the Limon River, marked by seasonal forest; the nearest foothills, completely deforested, are covered with savanna which is more or less burned over almost yearly; patches of deciduous seasonal forest remain only in their valleys; in the extreme distance on the right lies the montane cloud forest, capped with cloud and concealing Rancho Grande.

PLATE II.

Fig. 3. The west wing of Rancho Grande from the road. The laboratory windows show in the left-hand end of the building.

Fig. 4. Outlook from the roof of Rancho Grande toward Lake Valencia. The successive valleys and ridges are covered with montane cloud forest, semi-evergreen seasonal forest, deciduous seasonal forest, and on the deforested foothills near the lake, savanna.

PLATE III.

Fig. 5. Laboratory of the expedition's headquarters at Rancho Grande.

Fig. 6. Taking color motion pictures at the foot of a giant candelo tree (*Gyranthera caribensis*) beside the road in the cloud forest. The base of the tree extends in the background across the entire width of the picture. Among the distinguishable vegetation, terrestrial and epiphytic, are ferns, *Anthurium*, *Philodendron*, *Monstera*, *Heliconia*, *Calathea* and *Cecropia*.

PLATE IV.

Fig. 7. Candelo tree (*Gyranthera caribensis*) in front of Rancho Grande, showing epiphytes. The tree loses its leaves briefly in July, during the rainy season, and its enormous load of bromeliads, orchids and arums can best be seen at that time. Here the epiphytes are set off by the cloud mass pouring through Portachuelo Pass and hiding the mountain slope immediately behind.

Fig. 8. Tree-fern in Portachuelo Pass, with scandent ferns growing from its trunk. Method of collecting insects in inverted umbrella is shown.

PLATE V.

Fig. 9. Canopy study at Rancho Grande. On the trunk the most conspicuous growth is *Carludovica;* orchids are distinguishable on the branches.

Fig. 10. Aerial roots of arums and bromeliads silhouetted by a cloud rushing through Portachuelo Gorge. The adjacent mountain side is barely visible through the mist. Note vines climbing both up and down the roots.

FIG. 1.

FIG. 2.

ECOLOGY OF RANCHO GRANDE, A SUBTROPICAL CLOUD FOREST IN NORTHERN VENEZUELA.

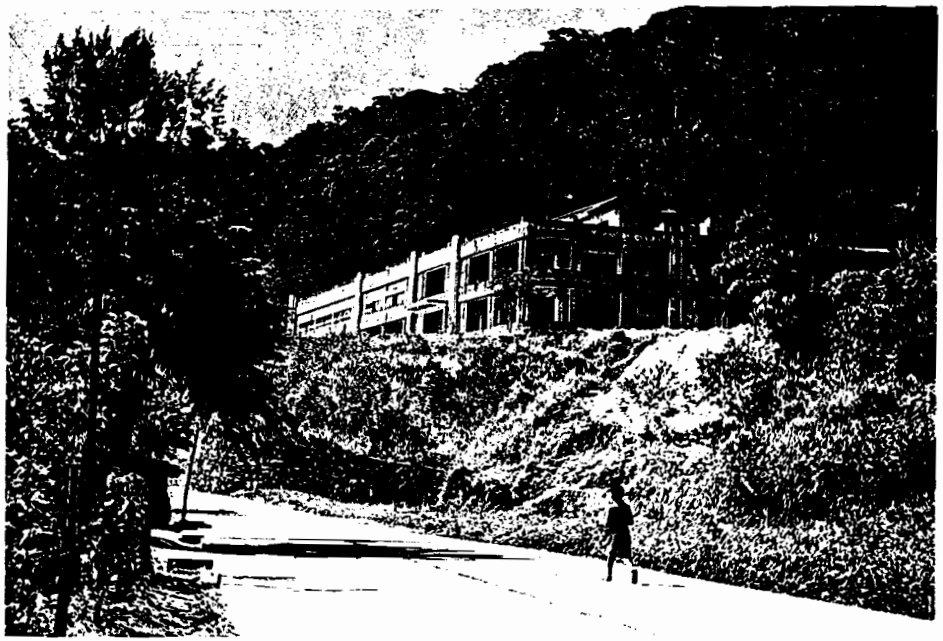


FIG. 3.

FIG. 4.

ECOLOGY OF RANCHO GRANDE, A SUBTROPICAL CLOUD FOREST IN NORTHERN VENEZUELA.

FIG. 5.

FIG. 6.

ECOLOGY OF RANCHO GRANDE, A SUBTROPICAL CLOUD FOREST IN NORTHERN VENEZUELA.

FIG. 7.

FIG. 8.

ECOLOGY OF RANCHO GRANDE, A SUBTROPICAL CLOUD FOREST IN NORTHERN VENEZUELA.

FIG. 10.

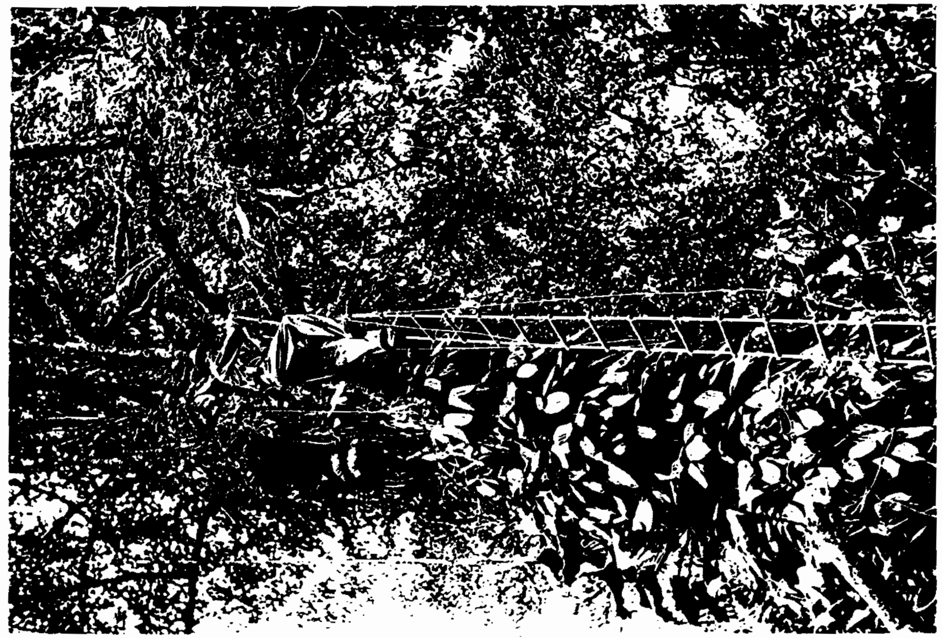


FIG. 9.

ECOLOGY OF RANCHO GRANDE, A SUBTROPICAL CLOUD