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THE STRUCTURE AND CLIMATE OF A TROPICAL MONTANE RAIN FOREST AND AN ASSOCIATED TEMPERATE PINE-OAK-LIQUIDAMBAR FOREST IN THE NORTHERN HIGHLANDS OF CHIAPAS, MEXICO

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ABSTRACT

There are two different forests on the Jicotol Ridge in the Northern Highlands of Chiapas, México. The ridge in the vicinity of Pueblo Nuevo Solistahuacan wehere this study was made, has an elevation of about 2042 M. and a general orientation of northwest to southeast so that the slopes from the ridge face northeast which is the direction toward the Gulf of Mexico. One of the forests is located on the crest of the windward slope and the other is found on the leeward slope at elevations about 1525 M. The forest on the crest is tropical in its orientation and is known as the Montane Rain forest. The other forest is known as the Pine-Oak-Liquidambar forest. The two forests are separated from each other by a relatively narrow transition forest which is now largely disturbed. The plant communities of Chiapas have been described by Miranda (1952) and by Miranda and Hernández X. (1963), but no detailed study of the forest in question had been undertaken.

These two closely situated but disparate forests were enough different in structure and composition to warrant a comparative study which might reveal factors which contribute to their differences. This is what the research attempted to discover.

The problem was approached in three different ways: 1) Climatic studies, 2) Soil studies, and 3) Structural and compositional studies. The climatic studies involved determining the mean amoung and distributional patterns of rainfall means and ranges of temperature and humidity, cloud cover differences and light patterns. Soil studies consisted of determining the structure and chemical composition of the soils and their moisture patterns. The structures of the forest were studied to determine density, basal area, mean tree height and canopy characteristics.

The generalized climatic pattern includes a wet season from June to November with a dry season from December to May. The elevation tends to moderate temperatures. Differences within this generalized climatic pattern are brought about by the interaction of the prevailing winds and the topography. The orographic effect of the mountain evidently helps to produce more rain in the Montane Rain forest as well as more cloud cover. During the study year, the Montane Rain forest received 565.15 more mm of rain and had 18.7% more cloud cover than the Pine-Oak-Liquidambar forest. Solar radiation is reduced by the cloud cover and air temperatures are correspondingly low. The mean yearly temperature in the Montane Rain forest was 13.2°C. The lower temperatures, greater cloud cover and increased rainfall produced higher relative humidities. The mean relative humidity for the Montane Rain forest was 87.1% for the period of study. The result of all of this is a low evapotranspiration in the Montane Rain forest. By contrast, the Pine-Oak-Liquidambar forest has less rainfall, higher temperatures (mean 17.3°C), less cloud cover, lower humidity, and consequently, higher evapotranspiration.

There are differences in the soils relative to their chemical compositions and

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structure but the outstanding difference is the difference in soil moisture. The climatic chain reaction that is set in motion by the mountain acting on the prevailing winds from the Gulf of Mexico produces a high soil moisture in the Montane Rain forest throughout the year. The higher evapotranspiration in the Pine-Oak-Liquidambar forest, especially during the months of the dry season results in a loss of soil moisture to the point of stress.

The tree densities of the two forest are similar, but their distributional patterns differ. The Pine-Oak-Liquidambar forest has some large distance measurements between trees which appear to be holes in an otherwise random distribution of trees. The Montane Rain forest distribution appears to be random. The tree basal area in the Montane Rain forest is higher than in the Pine-Oak-Liquidambar forest. This appears to be due to the presence of a few very large trees. There appears to be no species dominance in the Montane Rain forest while the pines and oaks dominate in the Pine-Oak-Liquidambar forest. The forest height is slightly greater in the Montane Rain forest, but the canopy height is greater in the Pine-Oak-Liquidambar forest. Even so, the canopy cover is greater in the Montane Rain forest. These canopy differences appear to be important. The Montane Rain forest considerably moderates the climate while the moderating effect of the Pine-Oak-Liquidambar forest is much less.

The two forests appear to be the result of climatic differences produced by the orographic effect of the mountain which produces a climatic chain reaction resulting in a cooler, wetter and more humid climate on the mountain crest that favors the Montane Rain forest.

Both forests appear to be in good condition for regeneration as indicated by the large number of trees with small diameters. These should be available to fill the gaps produced when larger trees fall. There is some evidence, however, that the Montane Rain forest has difficulty in recovering from extensive disturbance and that such disturbance favors an expansion of the Pine-Oak-Liquidambar forest. When there is large scale disturbance of the Montane Rain forest the climate in that clearing is more like that of the Pine-Oak-Liquidambar forest where there are periods of stress. In recovering, the Montane Rain forest must, but may not be able to, overcome the stress. The stress may be in the form of reduced soil moisture and soil erosion due to the heavier rainfall in the Montane Rain forest. A characteristic of tropical moist forests is that they are poorly equipped to cope with such stress and this one seems to be no exception.

RESUMEN

Hay dos bosques diferentes en la Cordillera del Jicotol en las tierras altas del norte de Chiapas, México. La cordillera en la vecindad de Pueblo Nuevo, Solistahuacan, donde fue hecho este estudio, tiene una altitud de alrededor de 2 042 m. y una orientación general de noroeste a suroeste, de manera que las pendientes de la cordillera ven al noreste que es la dirección hacia el Golfo de México. Uno de los bosques está localizado en la pendiente de barlovento y el otro se encuentra en la pendiente de sotavento en altitudes cercanas a 1 525 m. El bosque de la cima es tropical en su orientación y es conocido como bosque lluvioso de montaña. El otro bosque se conoce como bosque de pino-encino-liquidámbar. Los dos bosques están separados uno de otro por un bosque de transición relativamente angosto que ahora está muy perturbado. Las comunidades vegetales de Chiapas han sido descritas por Miranda (1952) y por Miranda y Hernández X. (1963) pero no se ha realizado un estudio detallado del bosque en cuestión.

Estos dos bosques cercanos pero disparejos fueron suficientemente diferentes en estructura y composición como para justificar un estudio comparativo que pudiera revelar los factores que contribuyen a sus diferencias. Esto es lo que esta investigación trata de descubrir.

El problema fue abordado en tres diferentes aspectos: 1) estudios climáticos, 2) estudios de suelo y 3) estudios estructurales y de composición. Los estudios climáticos

comprenden la determinación entre el promedio y los patrones de distribución de la precipitación, promedios y gamas de temperatura y humedad, diferencias entre cubierta de nubes y patrones de luz. Los estudios de suelo comprenden la determinación de la estructura composición química de los suelos y sus patrones de humedad. Las estructuras del bosque fueron estudiadas para determinar densidad, área basal, altura media de árboles y características del dosel.

El patrón climático generalizado incluye una estación húmeda de junio a noviembre con una estación seca de diciembre a mayo. La altitud tiende a moderar las temperaturas. Las diferencias dentro de este patrón climático general son debidas a la interacción de los vientos dominantes y la topografía. El efecto orográfico de la montaña evidentemente ayuda a producir más lluvia en el bosque de Montaña Lluviosa así como mayor cantidad de cobertura de nubes. Durante el estudio anual, el bosque lluvioso de Montaña recibió 565.15 mm más de lluvia y tuvo 18.7% más cobertura de nubes que el bosque de pino-encino-liquidámbar. La radiación solar es reducida por la cobertura de nubes y las temperaturas del aire son correspondientemente bajas. El promedio anual de temperatura en el bosque lluvioso de montaña fue 13.2°C. La disminución de temperaturas, mayor cobertura de nubes y aumento de precipitación, produjeron humedades relativas más altas. El promedio de humedad relativa para el bosque lluvioso de montaña fue 87.1% en el periodo de estudio. El resultado de todo esto es una baja evapotranspiración en el bosque lluvioso de montaña. Como contraste, el bosque de pino-encino-liquidámbar tuvo menos precipitación, más altas temperaturas (promedio 17.3° C), menos cobertura de nubes, más baja humedad, y consecuentemente más alta evapotranspiración.

Hay diferencias en los suelos en relación con sus composiciones químicas y estructura, pero la diferencia más sobresaliente es la diferencia en humedad del suelo. La reacción climática en cadena que es puesta en actividad por la acción de la montaña sobre los vientos dominantes del Golfo de México, produce una alta humedad del suelo en el bosque lluvioso de montaña a través del año. La evapotranspiración más elevada del bosque pino-encino-liquidámbar, especialmente durante los meses de la estación seca, resulta en una pérdida de humedad del suelo hasta el punto de "stress" fisiológico.

Las densidades de árboles en los dos bosques son semejantes, pero difieren en sus patrones de distribución. El bosque pino-encino-liquidámbar tiene algunas distancias grandes entre árboles que aparecen como huecos en una distribución aleatoria de los árboles. En el bosque lluvioso de montaña la distribución de los árboles parece ser al azar. El área basal de árboles en el bosque lluvioso de montaña es más alta que en el bosque pino-encino-liquidámbar. Parece que esto se debe a la presencia de algunos árboles muy grandes. En el bosque lluvioso de montaña parece ser que no hay dominancia de especies, mientras que los pinos y encinos dominan en el bosque pino-encino-liquidámbar. La altura del bosque es ligeramente mayor en el bosque lluvioso de montaña, pero la altura del dosel es mayor en el bosque pino-encino-liquidámbar. Aun así, la cubierta del dosel es mayor en el bosque lluvioso de montaña. Estas diferencias en el dosel parecen ser importantes. El bosque lluvioso de montaña modera el clima considerablemente, mientras que el efecto moderador del bosque pino-encino-liquidámbar es mucho menor.

Los dos bosques parecen ser el resultado de diferencias climáticas producidas por el efecto orográfico de la montaña que produce una reacción climática en cadena, resultando en un clima más fresco, y más húmedo en la cresta de la montaña que favorece el bosque lluvioso de montaña.

Ambos bosques parecen estar en buenas condiciones de regeneración, como lo indica el gran número de árboles con pequeños diámetros. Esto podría aprovecharse para llenar los huecos producidos cuando caen árboles grandes. Sin embargo, hay cierta evidencia de que el bosque lluvioso de montaña tiene dificultad para recuperarse de una perturbación extensa, y que tal perturbación favorece una extensión del bosque pino-encino-liquidámbar. Cuando hay una perturbación a gran escala del bosque lluvioso de montaña, el clima en ese claro es más parecido al del bosque pino-encino-liquidambar, donde hay periodos de "stress" fisiológico. Al recu-

perarse, el bosque lluvioso de montaña, debe, pero puede no estar capacitado para vencer dicho "stress". La tensión puede ser en forma de reducción de contenido de humedad del suelo y erosión del suelo debido a lluvias más abundantes en el bosque lluvioso de montaña. Una característica de los bosques tropicales húmedos es que están escasamente adaptados para hacer frente a tal "stress" y esto parece ser el caso en los bosques estudiados.

INTRODUCTION

Two forest types, one a Tropical Montane Rain forest, the other a Temperate Pine-Oak-Liquidambar forest, occur on opposite sides of a mountain ridge in the vicinity between Rayon and Pueblo Nuevo Solistahuacan, Chiapas, Mexico. The forests were studied in the field from June 18, 1970, to October 31, 1971. Structure, characteristic plant species composition and microclimate were analyzed in an attempt to determine the factors which separate the tropical and temperate forests in this region.

The Montane Rain forest was studied most closely, using the nearby temperate forest of pine, oak, and liquidambar as a control to help understand factors responsible for the presence of the tropical forest.

A main study site was selected in each forest type approximately three miles northwest of Pueblo Nuevo Solistahuacan for vegetation measurements and weather studies. The overall area between Rayon and Jicotol, at elevation levels between 1463 and 2042 M, was observed and sampled for physiognomic features and species collections.

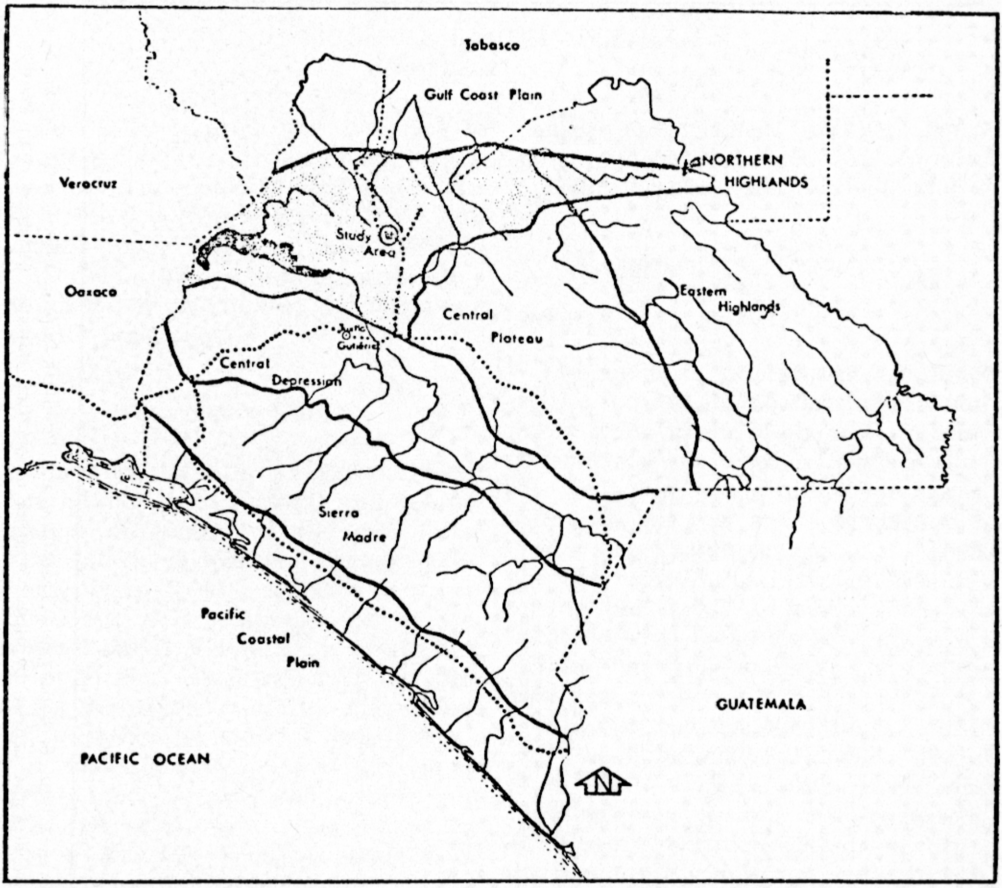
Although field work lasted for approximately one year and four months, most references to weather measurements in this paper refer to one complete study year, October 1, 1970, through September 30, 1971.

Previous works have been primarily taxonomic and floristic. The outstanding study is the description of the vegetation of Chiapas by Miranda (1952) in which a generalized consideration of the two forest types of the study area is given. Another more generalized study is that of Miranda and Hernández X. (1963) which briefly describes the plant communities of Mexico including those of Chiapas.

LOCATION AND TOPOGRAPHY

The forest study sites are located at the extreme northern end of the Jitotal Ridge (Map 2 and Plates 1 and 2) of the Northern Highlands Physiographic Province of Chiapas, Mexico (Map 1), at approximately 92°, 55′ W. Long.; 17°, 8′ N. Lat. These sites include the area between Puerto del Viento, Municipio de Rayon and Pueblo Nuevo Solistahuacan, Municipio de Solistahuacan, in the Distrito de Simojovel, at elevations between 1463 and 2042 M. The Jicotol Ridge is part of the central mesa of Chiapas, described by Miranda (1952) as being formed principally by Limestone characteristics of the Cretaceous geological period (translation). The Jicotol Ridge crest is abrupt with slopes averaging 18.5 degrees occuring in the study area.

The Montane Rain forest occurs on the crest and northeast slopes of the ridge with the Pine-Oak-Liquidambar forest located on the southwest slopes (Plates 1 and 2). This latter forest stops short of the crest but includes a narrow (approximately 396 M wide) transition



Map 1. Physiographic regions of Chiapas, Mexico showing approximate location of the Montane Rain and Pine-Oak-Liquidambar forest study sites in the Northern Highlands. (Adapted from Mullerried, 1957)

forest with a mixture of plant species from both forest (Plate 2 and Map 2). However, the contribution of species from the Montane Rain forest is slight in the transition forest and the physiognomy, structure, and species composition remain primarily that of the Pine-Oak-Liquidambar forest.

The orographic effects of the Jitotol Ridge on local weather of the study site are important. The northeasterly winds blowing in from the Gulf of Mexico bring moisture laden clouds to the 2 042 M high ridge of the study area with a resultant rain shadow effect on the southwestern side. In addition to dropping more rain (Table 2) on the Montane Rain forest windward side of the ridge than on the lee side with the Pine-Oak-Liquidambar forest, the clouds tend to linger over the crest of the ridge longer than over the lee side. The overall result of this is less solar radiation reaching the Montane Rain forest as compared to the Pine-Oak-Liquidambar forest.

Map 2. The study area indicating the Montane Rain, Secondary and Transition and Pine-Oak-Liquidambar forests. Pueblo Nuevo Solistahuacan, Chiapas, Mexico. The four straight arrows point out weather observation stations. (Adapted from Plate 2)

FIELD RESEARCH METHODS

OBJECT

The field research was designed to compare the factors contributing to the structure and composition of a Montane Rain forest and nearby Pine-Oak-Liquidambar forest in an attempt to determine the factors responsible for the close proximity of the tropical and temperate forest types.

GENERAL METHODS

There are three broad approaches to determining the structural and compositional differences of the two forest types and the factors that produce them. These were: 1) Microclimatic measurements, 2) Soil sampling and measurement, and 3) Vegetation sampling and measurement. The climatic measurements were for rainfall, temperature, relative humidity, cloud cover and light. The soils were sampled to determine texture and chemical composition and measured for temperature and moisture tension. The vegetation was sampled for floristic composition and physiognomic diversification and measured for density, canopy cover and three height. Topographic features such as slope, exposure, and elevation were determined and correlated with the two forest types.

Weather and soil measurements were made at stations in both forests. Four observation stations were set up. Two stations were located in the Montane Rain forest and two in the Pine-Oak-Liquidambar forest. In each of the two forests one station was in a clearing and the other under canopy.

SITE SELECTION

Climatic and vegetation data were collected at randomly selected sites in the Montane Rain an Pine-Oak-Liquidambar forest. These sites were typical of the forest they were to represent. Specific locations are given on Map 2.

MICROCLIMATIC MEASUREMENT

Rainfall

The amount of rainfall was determined at the stations in the clearings in both forest types. In the Montane Rain forest rainfall was measured by both a Khalsico recording gauge of the mechanical tilting budket type and a standard U. S. Forest Service rain gauge as a support for the recording rain gauge. Rainfall in the Pine-Oak-Liquidambar forest was measured by a standard U. S. Forest Service rain gauge only. Weegly readings were made.

Rainfall data for the Montane Rain and the Pine-Oak-Liquidambar forests were used to determine yearly and monthly totals, the wet and dry seasons, the three consecutive wettest and driest months and the uniform seasonal ratio. The uniform seasonal ratio was determined by dividing the amount of rain that fell during the three consecutive wettest months by the amount that fell during the three consecutive driest months.

Hourly determinations of rainfall in the Montane Rain forest were made with data from the recording rain gauge. These were used to make a frequency distribution curve (Figure 3) showing the percent amount and percent of time for the study year and for the three consecutive wettest and driest months. The average number of rainy days per month and the mean rainfall for each day of rain were also determined.

Rain throughfall was determined by rain gauges set out 3 M apart along a straight line under the canopy in the

Montane Rain forest. Weekly readings were made. The amoung of rain throughfall was compared with the rainfall in the clearing for the three consecutive wettest and driest months (Figure 13).

Air Temperature

Air temperature was determined by means of maximum and minimum thermometers, two hygrothermographs and a Bacharoch Tempscribe. Maximum and minimum thermometers were placed under the canopy and in the clearings in both forest types. Maximum and minimum thermometers were also placed vertically at 0, 1.2, 3 and 6 M from the ground in the Montane Rain forest. Readings were made three times a week. Temperature recordings were made under the canopy in both forests and in the clearing in the Montane Rain forest for weekly periods.

To complement the climatic data obtained, potential evapotranspiration and the potential evapotranspiration ratio (Table 4) were computed from biotemperature and rainfall data according to Holdridge (1964). Periodicity variations and hourly averages for the study year and three consecutive wettest and driest months were determined for the Montane Rain forest. The monthly temperature means and ranges were determined for both forests. Monthly mean temperatures at vertical positions from ground level were determined for the Montane Rain forest.

Relative Humidity

Relative humidity was determined by means of two hygrothermographs placed under the canopy in the Montane Rain and Pine-Oak-Liquidambar forests and in the clearing in the Montane Rain forest. One hygrothermograph was placed under the Montane Rain forest canopy throughout the study year. During the period from October 1970 to April 1971 the second hygrothermograph was in a clearing in the Montane Rain forest. From April to October 1971 the second hygrothermograph was under the canopy in the Pine-Oak-Liquidambar forest. This permitted a comparison with the Pine-Oak-Liquidambar forst and also permitted a determination of the effect of the Montane Rain forest canopy on relative humidity within the forest.

The mean and the range of relative humidity were determined for the study year in the Montane Rain forest and for a position of the study year in the Pine-Oak-Liquidambar forest.

Cloud Cover

Cloud cover differences were determined by two Kahlsico 01AM100 bimetallic actinographs of the Robitzch type. One actinograph was placed in the Montane Rain forest while the other was placed in the Pine-Oak-Liquidambar forest. These instruments measure and record the intensity of the daily radiation incident at the earth's surface. They were set up in an east west orientation in locations that would give a maximum view of the sky. Recordings were made for weekly periods. The area under each of the tracings representing daily radiation was measured by means of a K + E Compensating Polar Planimeter (Model 62 0005). The areas of the daily radiation graphs in the Montane Rain forest were compared to those from the Pine-Oak-Liquidambar forest. The percentage of increase of cloudiness in the Montane Rain forest was determined for monthly periods and for the study year.

Light

Light measurements were made with a Gossen Lunar-probe light meter. All readings were converted to foot-candles and the under canopy readings were transformed as percentages of the light in the clearings. Light penetration of the canopy of the Montane Rain forest was measured at ten permanent locations where throughfall of rain were also measured. Light readings were made at ground level and at 1.2, 3 and 6 M above ground. Canopy light penetration in the Pine-Oak-Liquidambar forest were also measured and compared with the clearing light.

Soil Sampling and Measurement

Soil samples were randomly collected at 30 and 45 cm depths from the Montane Rain and Pine-Oak-Liquidambar forest on June 6, 1971. These were sent to the Texas Soil Laboratory, McAllen, Texas. The samples were assessed for texture, pH, soluble salts, and nutrients. Nutrient analysis was made only on the soils taken at 30 cm depths. The nutrients tested for were nitrates and nitrogen, phosphates and potassium.

Soil temperature measurements were made by cable probe thermometers at 60 cm depths and by soil thermometers at 10 cm depths. Soil temperature were determined *at* the same time as air temperatures to show their relationship.

Soil moisture tension was assessed in the soils of both forests by means of Delmhorst cylindrical gypsum blocks buried at 60 cm depths at 10 cm intervals along a 30 M line. Readings were made fortnightly through the study year with a Soiltest Moisture Meter (Model MC-300A). Soil moisture was determined by converting the dial readings in microamperes to ohms of resistance then to centibars of soil suction by the use of a graph prepared from calibration of the soil cells. The maximum possible reading was 200 microamperes. This would occur when there was no resistance. Field capacity was assumed to occur at this point.

Vegetation Sampling

Tree density and basal area in the two forest types were measured by means of the wandering quarter method (Catana, 1963). In the wandering quarter method the distance to the nearest tree in a quarter, in the direction of a selected compass course, is measured, followed by measuring the distance to the next nearest tree in the quarter along the same compass course and so on. In the Pine-Oak-Liquidambar forest, 159 such measurements were made and 170 measurements in the Montane Rain forest in 5 transects each. The d.b.h. was recorded for each tree. The identification of the tree was recorded when known.

A frequency distribution of the distance measurements was made and the mode was computed. Distance measurements longer than a distance of three times the mode were considered to be either between clumps of trees or across holes (clearings). The coefficient of variation was computed for each of the two sets of measurements to indicate if the population was randomly distributed, clumped or with holes. Catana (1963) found all random populations to have a coefficient of variation between 40% and 60%. Discretely clumped populations were found to range from 126.43% to 344.20%. Where holes occurred in an otherwise random population the coefficient of variation was higher than for random populations and lower than for clumped populations. The methods for computing the density per hectare varies depending upon the occurrence or not of distance measurements longer than three times the mode, and upon whether the population is random, clumped, or with holes as indicated by the coefficient of variation. The density per hectare was computed according to these findings.

The basal area per hectare was based on the frequency per hectare and the mean diameter of the trees. Basal area per hectare was computed for both forest types. Relative dominance was computed for the pines, oaks, *Liquidambar, Arbutus* and the aggregate of all others in the Pine-Oak-Liquidambar forest and for *Podocarpus* and the tree fern (*Cyathea* and *Alsophila*) in the Montane Rain forest.

Canopy cover was determined by use of a Paul E. Lemon Forest spherical Densiometer, Model A. This instrument consists of a convex mirror with 24 equal squares etched on its surface. The instrument is held at waist height at about 45 cm in front of the body under the canopy site to be measured. Looking into the mirror at this position, the person counts the total quarter squares which are free from reflections of overhead leaven and twigs, indicating canopy openings. Standing at one point in each site, four readings are made, one at each of the four compass directions. The mean of the four measurements is then multiplied by .96 to obtain the canopy opening. The canopy opening is subtracted from 100 to obtain the overstory density, of canopy cover in percent. Canopy cover was determined by the above methods at eight randomly selected sites in the Pine-Oak-Liquidambar forest and at fourteen such sites in the Montane Rain forest (Table 9).

Total tree height and height to the first branch were determined by the Bitterlich method using a Spiegel relaskop. Twenty randomly selected canopy trees were measured by this method in the Pine-Oak-Liquidambar forest and thirty-five such trees by the same method in the Montane Rain forest (Table 9).

Layers in the forest structure were considered to be continuous or near continuous strata of vegetation as exhibited by the canopy and understory trees, the shrub and ground layers, and in the Montane Rain forest alone, the field layer. The field layer was considered to be the layer of ground ferns and palms occurring in the lower part of the shrub layer.

Synusiae were considered to be two or more life forms living together under similar ecological conditions, such as epiphytes, parasites and lianas (Richards, 1964). Life forms within some layers and synusiae were also considered, such as woody and herbaceous perennials of the ground layer or goody and herbaceous lianas.

The species of the floristic composition used to describe the forest structures were identified from field observations and from examination of herbarium specimens collected in the vicinity of the study sites.

RESULTS

MICROCLIMATE OF THE SITES

Rainfall

Monthly rainfall totals for the Montane Rain and Pine-Oak-Liquidambar forest sites are listed in Table 3 and are shown graphically in Figure 1. These data indicate a seasonality with an approximate rainy season from June through November and a dry season from December through May. The uniform seasonal ratios for the two forest study sites (Table 2), based on a ratio of the three consecutive wettest months of the year to the three consecutive driest months, are high, indicating a high degree of seasonality. The potential evaporation ratios (Table 2), as defined by Holdridge *et al.* (1971), for mar- the two forest sites also indicate seasonality. For comparative purposes, however, rainfall data for the Montane Rain forest sites for the study year, October 1, 1970,

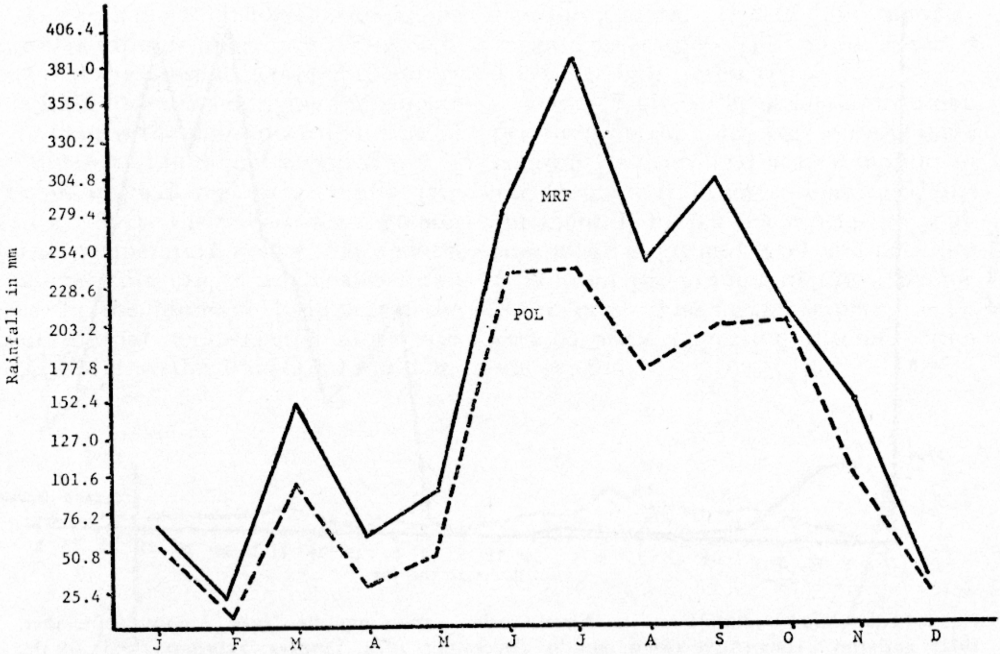


Fig. 1. Rainfall. Montane Rain (MRF) and Pine-Oak-Liquidambar (POL) forests, Pueblo Nuevo Solistahuacan, Chiapas, Mexico. October 1, 1970-September 30, 1971, by months in mm.

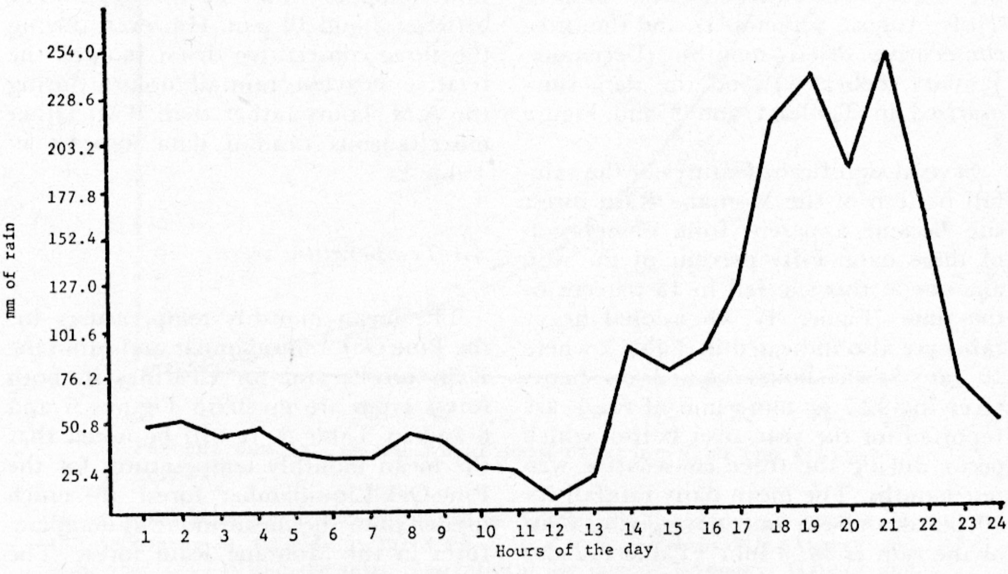


Fig. 2. Total hourly rainfall for the study year October 1, 1970-September 30, 1971, in a Montane Rain forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico

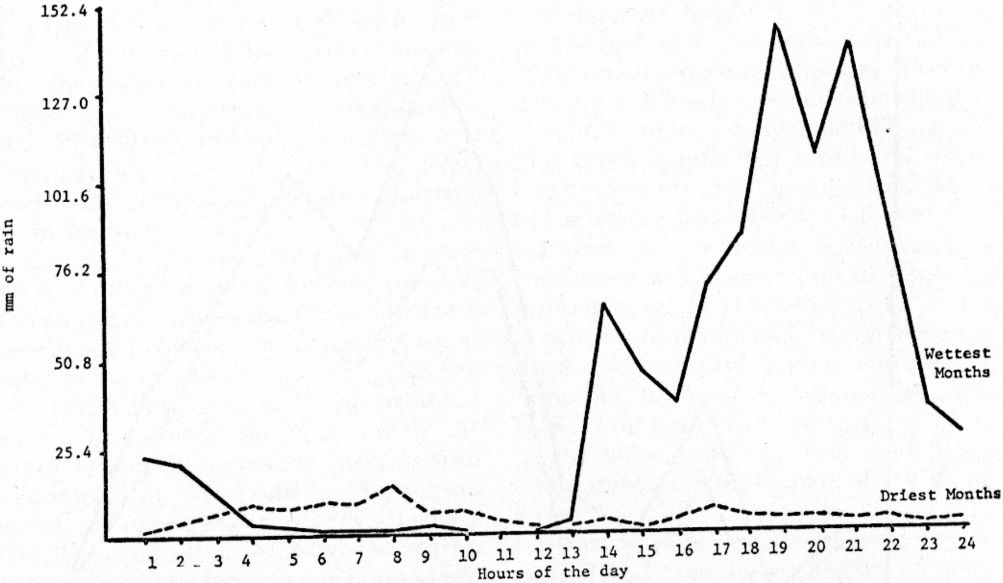


Fig. 3. Total hourly rainfall for the 3 consecutive wettest months (July, August, September, 1971) and the 3 consecutive driest months (December, 1970; January, February, 1971) of the study year October 1, 1970-September 30, 1971, in a Montane Rain forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

to September 30, 1971, is divided into the three consecutive wettest months (July, August, September) and the three consecutive driest months (December, January, February) and the data summarized in Tables 1 and 3 and Figure 3.

Several significant features of the rainfall pattern of the Montane Rain forest site became apparent from observation of these data. Fifty percent of the rain amount at this site fell in 13 percent of the time (Figure 4). Occasional heavy rains are also indicated in Table 2 where 16 rain storm hours (based on hours receiving 12.7 or more mm of rain) are reported for the year, over half of which occur during the three consecutive wettest months. The mean daily rainfall for 10 percent of the rain days giving most of the rain is 33. 8 mm (Table 2), also indicating occasional heavy rains.

Diurnal hourly rainfall patterns (Figures 2 and 3) indicate that the heaviest rain hours for most of the year occur between 2 and 10 p.m. However, during the three consecutive driest months the relative heaviest rainfall occurs during the A.M. hours rather than P.M. Other miscellaneous rainfall data appears in Table 2.

Air Temperature

The mean monthly temperatures for the Pine-Oak-Liquidambar and Montane Rain forests and for clearings in both forest types are given in Figures 5 and 6 and in Table 3. It will be noted that the mean monthly temperatures for the Pine-Oak-Liquidambar forest are much higher than the mean monthly temperatures in the Montane Rain forest. The temperature difference between the forests and the forest clearings is greater in the Montane Rain forest than in the Pine-Oak-Liquidambar forest. This indicates that the dense structure of the Montane Rain forest is modifying the climate more than is the more open structure of the Pine-Oak-Liquidambar forest.

As in tropical regions generally (Richards, 1964) there was seen greater diurnal temperature ranges than monthly temperature ranges in the two forest types. In the Montane Rain forest the mean diurnal temperature range was 9.1°C while in the Pine-Oak-Liquidambar forest it was 11.3°C. The monthly mean temperatures had a mean range of 1.1°C for both forest types.

Figure 7 gives the mean hourly temperatures for the study year and the three consecutive driest and wettest months in the Montane Rain forest. Figure 8 shows the monthly means of temperature readings made at ground level and at 3 and 6 M from the ground in the Montane Rain forest. The mean temperature increased with increasing distance from the ground.

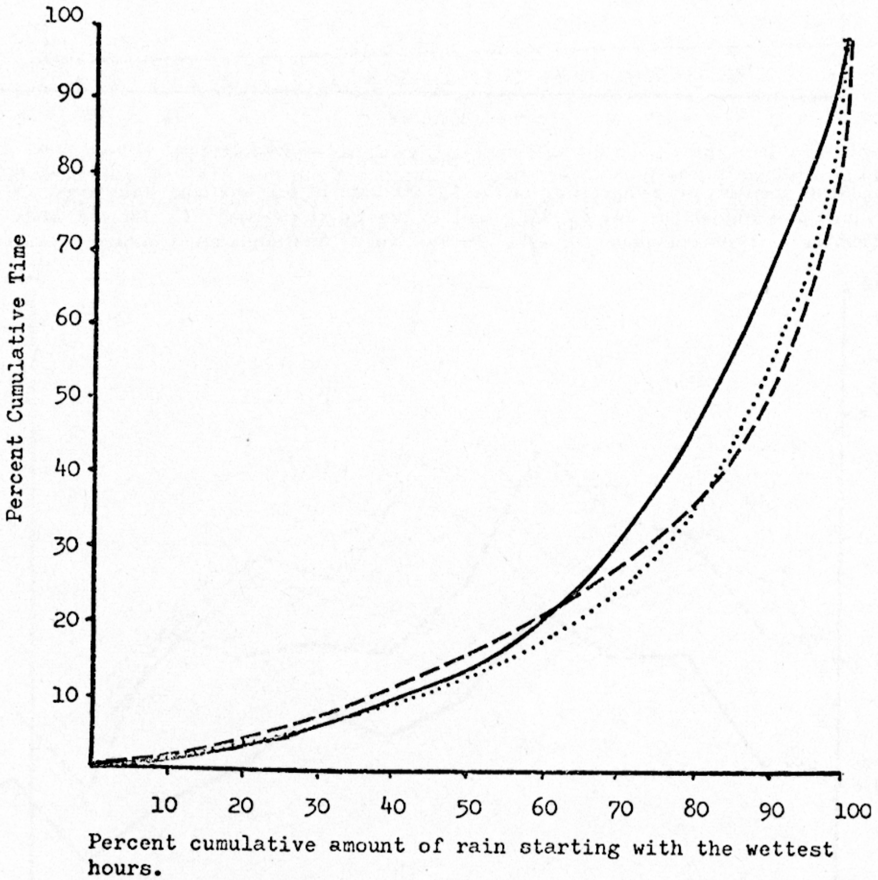


Fig. 4. Cumulative frequency distribution of rainfall for the study year October 1, 1970-September 30, 1971 (. . .), the 3 consecutive wettest months July, August, and September (——), and the three consecutive driest months December, January, and February (——) in a Montane Rain forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

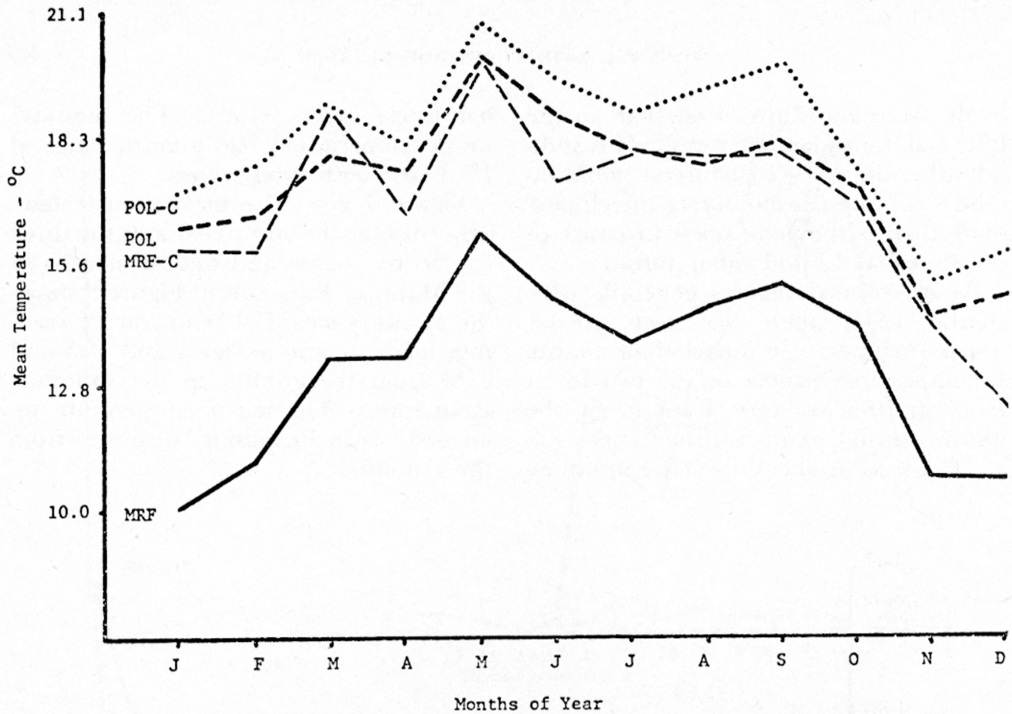


Fig. 5. Mean monthly air temperature at the 1.37 M level in the Montane Rain forest (MRF) and Pine-Oak-Liquidambar forest (POL) and in the forest clearings (C) for the study year October 1, 1970-September 30, 1971. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

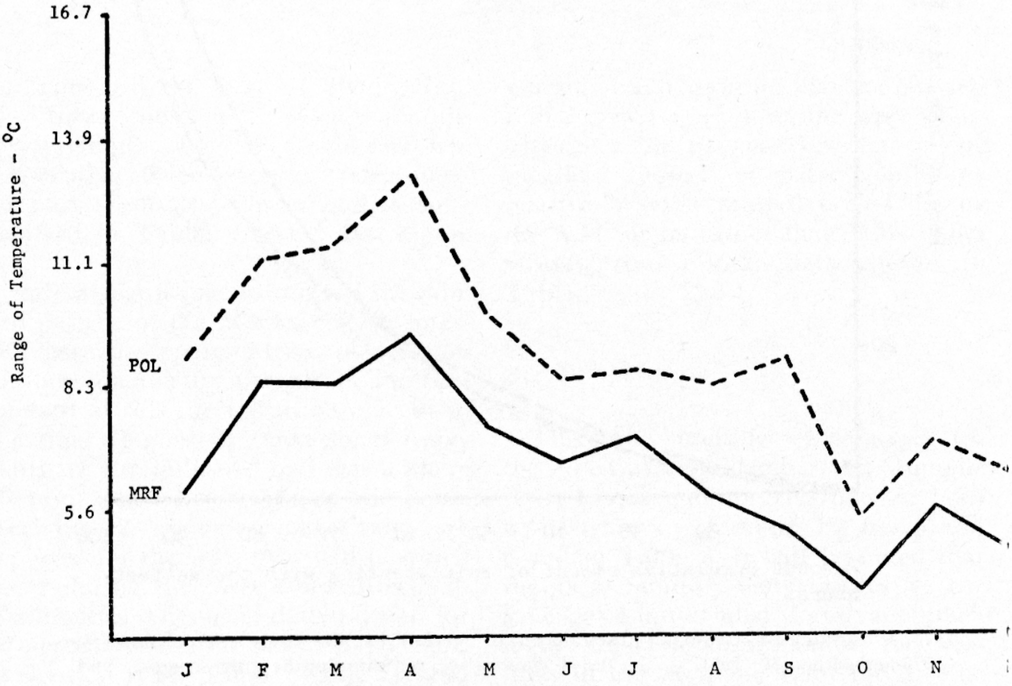


Fig. 6. Mean monthly range of temperature in the Montane Rain forest (MRF) and Pine-Oak-Liquidambar forest (POL) for the study year October 1, 1970-September 30, 1971. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

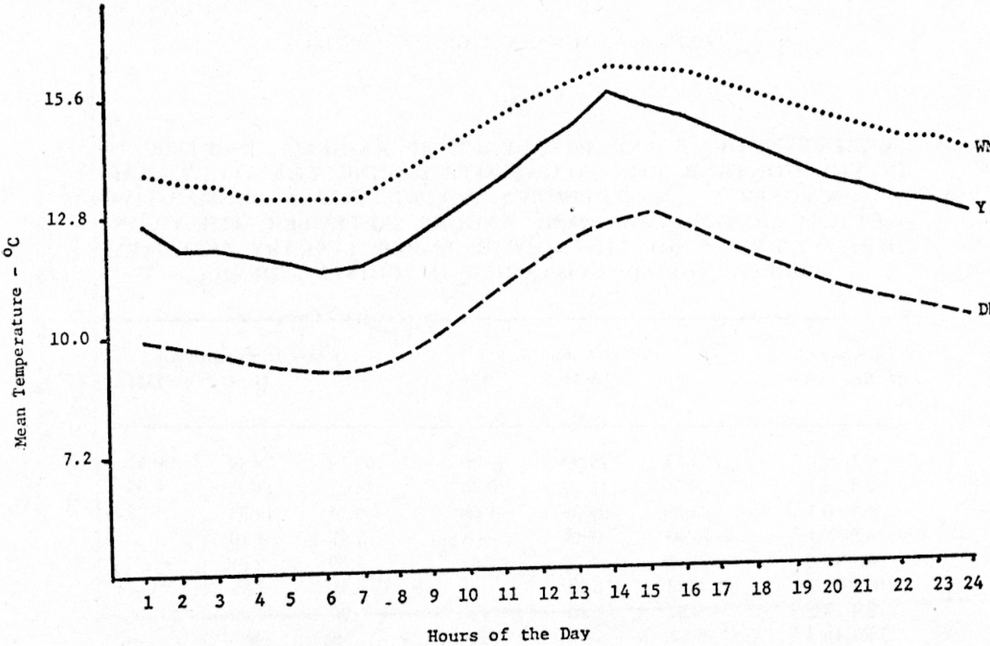


Fig. 7. Mean hourly temperatures in the Montane Rain forest for the study year (Y) October 1, 1970-September 30, 1971; for the 3 consecutive driest months (DM), December, January, February; and for the 3 consecutive wettest months (WM), July, August, September. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

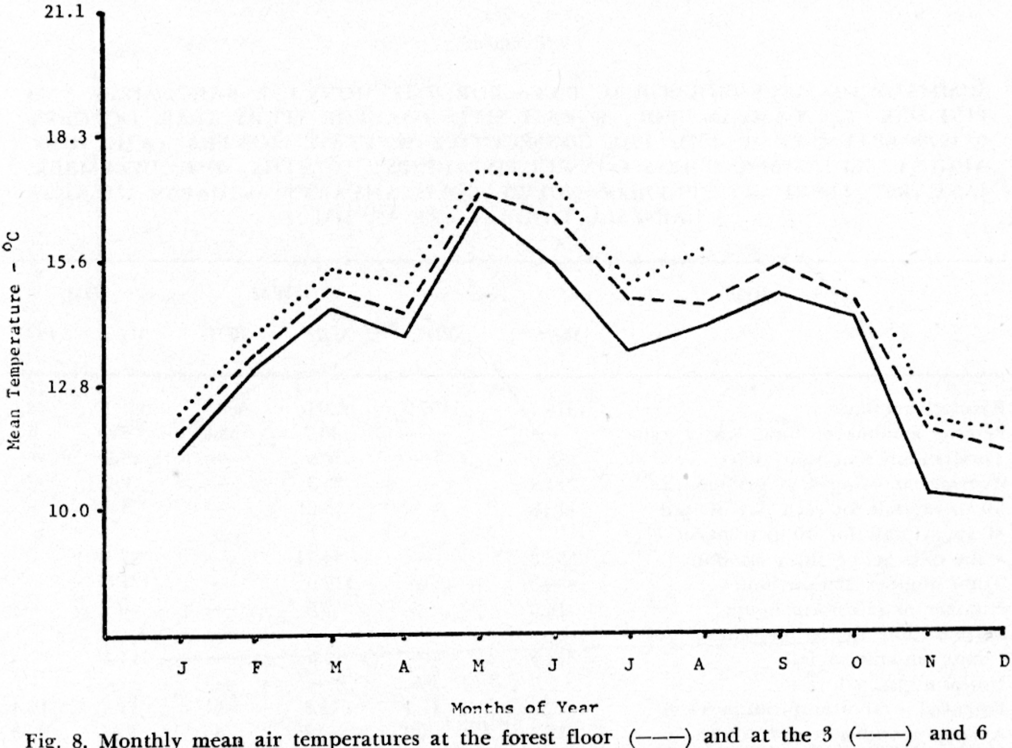


Fig. 8. Monthly mean air temperatures at the forest floor (——) and at the 3 (– – –) and 6 (. . .) M levels in the Montane Rain forest. For the study year October 1, 1970-September 30, 1971. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

TABLE 1

PERCENT AMOUNT AND FREQUENCY OF RAINFALL INCREMENTS IN THE MONTANE RAIN FOREST SITE DURING THE STUDY YEAR (Y) OCTOBER 1, 1970-SEPTEMBER 30, 1971; THE 3 CONSECUTIVE WETTEST MONTHS (WM) JULY, AUGUST, SEPTEMBER; THE 3 CONSECUTIVE DRIEST MONTHS (DM) DECEMBER, JANUARY, FEBRUARY. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

Increments of Rain-mm	*Percent Amount*			*Percent Frequency*		
	Y	*WM*	*DM*	*Y*	*WM*	*DM*
0.3- 2.0	21.94	15.99	58.90	69.19	58.99	90.51
2.3- 4.1	18.15	15.82	28.60	13.21	14.82	8.03
4.3- 6.1	21.09	25.95	4.66	9.14	14.51	.73
6.3- 8.1	10.06	9.43	—	3.27	4.10	—
8.4-10.2	7.00	7.79	7.84	1.69	2.52	.73
10.4-12.2	6.88	6.14	—	1.35	1.57	—
12.4-14.2	5.31	8.61	—	.90	1.89	—
14.5-16.3	3.87	—	—	.56	—	—
16.4-18.3	2.62	3.70	—	.34	.63	—
18.5-20.3	2.00	4.27	—	.23	.63	—
20.6-22.4	1.06	2.28	—	.11	.31	—

TABLE 2

SUMMARY OF METEOROLOGICAL DATA FOR THE MONTANE RAIN (MRF) AND PINE-OAK-LIQUIDAMBAR (POL) FOREST SITES FOR THE STUDY YEAR, OCTOBER 1, 1970-SEPTEMBER 30, 1971; THE CONSECUTIVE WETTEST MONTHS (WM) JULY, AUGUST, SEPTEMBER; THE 3 CONSECUTIVE DRIEST MONTHS (DM) DECEMBER, JANUARY, FEBRUARY. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO. RAINFALL FIGURES ARE IN MM

Item	*Year*		*WM*		*DM*	
	MRF	*POL*	*MRF*	*POL*	*MRF*	*POL*
Rainfall amounts	1978.7	1407.2	929.0	609.7	119.3	88.9
Percent amount of total yearly rain	—	—	46.7	43.0	6.0	6.5
Total number of rainy days	176.0	—	70.0	—	24.0	—
Average no. rainy days per month	14.6	—	23.3	—	8.0	—
Mean rainfall for each day of rain	11.18	—	13.21	—	4.83	—
Mean rainfall for 10 percent of the days giving the most rain	33.78	—	34.54	—	27.43	—
Total number of rain hours	886.0	—	317.0	—	137.0	—
Number of rainstorm hours	16.0	—	9.0	—	0	—
Percent time for 50 percent of the rain amount to fall	13.0	—	13.5	—	14.5	—
Uniform-seasonal ratio	7.7	6.5	—	—	—	—
Potential evapotranspiration ratio	.39	17.3	14.3	18.1	11.4	15.4
Average monthly temperatures, °C	13.2	.72	.24	.45	1.66	3.68

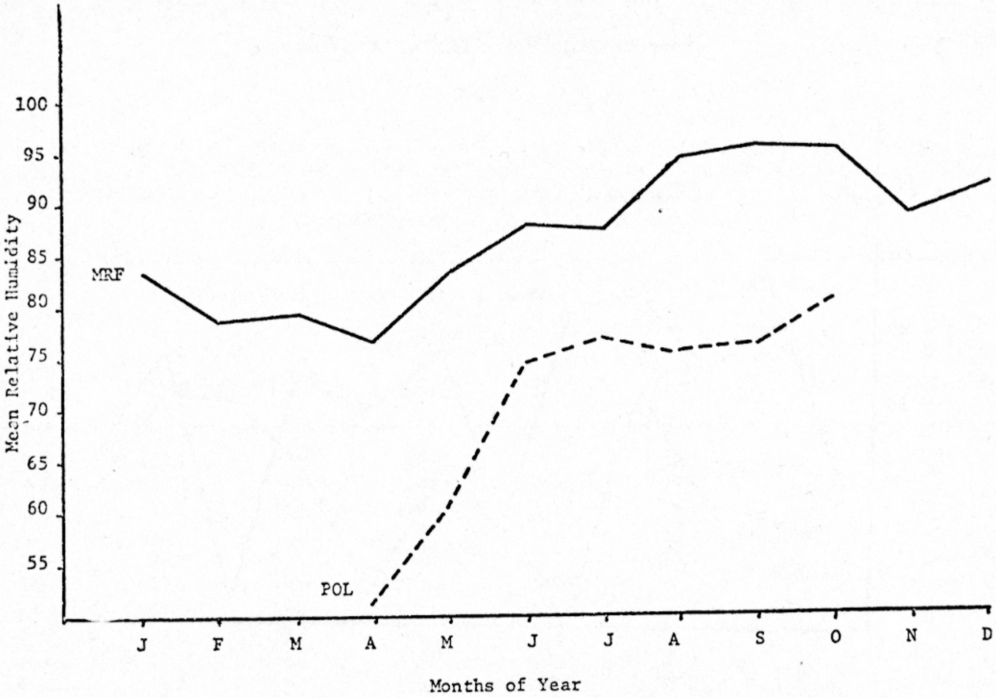


Fig. 9. Mean relative humidity by months in the Montane Rain forest (MRF) from October 1, 1970-September 30, 1971, in the Pine-Oak-Liquidambar forest (POL) for selected months of the same period. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

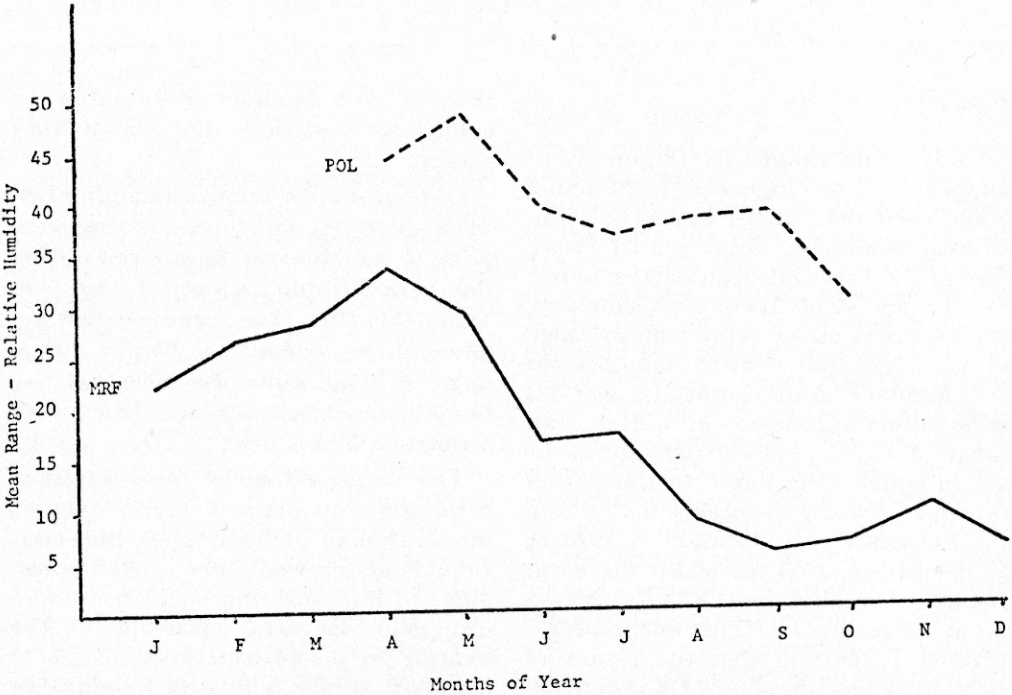


Fig. 10. Mean range of relative humidity by months in the Montane Rain forest (MRF) from October 1, 1970-September 30, 1971 and in the Pine-Oak-Liquidambar forest (POL) for selected months of the same period. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

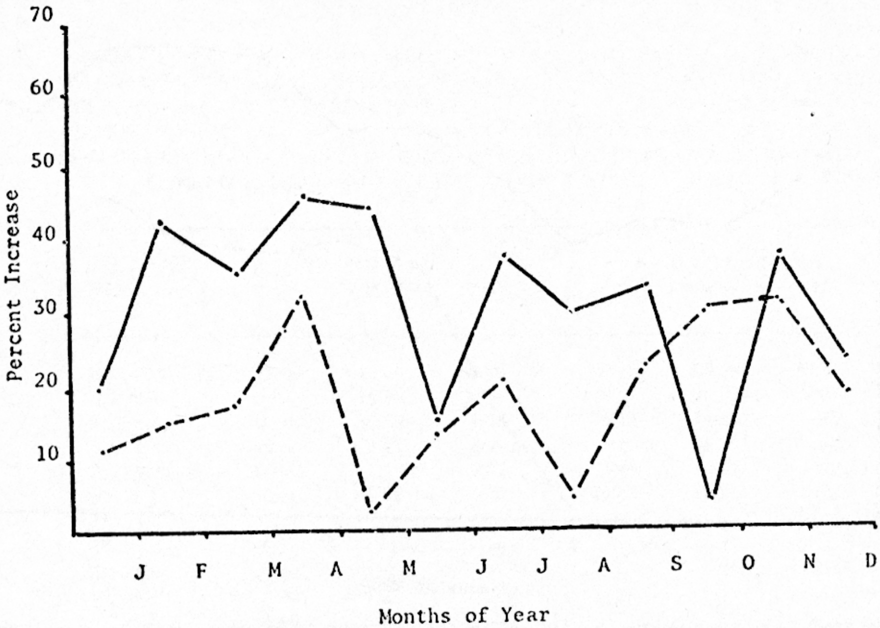


Fig. 11. Percent increase of rainfall (——) and cloud cover (– – –) in the Montane Rain forest as compared with the Pine-Oak-Liquidambar forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico, during the study year from October 1, 1970, to September 30, 1971.

Relative Humidity

Mean relative humidity (Figures 9, 10 and Table 3) was higher in the Montane Rain forest than in the Pine-Oak-Liquidambar forest. The mean relative humidity in the Pine-Oak-Liquidambar forest for the period of April 1 to September 30, 1971, was 69.3% with a mean range of 41. The mean relative humidity for the Montane Rain forest during this same period of time was 87 with a mean range of 19.7%. These latter figures for the Montane Rain forest for this period of time compare favorably with those for the study year, October 1, 1970 to September 30, 1971, in which the mean relative humidity was 87.1% with a mean range of 17.6. This might be explained in part in that the period of time in which the Pine-Oak-Liquidambar forest relative humidity was compared with the Montane Rain forest included parts of both the dry and wet seasons.

Comparisons in relative humidity between the forest and forest clearing were made in the Montane Rain forest during the period from October 1, 1970 to March 31, 1971. The mean relative humidity in the forest was 85.5% with a range of 17.5 while the mean relative humidity in the clearing was 72.9% with a range of 32.1.

The denser Montane Rain forest is helping to maintain a higher relative humidity than the more open Pine-Oak-Liquidambar forest. The denser forest also had less fluctation in relative humidity than the more open forest. The clearing in the forest also is unable to maintain as high a relative humidity or as low a range as within the forest.

TABLE 3

BIOTEMPERATURE, PRECIPITATION AND RELATIVE HUMIDITY BY MONTHS IN THE MONTANE RAIN (MRF) AND PINE-OAK-LIQUIDAMBAR (POL) FOREST SITES FOR THE STUDY YEAR, OCTOBER 1, 1970-SEPTEMBER 30, 1971. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

	Biotemperature (°C)		*Precipitation mm*		*Mean Relative Humidity*		
Months	*MRF*	*POL*	*MRF*	*POL*	*MRF*	*POL*	*MRF-clearing*
Jan.	10.1	16.3	66.0	53.3	83.4	—	67.2
Feb.	11.2	16.6	20.3	10.2	78.9	—	59.0
Mar.	13.4	17.9	149.9	96.5	79.5	—	71.8
Apr.	13.5	17.6	55.9	30.5	76.9	51.5	—
May	16.2	20.2	88.9	48.3	83.5	60.5	—
June	14.8	18.9	279.4	236.2	88.0	75.0	—
July	13.3	18.1	383.5	238.8	87.6	77.0	—
Aug.	14.6	17.7	243.8	170.2	94.3	75.8	—
Sept.	15.1	18.3	299.7	200.7	96.0	76.8	—
Oct.	14.2	17.1	210.8	203.2	95.5	—	87.1
Nov.	10.8	14.4	147.3	94.0	89.4	—	73.9
Dec.	10.7	14.9	33.0	25.4	92.1	—	78.7
Average	13.2	17.3	1 978.7	1 407.2	87.1	69.4	72.9
Mean-Range	6.1	5.8	—	—	17.6	41.0	32.1

Cloud Cover

Winds were observed to prevail from a northeasterly direction in the study area. This corresponds to the observation of Miranda (1952) for most of Chiapas and would place the Montane Rain forest on the crest of the Windward slope (Plate 1). Clouds were observed frequently covering the ridge where the Montane Rain forest is located while the slope of the Pine-Oak-Liquidambar forest was practically unclouded. Lambert (1970) studied net radiation and noted that it was reduced by clouds passing overhead. Clouds, undoubtedly, are a factor in the lower temperatures and higher humidities in the Montane Rain forest. Along with greater rainfall the increased cloud cover over the Montane Rain forest appears to be an important factor in producing its large species diversity, including the abundant epiphytes and lianas.

The percentage of cloud cover increase in the Montane Rain forest is given in Table 6 and Figure 11 along with the percentage of rainfall increase in the Montane Rain forest. During most of the year the percentage of rainfall increase was much greater than the percentage of cloud cover increase. This suggests that during these times there are clouds that pass over the ridge that do not deposit rain in the Pine-Oak-Liquidambar forest. This is especially true during the autumn, winter and spring months. Synoptic weather during the summer brings heavy and widespread rainfall throughout the State. Thus, the summer rains in the study vicinity are not due to the orographic effect of the mountain alone. This is reflected in the decreased difference in cloud cover and rainfall at this time of the year.

Light

Light readings were used primarily to compare canopy structure of the two forests. A comparison of light within the forests to that in the forest clearings (Table 7) shows that the Montane Rain forest floor is receiving only about 1 percent of the forest clearing light or about 11.8 percent of the light which reaches the floor of the Pine-Oak-Liquidambar forest.

Light readings were also made at various vertical intervals within the Montane Rain forest and these compared to readings in the forest clearing (Table 8 and Figure 12). These data indicate the effectiveness of the canopy in redu-

TABLE 4

POTENTIAL EVAPOTRANSPIRATION IN MM IN THE MONTANE RAIN (MRF) AND PINE-OAK-LIQUIDAMABAR (POL) FORESTS. FOR THE STUDY YEAR, OCTOBER 1, 1970-SEPTEMBER 30, 1971. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

Months	*MRF*	*POL*
Jan.	50.8	73.7
Feb.	50.8	76.2
Mar.	66.0	88.9
Apr.	66.0	86.4
May	81.3	101.6
June	71.1	91.4
July	66.0	91.4
Aug.	73.7	88.9
Sept.	73.7	88.9
Oct.	71.1	83.8
Nov.	53.3	68.5
Dec.	53.3	76.2

TABLE 5

SOIL MOISTURE AND TEMPERATURE BY MONTHS IN THE MONTANE RAIN (MRF) AND PINE-OAK-LIQUIDAMABAR (POL) FOREST STUDY SITES FOR THE STUDY YEAR, OCTOBER 1, 1970-SEPTEMBER 30, 1971. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

	Soil moisture-percent of field capacity-depth 60 cm		*Mean soil temperature °C depth 10 cm*		*Mean soil temperature °C depth 60 cm*	
Months	*MRF*	*POL*	*MRF*	*POL*	*MRF*	*POL*
Jan.	96	62	10.7	14.6	10.9	14.3
Feb.	96	32	11.3	16.6	10.3	14.4
Mar.	95	28	13.0	17.8	10.7	15.2
Apr.	96	52	11.7	19.4	11.5	15.7
May.	89	78	14.9	20.7	11.6	16.8
June	89	97	14.6	18.6	12.4	16.8
July	96	86	12.9	17.5	12.3	16.4
Aug.	93	80	13.1	16.7	12.3	16.7
Sept.	92	98	13.6	16.7	12.4	17.0
Oct.	96	97	11.2	16.4	12.7	16.6
Nov.	—	97	10.2	—	11.7	15.3
Dec.	96	79	10.0	—	10.6	14.3

cing light and that the canopy of the Montane Rain forest is denser than the canopy of the Pine-Oak-Liquidambar forest. This compares favorably with the canopy cover percent determined by use of a forest densiometer (Table 11).

A comparison of the light received under the canopy with that received in the clearing along with a comparison of rain throughfall with rainfall in the clearing of the Montane Rain forest

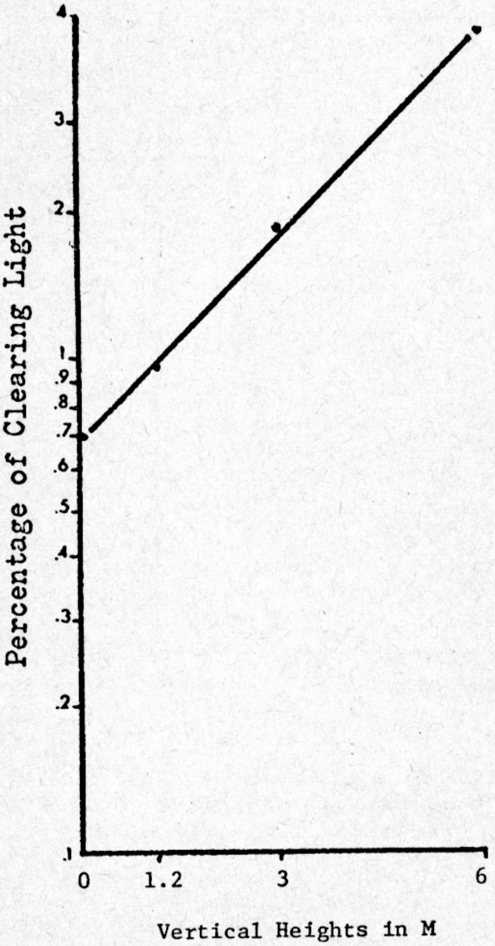


Fig. 12. Canopy light penetration at four different vertical positions from the ground as a percentage of light in a nearby clearing in the Montane Rain forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

TABLE 6

PERCENTAGE OF INCREASE OF CLOUD COVER AND RAINFALL IN THE MONTANE RAIN FOREST AS COMPARED WITH CLOUD COVER AND RAINFALL IN THE PINE-OAK-LIQUIDAMBAR FOREST. FOR THE STUDY YEAR OCTOBER 1, 1970-SEPTEMBER 30, 1971. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

	Percentage of Increase	
Month	*Cloud Cover*	*Rainfall*
Jan.	11.5	19.6
Feb.	15.6	43.4
Mar.	17.0	35.9
April	32.7	46.9
May	2.5	45.0
June	12.7	15.7
July	20.9	37.5
Aug.	4.5	29.5
Sept.	22.3	33.7
Oct.	30.6	4.0
Nov.	31.4	37.6
Dec.	23.1	18.3
Mean Monthly Increase	18.7	30.6

TABLE 7

A COMPARISON OF THE PERCENTAGE OF LIGHT PENETRATING THE CANOPY IN THE MONTANE RAIN FOREST (MRF) AND IN THE PINE-OAK-LIQUIDAMBAR FOREST (POL). PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

Time Period	*% of Clearing Light*		*MRF as % of POL*
	MRF	POL	
January to October (1971)	.99%	8.4%	11.8%

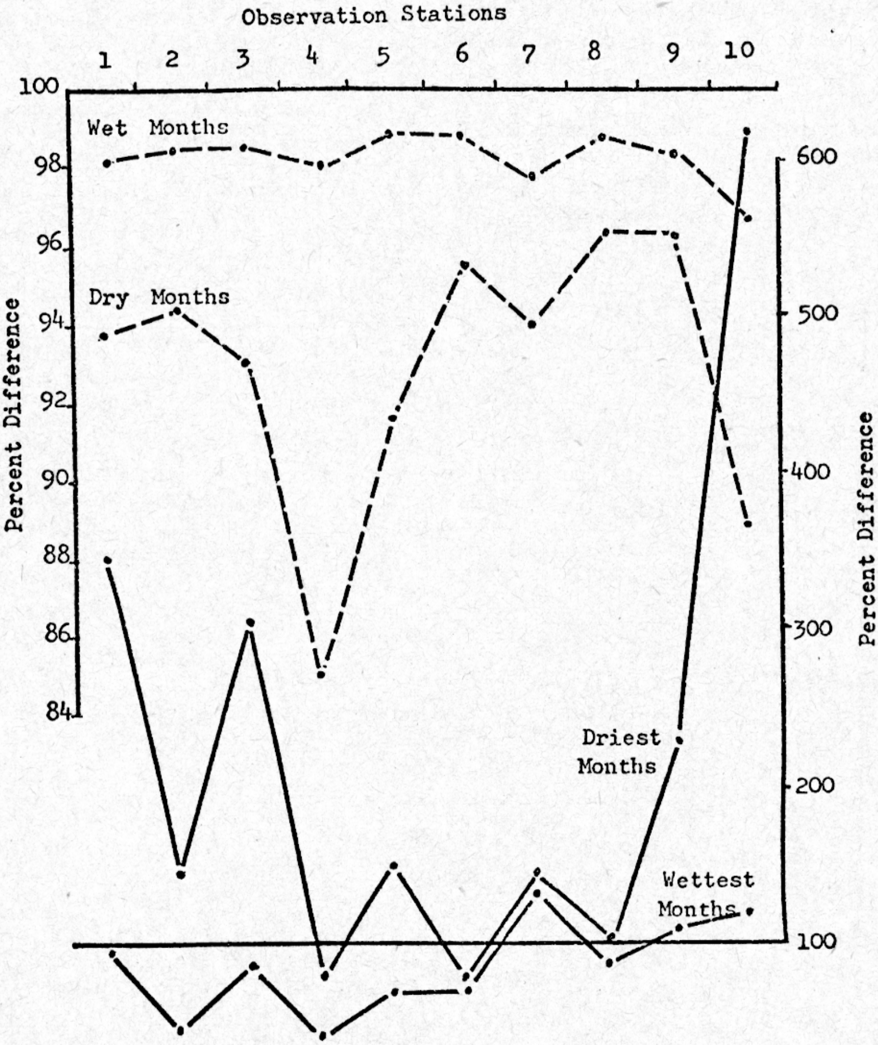


Fig. 13. Light (– – –) deflected from the canopy, as a percentage of light in a clearing, and throughfall (——) as a percentage of rainfall from a nearby clearing in the Montane Rain forest, Pueblo Nuevo Solistahuacan, Chiapas, Mexico. Observations were made at 10 stations under the canopy. The throughfall shown was for the 3 consecutive driest and wettest months (December, 1970; January, February, 1971, and July, August, September, 1971, respectively). The light deflected from the canopy was averaged from 5 sets of observations during January, February and March, 1971, for the dry season from 18 sets of readings during June, July, August, September, and October, 1971, for the wet season.

(Figure 13) indicates some seasonal changes in the canopy. Marked deciduousness in the Montane Rain forest was not observed, but there did appear to be a reduction of foliage during the dry season.

CLASSIFICATION OF THE CLIMATE

The climatic measurements taken at the study sites were primarily microclimatic. However, a classification of the macroclimate of the study sites has been determined from the climatic classification of Garcia (1973). This system is a modification of Köppen (1931) for particular conditions in Mexico and includes a series of climatic maps. The Villa Hermosa 15QVIII map (Garcia, 1970) classifies the climate of the Montane Rain forest site as type (A) C (M) and

TABLE 8

PERCENTAGE OF CANOPY LIGHT PENETRATION DATA, FROM THE MONTANE RAIN FOREST, PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO, AVERAGED OVER A PERIOD OF TEN MONTHS (JANUARY-OCTOBER, 1971) SHOWING THE EFFECTIVENESS OF THE CANOPY IN REDUCING LIGHT. READINGS WERE MADE AT VERTICAL INTERVALS STARTING AT GROUND LEVEL

Percentage of Clearing Light			
Distance from the ground in M			
0	*1.2*	*3*	*6*
.70%	.99%	1.9%	4.6%

TABLE 9

STRUCTURE AND CHEMICAL COMPOSITION OF SOILS FROM THE MONTANE RAIN FOREST (MRF) AND THE PINE-OAK-LIQUIDAMBAR FOREST (POL). PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO

Characteristic	*MRF*		*POL*	
	cm Depth		*cm Depth*	
	30	*45*	*30*	*45*
Solt. Salts-mmho	.34	.27	.31	.32
Soil Texture	Sand Loam	Sandy Loam-Sand	Clay	Clay
Carbonates	none	none	none	none
pH	4.8	4.8	5.3	5.2
Phosphotes Kg/ha	49.42	——	29,21	——
Potassium Kg/ha	242.6	——	215.64	——
Organic Matter %	4.9	——	5.2	——
Nitrates Kg/ha	46.06	——	20.21	——
Nitrongen Kg/ha	266.20	——	195.43	——

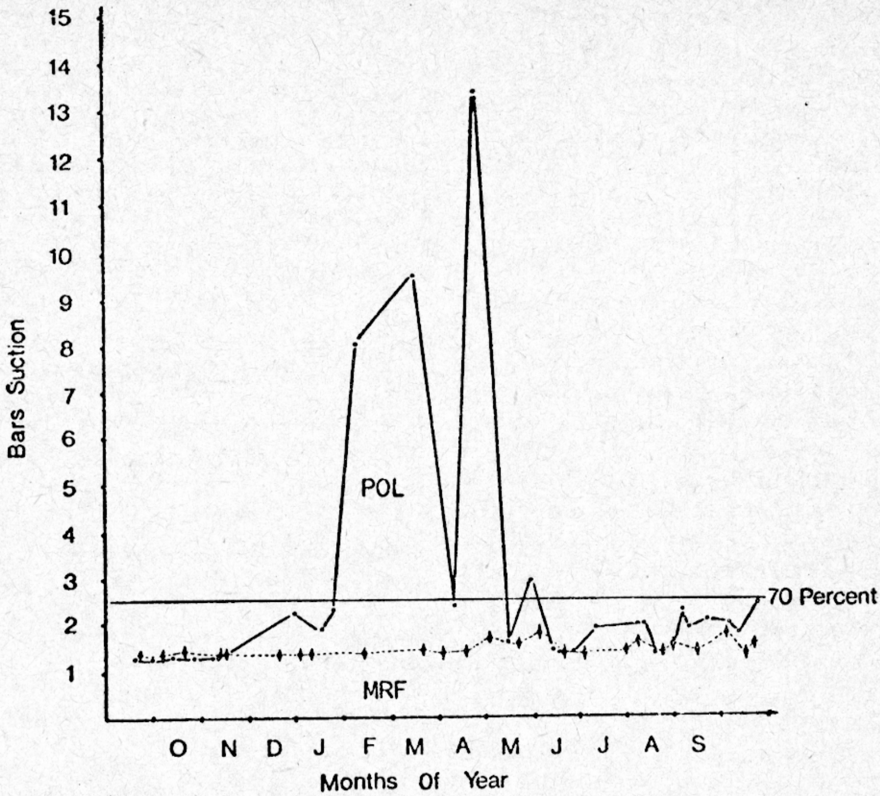


Fig. 14. Soil moisture at 60 cm depths in the Montane Rain forest (MRF) and the Pine-Oak-Liquidambar forest (POL). Pueblo Nuevo Solistahuacan, Chiapas, Mexico. Each point is the average of ten readings. Note the 70% of field capacity line that cuts off the effective dry months in the soil from the Pine-Oak-Liquidambar forest.

the climate of the Pine-Oak-Liquidambar forest as type (A) C (W2). Both of these climatic types are subgroups of C climates. C climates are cool temperate climates in which the mean temperature of the coldest month is between −3 and 18°C. The (A) C (M) subgroup is a humid climate and the (A) C (CW) subgroup is a subhumid climate. Both (A) C (M) and (A) C (CW) are forest climates with rains primcipally in the summer and include a seasonal drought in which the mean rainfall of the driest month is less than 4 mm. The mean annual rainfall listed for (A) C (M) climates is 2 000 mm and 1 500 mm for (A) C (CW) climates (García, 1970).

The climates of the two forest types, as determined by the climatic classification of García (1970, 1973), compares favorably with the climate measured at the two forest sites during the study year, particularly in relation to temperature, humidity and rainfall (Tables 2 and 3). Miranda (1952) states that the Selva Negra (Montane Rain forest) near Pueblo Nuevo Solistahuacan, Chiapas, receives an average of 2 000 mm of rain fall per year. This is very close to the amount of rain received at the Montane Rain forest site during the study year (Table 2). The nearest official weather station on the north or Montane Rain forest side of the Jicotol Ridge is 100

Km north at an elevation of 320 M at Teapa, Tabasco. The climatic classification here is Af (Garcia, 1973) with a mean annual temperature of 26.9°C and a mean annual rainfall of 3 900 mm, a much hotter and wetter climate than that of the Montane Rain forest site.

The nearest weather station on the south or Pine-Oak-Liquidambar side of the ridges is at Bochil, Chiapas. This station is at an elevation of 1 100 M and is approximately 46 Km south of the study site. The climate here is Aw2 (García, 1973) with a mean annual temperature of 22.6°C and a mean annual rainfall of 1 284.1 mm. This climate is warmer and drier than the climate of the Pine-Oak-Liquidambar forest site.

The climate studied at the two forest types during the study year was very local and microclimatic in nature and thus does not relate directly to the weather at these two nearest weather stations. However, the differences in rainfall on the north and south sides of the Jitotol Ridge, as recorded at the two weather stations, is also borne out in a similar difference in rainfall recorded at the two forest types during the study year (Tables 2 and 3).

SOILS OF THE SITES

Starting in December and extending through the Winter and Spring months the amount of rainfall is much lower than during the Summer and Autumn months. To be reflected in the vegetation, the reduced rainfall must produce

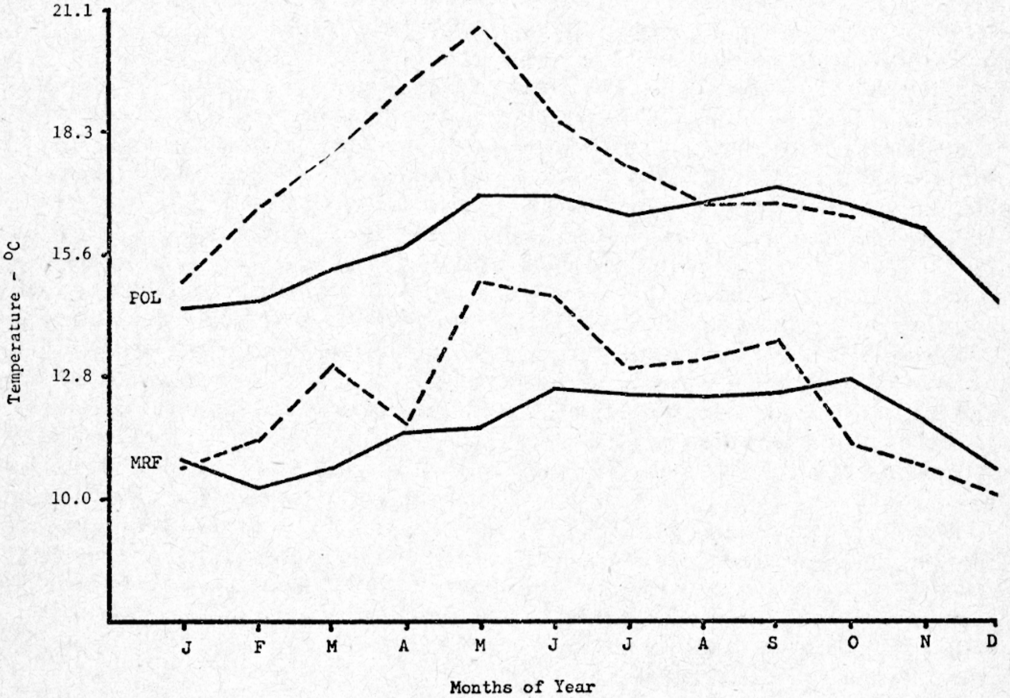


Fig. 15. Mean monthly soil temperature at 10 (–––) and 60 (–––) cm increments in the Montane Rain forest (MRF) and the Pine-Oak-Liquidambar forest (POL) for the study year October 1, 1970-September 30, 1971. Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

TABLE 10

CLASSIFICATION OF THE STUDY SITE COMMUNITIES ON THE NORTHEAST AND SOUTHWEST SLOPES OF THE JITOTOL RIDGE (MAP 2). PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO. BASED ON SELECTED AUTHORS

Author	*Southwest Slope*	*Northeast Slope*
Beard (1944)	Montane Rain Forest	Mountain Oak Forest
Holdridge (1964)	Montane Rain Forest	Mountain Pine Forest
Miranda (1952) and Miranda and Hernández X (1963)	Low Semi-evergreen Forest (translation)	Deciduous Forest (translation)
Richards (1964)	Montane Rain Forest	Montane Wet Forest

a reduced soil moisture. Figure 14 and Table 5 shows the soil moisture differences between the Montane Rain forest and the Pine-Oak-Liquidambar forest. It will be noted that, starting with the reduced rainfall in November and December, the soil moisture begins to decline in the soil of the Pine-Oak-Liquidambar forest, but not in the Rain forest soil. The soil moisture in the Pine-Oak-Liquidambar soil dropped below 70% of field capacity from January to May or June. The Rain forest soil moisture did not drop below this level at any time during the study year.

These two climatic features of the Montane Rain forest, greater cloud cover and higher rainfall, tend to favor the retention of soil moisture for this forest rather than for the Pine-Oak-Liquidambar forest.

Miranda (1952) classifies the soil of the low evergreen forest, with which he specifically associates the forest near Pueblo Nuevo Solistahuacan, as red or yellow semipodsolic. Table 9 charts the textural and chemical composition of the soils of the two forest types of this study. The surface soil of the Montane Rain forest is a dark brown clay loam with the subsoil being a reddish yellow clay loam. The soil is markedly acid (pH = 4.8).

The surface soil of the Pine-Oak-Liquidambar forest is a brownish silty clay loam turning into a rather tight reddish clay at greater depths. The soil of this forest is also acid (pH at 30 cm = 5.3 and at 45 cm = 5.2). Soil nutrients and their amounts and the percent organic matter of the soils of the two forest types are listed in Table 9.

Soil temperatures at 10 and 60 cm depths (Figure 15 and Table 5) showed a marked difference between the Montane Rain forest and the Pine-Oak-Liquidambar forest. Soil temperatures tended to reflect air temperatures. The temperatures taken at 10 cm depth were more variable than those from the 60 cm depth and more nearly reflected the actual air temperatures at the time the temperatures were measured. Temperatures measured at the 60 cm depth varied only very slightly and slowly in response to air temperature changes.

VEGETATION OF THE SITES

Summarizing the classification of the study sites of this project (Table 10), the northeast slope site consists of diverse tree species, including *Podocarpus, Magnolia, Persea* and *Cyathea* and is considered to be a Montane Rain forest. The southeast slope site is essentially a mixture of Pine, Oak and Liquidambar (deciduous) forests and is thus termed a Pine-Oak-Liquidambar forest. The general appearance of these forests are shown in Plates 3 to 8. Structural features of the Montane Rain and Pine-Oak-Liquidambar forest study sites are summarized in Tables 11 and 12 and in Figures 16 and 17.

Plant species characteristic for the Montane Rain and Pine-Oak-Liquidambar forest study sites were compiled from herbarium specimens of those who have done botanical collecting in the study vicinity in recent years, primarily Drs. Dennis A. Breedlove and Robert F. Thorne. Their first set of collections are deposited in the herbaria of their respective institutions, the California Academy of Sciences, Golden Gate Park, California and Rancho Santa Ana Botanic Garden, Claremont, California. The representative species chosen are based upon the stratum in which a mature individual occurs, as well as upon their life from and synusae, i.e., trees, lianas, shrubs, herbs, epiphytes, etc. Classification of the angiosperm families follows that of Thorne (1970).

The Montane Rain forest is essentially a taller forest with higher boles and a more compact and dense canopy than the Pine-Oak-Liquidambar forest. The Montane Rain forest trees also have greater basal area than the Pine-Oak-Liquidambar forest trees. However, since both forests have similar tree density and mean distance between trees, the greater basal area of the former forest indicates that many of the trees of the Montane Rain forest are generally larger with wider trunks (Figure 16). Both forests have relatively large numbers of

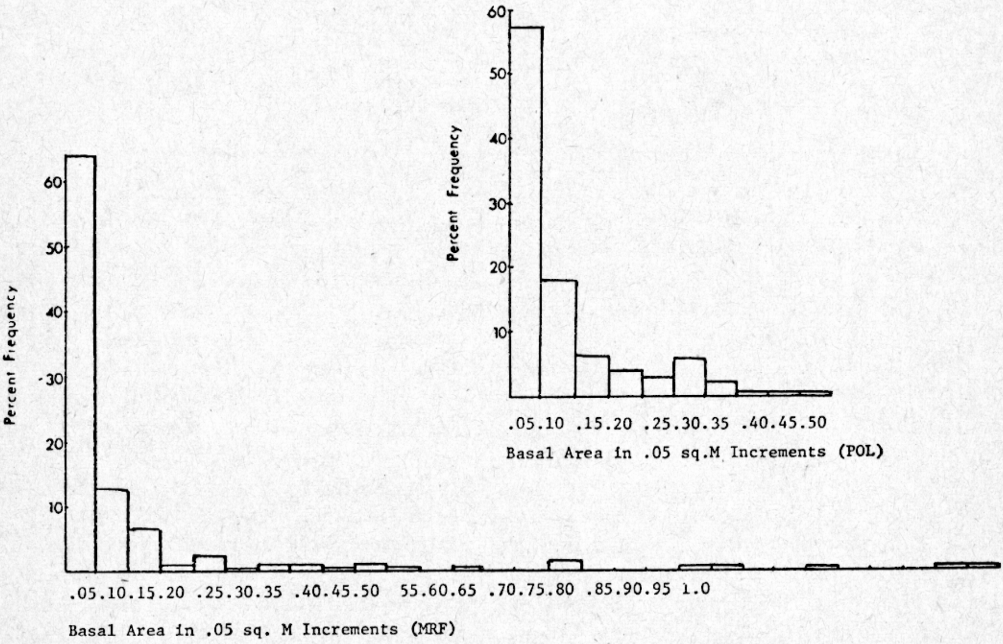


Fig. 16. Frequency distributions of basal areas of trees in the Montane Rain forest (MRF) and the Pine-Oak-Liquidambar forest (POL). Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

TABLE 11

TREE STRUCTURE OF THE MONTANE RAIN (MRF) AND PINE-OAK-LIQUIDAMBAR (POL) FOREST SITES. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO. N = NUMBER OF SAMPLES; DBH = DIAMETER BREAST HEIGHT

Tree Structure	*N*	*MRF*	*N*	*POL*
Mean distance between trees in M	170	3.23	159	12.1
Coefficient of variation	170	52.9	159	60.0
Median (M)	170	2.99	159	10.4
Mode (M)	170	2.47	159	6.9
3 X Mode (M)	170	7.41	159	20.8
No. distance measurements greater than 3 X Mode	170	2	159	15
Mean distance excluding holes (M)	—	—	159	10.3
Mean distance across holes (M)	—	—	159	129.4
Number of holes per ha	—	—	159	2.6
Area devoid of trees per ha (sq. M)	—	—	159	3 698.6
Area with tress per ha (sq. M)	—	—	159	39 861.4
Density numer 2.54 cm dbh/ha	176	963.4	164	933.5
Basal area in sq. M/ha	176	102.01	164	63.28
Mean basal area in sq. M	176	.10	164	.07
Mean height in M	35	27.01	20	24.26
Mean height to the first branch in M	35	15.03	20	11.28
Mean canopy height in M	35	11.98	20	12.98
Mean percent canopy cover	56	84.6	32	79.1

very small trees, probably due to a small amount of secondary growth due to past cutting or other disturbance in localized spots, which helps to account for similar distance measurements.

Analysis of the densities of the two forest types by the wandering quarter method (Catana, 1963) showed that the densities were similar (Table 11). There were 15 distance measurements in the Pine-Oak-Liquidambar forest longer than 3 times the mode, as compared with 2 in the Montane Rain forest. The coefficient of variation was 52.9% for the Montane Rain forest and 60.0% for the Pine-Oak-Liquidambar forest. Sixty percent was not as high a coefficient of variation as is found for clumped populations and was nearest that found in randomly distributed populations with holes in them. Exclusion of the holes from the density determinations produced the similar densities for the two forests. The means of the distance measurements were also very similar when the holes were excluded. Figure 17 shows the distance measurements of the two forests in a frequency histogram.

Deciduousness is much more evident in the Pine-Oak-Liquidambar forest during the dry season, particularly among the oaks, *Liquidambar* and other associates, than in the Montane Rain forest, which is primarily evergreen.

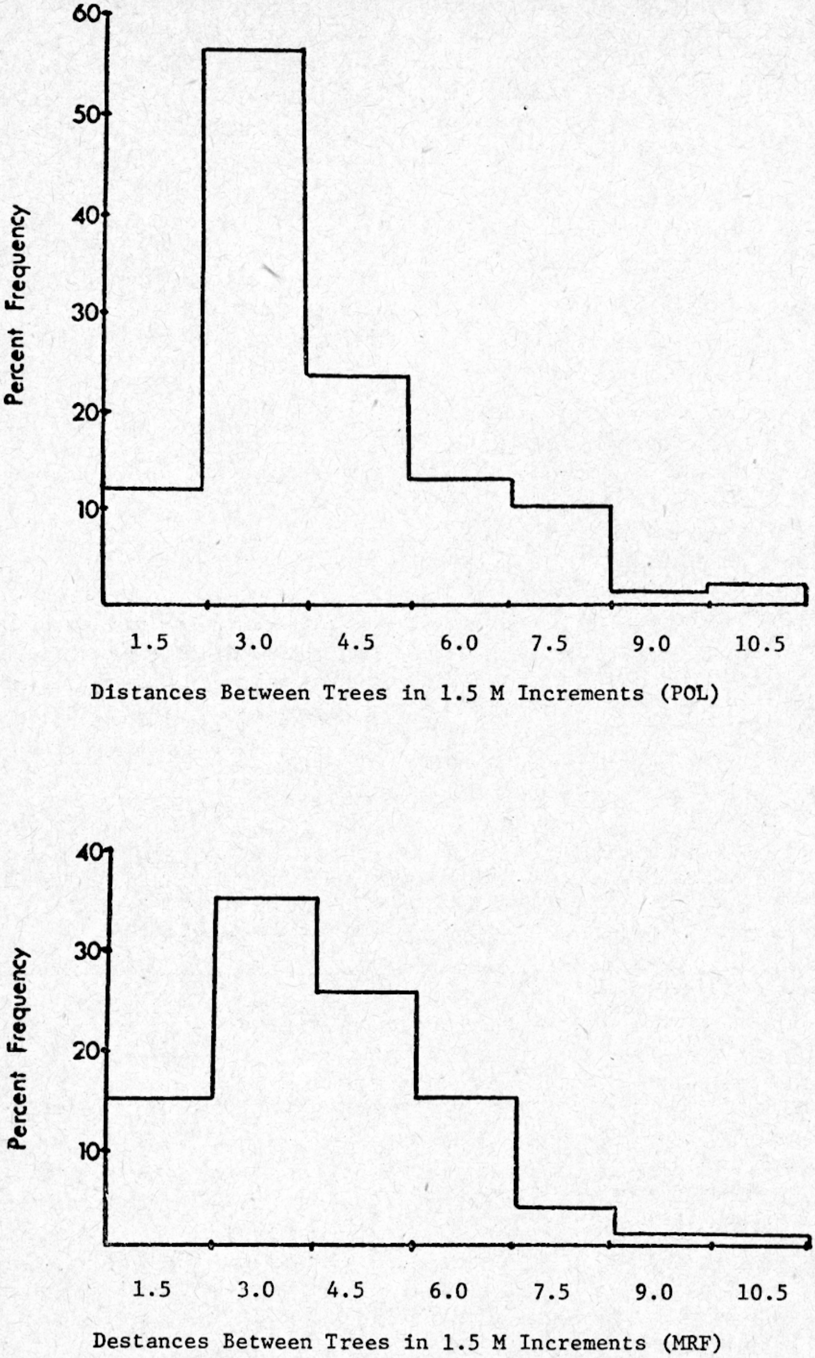


Fig. 17. Frequency distribution of distance measurements between trees in the Montane Rain forest (MRF) and the Pine-Oak-Liquidambar forest (POL). Pueblo Nuevo Solistahuacan, Chiapas, Mexico.

Both forest exhibit characteristic epiphytes, lianas, tree strata (only approximate canopy and below canopy trees), shrub and ground layers as well as other life forms but these features differ considerably in degree and species composition between the two forests.

LAYERS AND SYNUSAE-MONTANE RAIN FOREST

Canopy Trees

A description of the forest study sites by means of species composition of some of the characteristic trees, lianas, shrubs, herbs, epiphytes, etc. is now in order. However, the few species listed can only serve to give an example of the diversity of the tree species present. There is no climax dominant in the Montane Rain forest but rather many diverse species characterize the canopy trees. Among the tallest of the upperstory trees in the Montane Rain forest is a broad-leaved gymnosperm, *Podocarpus matudae* Lundell (Podocarpaceae), an oak, *Quercus acatenangensis* Trel. (Fagaceae), and a magnolia, *Magnolia sharpii* Miranda (Magnoliaceae). Several associated Laurels (Lauraceae) are *Persea americana* L., P. *donnell-smithii* Mez. and *Phoebe helicterifolia* (Meissn.) Mez. Other characteristic species present include *Brunellia mexicana* Standl. (Brunelliaceae), *Oreopanax sanderianum* Hemsl., *Dendropanax arboreum* (L.) Planch. and Dec. (Araliaceae), *Turpinia occidentalis* (Sw.) D. Don. (Staphyleaceae) and *Stemmadenia obovata* (H. & A.) Schum. (Apocynaceae).

Understory Trees

These species are usually either shade tolerant species adapted to the low light intensities under the canopy or are canopy species on their way up. These

TABLE 12

STRUCTURE COMPOSITION OF SELECTED CHARACTERISTIC TREE GENERA IN THE MONTANE (MRF) AND PINE-OAK-LIQUIDAMBAR (POL) FOREST SITES. PUEBLO NUEVO SOLISTAHUACAN, CHIAPAS, MEXICO. N = NUMBER OF SAMPLES; X = PRESENT

Genera	*N*	*MRF*	*POL*	*Percent Basal Area*	*Percent Frequency*
Cythia	17	X		2.4	9.8
Podocarpus	7	X		23.3	4.0
Aggregate (including *Magnolia, Quercus, Brunnellia, Persea, Oreopanax,* others)	152	X		74.3	86.2
Pinus	84		X	76.8	51.2
Quercus	43		X	13.8	26.2
Liquidambar	7		X	2.9	4.2
Arbutus	6		X	3.1	3.6
Aggregate (including *Saurauia, Inga, Nyssa, Cornus,* others)	24		X	3.3	14.6

latter trees are normally held back in their growth due to lack of sufficient light but they shoot on up when a canopy clearing occurs due to heavy wind storms, fire, or tree felling.

The physiognomy of the understory trees is dominated by the presence of tree ferns, some of which are up to forty feet high. The two species present are *Alsophila salvinii* Hook. and *Cyathea fulva* (Mart. & Gal.) Fee. (Cyatheaceae). Some of the characteristic trees associated with the tree ferns in the understory are *Oreopanax liebmanni* Marchal., *Phyllanthus grandifolius* L. (Euphorbiaceae), *Billia hippocastanum* Peyr. (Hippocastanaceae) and *Eugenia ravenii* Lundell (Myrtaceae).

Shrubs

The shrub layer is made up of diverse species with no dominance. However, some species are more characteristic in the Montane Rain forest than others as *Miconia donnell-smithii* Cogn., *M. glaberrima* (Schlecht.) Naud. (Melastomataceae), *Parathesis microcalyx* Donn. Sm. (Myrsinaceae), and *Zanthoxylum foliosum* Donn. Sm. (Rutaceae).

Epiphytes

Plants in this life form are abundant on trunks and branches of trees and shrubs and at times are attached to low vegetation of the forest floor as well as to over loose leaf litter. In growth they vary from small filmy ferns to woody shrubs. While there is also no species dominance in this life form, the most characteristic groups of epiphytes are the ferns, orchids, aroids, bromeliads and peperomias.

The ferns are particularly abundant with filmy ferns (Hymenophyllaceae) represented by *Hymenophyllum fucoides* var. *pedicellatum* (Kuntze) Morton and *Trichomanes radicans* L. Other larger fern epiphytes include *Asplenium auriculatum* (Thunb). Kuhn. (Aspleniaceae), *Polypodium astrolepis* Liebm., *P. Lanceolatum* (L.) Watt., *P. loriceum* L. (Polypodiaceae), *Polystichum muelleri* Fourn. (Aspidiaceae) and *Vittaria filifolia* Fee. (Vittariaceae).

A few of the charactteristic orchids (Orchidaceae) are *Brassia maculata* R. Br., *Crybe rosea* Lindl., *Epidendrum laucheanum* Rolfe, *E. vitellinum* Lundl., *E. ramosum* Jacq., *Isochilus major* C. & S., *I. linearis* (Jacq.) R. Br., *Odontoglossum bictoniense* (Batem.) Lindl. and *O. egertonii* Lindl.

Some of the typical broad leaved aroids (Araceae) are *Anthurium montanum* Hemsl., *A. seleri* Engl., *A. tuerckheimii* Engl., *Monstera friedrichsthallii* Schott and *Philodendron dedraceum* (Jacq.) Schott.

The bromeliads (Bromeliaceae), along with abundant mats of mosses, lichens, club mosses and other epiphytes, almost totally cover the boles and branches of many of the forest trees. The tillandsias are the most common of the bromeliads. They occur as clusters of narrow arching leaves attached to tree trunks and branches. A few of the characteristic species are *Tillandsia fasciculata* var. *rotunda* L. B. Smith, *T. guatemalensis* L. B. Smith, *T. rodriqueziana* Mez. and *T. violaceae* Baker. An example of a similar bromeliad with clustered but much broader leaves is *Catopsis sessiliflora* (R. & P.) Mez. Two other smaller-leaved bromeliads are *Vriesea ovandensis* Matuda and *V. werckleana* Mez.

The peperomias (Piperaceae) are herbaceous epiphytes which have succulent stems and leaves and vine-like growth. They occupy many niches in the forest but are particularly abundant over moss covered rocks, tree trunks, stems of woody lianas and many other objects in the forest. The largest species of these, which has leaves the size and shape of an American elm, is *Peperomia obtusifolia* (L.) A. Dietr. Other characteristic species with smaller leaves include *Peperomia quadrifolia* (L.) HBK., P. *reflexa* (L. F.) A. Deitr., *P. liebmanni* C. DC., *P. deppeana* S. & C., and *P. galioides* HBK.

No true epiphytic trees or shrubs were found growin in the Montane Rain forest study site but there were some woody species present which were growing epiphytically on large trees. These species, however, will eventualy become trees or shrubs rooted on the ground. These species are, in some places, so abundant on large trees which they use for support, that it is difficult to look up under the canopy of such a tree and distinguish between the leaves and branches of the host and the temporary epiphytes. Some of these species are *Oreopanax obtusifolium* L. Wms., *Clusia salvinii* Donn. (Hypericaeae), *Cavendishia guatemalensis* Loess, *Macleania insignis* Mart. & Gal., *Sphyrospermum majus* Griseb. (Ericaceae), *Columnea erythrophaea* Dcne. (Gesneriaceae) and *Weinmannia pinnata* L. (Cunoniaceae).

Club mosses grow in dense mats over both the forest floor and high into the vegetation. These include *Lycopodium clavatum* L., L. *skutchii* Maxon, *L. reflexum* Lam. (Lycopodiaceae), *Selaginella hoffmannii* Hieron. and *S. illecebrosa* Alston. (Selaginellaceae).

Two species of epiphytes in the Montane Rain forest study site are members of the cactus family (Cactaceae). Their long slender succulent leaves are found among ferns and bromeliads on the boles of large trees. Two species were found here, *D i s o c a c t u s macrantus* (Alex.) Kimn. and Hutchis. and *Nopalxochia conzattiana* Mac Dougall.

Parasites and Saprophytes

Two species of this life form were found growing on the Montane Rain forest floor. One was a small root parasite, *Conopholis americana* Wallr. (Orobanchaeae). The other was *Monotropa uniflora* L. forma *coccinea* Zucc. (Ericaceae), a small red saprophyte growing in leaf mold.

Lianas

Both woody and herbaceous vines grow over vegetation in the Montane Rain forest, some hanging down many feet from the tall canopy trees. They form an integral aspect of the physiognomy of the forest and are represented by a wide variety of species. A few of the species include *Smilax subpubescens* A. DC. (Liliaceae), *Gonolobus uniflorus* HBK. (Apocynaceae), *Centropogon cordifolius* Benth. (Campanulaceae), *Mucuna argyrophylla* Standl. (Fabaceae) and *Vitis bourgeana* Planch. (Vitaceae).

Field Layer

This structural division of the forest occurs sparsely in the lower part of the shrub layer. It consists mostly of ground palms, large ground ferns and tall perennials. Two species of ground ferns in this layer are *Baceragenia glandulosa* Leonard (Schizaeaceae) and *Marattia weinmanniifolia* Liebm. (Marattiaceae). Characteristic species of ground palms present are *Chamaedorea ehrenbergiana* H. Wendl. and *C. concolor* Mart. (Arecacea). Some of the perennial herbs of the field layer are *Coaxana ebractea* Rose (Araliaceae), *Canna edulis* Ker. (Cannaceae), *H e l i c o n i a schiedeana* Klotzsch. (Musaceae) and *Cephaelis axillaris* Sw. (Rubiaceae).

Ground Layer

The forest floor in dense shade supports sparse vegetation with relatively few species represented. However, this is not true for areas where more intense light reaches the forest floor such as stream banks, clearings and trails. Most plants presented are herbaceous annuals and perennials. Species typical for the shaded forest floor include *Pseuderanthemum cuspidatum* (Nees) Radlk. (Acanthaceae), *Centropogon grandidentatus* (Schlecht.) Zahlbr. (Campanulaceae) and *Rhynchoglossum azureum* (Schlecht.) Burtt. (Gesneriaceae).

Moist stream banks in the forest usually have additional species such as *Begonia oaxacana* A. DC. (Begoniaceae), *Tripogandra elongata* (G. F. Mey.) Woods (Commelinaceae) and a characteristic matted growth of a small delicate herb, *Pilea costaricensis* Donn. Sm. (Urticaceae). Grass species (Poaceae) are common along the edge of trails and clearings, such as *Ichnanthus axillaris* (Nees) Hitchc. and Chase, *I. nemorosus* (Sw.) Doll. and *Lasiacus divaricatus* (L.) Hitchc. Also common here is a herb, *Aploeia mondra* (Sw.) H. D. Moore (Commelinaceae) and a small sedge, *Uncina hamata* (Sw.) Urban. (Cyperaceae).

LAYERS AND SYNUSAE
PINE-OAK-LIQUIDAMBAR FOREST

Canopy Trees

There is no dense canopy in this forest but the taller trees are often close enough together to cut out some of the light to the forest floor. While there is a relatively rich diversity of species in this forest, species dominance does exist. The dominants are pine, oaks, and the associated *Liquidambar.*

The dominant pines (Pinaceae) are *Pinus oocarpa* Scheide. and *P. pseudostrobus* Lindl. Among the prominant oaks are *Quercus candicans* Nee., *Q. rugosa, Q. peduncularis* Nee. and *Q. mexicana* H. and B.

Important associated trees with the pines and oaks of this forest are *Liquidambar macrophylla* Oerst. (Hamamelidaceae), *Ternstroemia tepezapote* (Ternstroemiaceae) and *Inga eriocarpa* (Fabaceae).

Understory Trees

Saurauias (Actinidaceae) and tree legumes (Fabaceae) are characteristic trees of the Pine-Oak-Liquidambar forest but the predominate in the understory and seldom reach the height of the taller trees. Typical of the saurauias are *Saurauias comitis-rossei* Schultes, *S. villosa* DC. and *S. scabrida* Hemsl. Tree legumes include *Acacia angustissima* (Mill.) Kuntze, *A. pennatula* (S. and C.) Benth., *Calliandra houstoniana* (Mill.) Standl., *Cassia occidentalis* L. and *Erythrina florenciae* Krukoff.

Other understory trees include *Cornus excelsa* (Cornaceae), *Arbutus xalapensis* (Ericaceae), *Psidium guajana* (Myrtaceae) and *Myrica cerifera* (Myricaceae).

Shrubs

There is considerable diversity of shrubs in this forest as there is in the Montane Rain forest. Some of the more common species are *Rhus terebinthifolia* S. and C. (Anacardiaceae), *Phyllanthus miruri* L. (Euphorbiaceae), *Mimosa albida* H. and B. (Fabaceae) and *Triumfetta grandiflora* Vahl. (Tiliaceae).

Epiphytes

Epiphytes are not nearly as dense or as diverse in the Pine-Oak-Liquidambar forest as they are in the Montane Rain forest but there is still a wide variety present. Representative bromeliads include *Catopsis subulata* L. B. Sm., *Tillandsia juncea* (R. and P.) Poir, *I. schediana* Standl. and the familiar spanish moss, *I. usneoides* L. A typical aroid bole epiphyte is *Anthurium montanum* Hemsl.

Some of the representative epiphytic ferns are *Polypodium angustifolium* Swartz, *P. biauritum* Maxon. and *Pteris vittata* L. (Pteridaceae). Typical orchid epiphytes are *Nageliella purpurea* (Lindl.) L. and *Epidendrum ochraceum* Lindl. The peperomias typical in this forest are *Peperomia collocata* Trel., *P. deppeana* S. and C. and *P. peltilimba* C. DC.

Parasites

Only one parasite was found in the Pine-Oak-Liquidambar forest floor. This was *Conopholis americana* Wallr., the same root parasite which was found growing in the Montane Rain forest floor. There species of woody semiparasites (Visaceae) were found growing on trees here. These were *Phoradendron falcatum* (C. and S.) Trel., a parasite on *Liquidambar Psittacanthus calyculatus* (DC.) C. Don., parasitic on pines and oaks and *Struthanthus marginata* (Desr.) Blume, parasitic on *Crataegus*.

Lianas

There are considerably fewer species of Lianas in this forest than in the Montane Rain forest. There is often considerable growth of the species which are present however.

Two subspecies of the poison ivy (Anacardiaceae) vine is common on trunks of many of the trees. These are *Toxicodendron radicans* ssp. *barkleyi* Gillis and *T. radicans* ssp. *radicans* (L.) Kuntze. Twining herbaceous lianas present include *Pachyrhizus strigosus* (Clausen (Fabaceae), *Phaseolus coccineus* L. (Fabaceae) and *Gaudichaudia albida* var. *substomentosa* Ndzu (Malpighiaceae).

Common species of the woody lianas in this forest are *Gelsemium sempervirens* (L.) Persoon (Loganiaceae), *Smilax bona-nox* L. (Liliaceae), *S. jalapensis* Schlecht. and *S. domingensis* Willd.

Ground Layer

Characteristic species of the forest floor, including natural grassy openings and clearings in the forest are *Equisetum myriochaetum* S. and C. (Equisetaceae), *Botrychium cicutarium* Swartz (Ophioglossaceae), *Ageratum houstonianum* Mill. (Asteraceae) and *Tagetes filifolia* Lag. (Asteraceae).

Typical ground orchids in the forest include *Calanthe mexicana* Reichb. F., *Dichaea neglecta* Schltr. and *Sobralia decora* Batem.

Some of the more common grasses (Poaceae) are *Briza rotundra* (HBK) Steud., *Olyra latifolia* L., *Panicum nitidum* Lam. and *Sporobolus junceus* (Michx.) Kunth.

EDAPHIC, TOPOGRAPHIC AND DISTURBED COMMUNITIES

Within the Montane Rain and Pine-Oak-Liquidambar forests are areas and habitats wich, due to lack of normal soil, gentle topography or disturbance, are not able to support the climatic vegetation of the region. Natural steep rocky slopes and wet rocky banks often provide edaphis and topographic habitats wich support plant spcies often found only in these particular habitats. One good example of a plant species restricted to steep talus slopes in clearings of the Montane Rain forest is a course perennial with leaves up to six feet wide on stalks up to eight feet long, *Gunnera killipiana* Lundell (Haloraginaceae).

Some characteristic species for calcareous limestone cliffs and rocky slopes of the study areas are two grasses: *Andropogon glomeratus* (Watt). BSP and *Arundinella deppeana* Nees; *Coriaria ruscifolia* L. (Coridriaceae), a shrub;

Epidendrum ibaqueuse HBK. (Orchidaceae), an orchid; *Pinguicula moranensis* HBK. (Lentibulariaceae), a small insect catching herb. Wet rocky cliffs in the Montane Rain forest provide an especially good microhabitat for species such as *Begonia barkeri* Knowl. and Westc. (Begoniaceae), *B. sartorii* Liebm. and *Pilea microphylla* (L.) Liebm. (Urticaceae).

Disturbance to the foreste of this study area (Plates 6 and 7) has created suitable habitats for a wide variety of plant species wich are generally not able to compete in the natural undisturbed communities. Species of this nature usually "take over" along roadsides and trails, in abandoned plowed fields, in recently cut over forests, in disurbed forest floors and in a wide variety of successional seres. For example, a fern, *Pteridium aquilinum* var. *feei* (Schaffn.) Maxon (Pteridaceae), has replaced many of the natural species components in disturbed forest floors in the Pine-Oak-Liquidambar forest.

Also two tree species, *Cordia ferruginea* R. and S. (Boraginaceae) and *Trema micrantha* (L.) Blume (Ulmaceae), are common only in secondary forest derived from destruction of the Montane Rain forest.

Other species wich are characteristic of the disturbed areas and older successional seres (Plate 7) of the Montane Rain and Pin-Oak-Liquidambar forest are *Polygala floribunda* Benth. (Polygalaceae), *Fuchsia microphylla* HBK, subps. *quercetorum* Breedlove (Onagraceae) and *Phytolacca riviniodes* Kunth and Bouche. (Phytolaccaceae).

SUCCESSIONAL OND CLIMAX STATUS OF THE STUDY SITES

Mature growth along with hte presence of small diameter trees, is exhibited in both the Montane Rain and Pine-Oak-Liquidambar forest sites (Figure 16). The climax nature of both forests is evidenced by their diversified and well developed life forms and synusae and the absence of successional indicator species, except in disturbed areas. Miranda (1952) refers to the Montane Rain an Pine-Oak-Liquidambar forest (Table 10) as mature climax communities of Chiapas (translation).

In consultation with Dr. Helmut Leith 1968 personal communication, concerning the stability of the forests of Chiapas, it is understoor that the Pine-Oak-Liquidambar forest of Chiapas, like the Montane Rain forest, is a natural climax community wich has been present in immediate history. However, unlike the Montane Rain forests of Chiapas wich have receded with disurbance, the Pine-Oak-Liquidambar forest has expanded its range with disturbance. Disturbance to the natural communities of the study area is related to and occurs primarily as a result of subsistance farming wich has been practiced for a very long time in this area of Chiapas. Tree cutting, forest burning and cattle grazing are typical of the disturbance wich takes place. Once the clearing and burning process is complete, the soil is good for about one year, and will hardly produce a crop the second year.

Successional seres are evidenced in both forests (see "disturbed communities" mentioned previously), but the Pine-Oak-Liquidambar forest appears to survive disturbance better than the Montane Rain forest. Gómez-Pompa, *et al.* (1972) notes that regeneration problems in tropical forests are quite different from regeneration problems in tropical areas with definite long dry seasons where regeneration under intensive exploitation is not very different from temperate areas. They said that plants in areas with long dry seasons are better adapted to exploitation since they possess better characteristics for survival during adverse conditions.

When the Montane Rain forest is disturbed there appears to be irreversible concomitant changes in the soil wich makes succession back to climax difficult if not impossible. With the vegetation cover gone, the relatively thin humus mantle of the Montane Rain forest soil is soon eroded away with heavy reins and drained of soil minerals by intense unfertilized crops. The Pine-Oak-Liquidambar forest, on the other hand, received less rain to cause erosión and has a relatively thicker humus soil layer tan the former forest, wich helps is to survive disturbance.

In summary, the Montane Rains forest of the study area appears to be a stable climax community in areas free of disturbance, but is relatively unstable when disurbed and is subject to complete extinction if repearted disturbance occurs at its present rate. The Pine-Oak-Liquidambar forest of the area is surviving disturbance better and appears to be relatively stable as evidenced by its encroachment onto drier and poorer soils created due to disturbance. Another factor to consider in the Pine-Oak-Liquidambar forest stability is the fact that the Montane Rain forest soil is relatively richer in soil minerals than the former forest, so this latter forest is preferred by subsistance farmers for conversion to crops.

DISCUSSION

The main differences in structure of the two forests are mainly differences in tree basal area, canopy cover and height, and tree height. The Montane Rain forest has taller trees with a greater canopy cover, a narrower canopy, and a greater basal area than the Pine-Oak-Liquidambar forest. The differences in species composition are most apparent in the epiphytes, ground ferns and tree species diversity. The Montane Rain forest has a greater abundance of epiphytic species and ground ferns, including tree ferns, and a greater tree species diversity than the Pine-Oak-Liquidambar forest (Table 13). The plant species in general in the Montane Rain forest are more tropical than those in the Pine-Oak-Liquidambar forest, which has many temperate species.

The difference in climate of the two forests appears to be the main factor for their differences in plant structure and composition. The difference in climate is apparently due to the differences in slope exposure of the Jitotol Ridge with the resultant rain shadow effect wich this topographic feature produces with the aid of prevailing northeasterly winds.

Both forest types appeared to be stable climax communities where not disturbed. Both forests have been cut over and disturbed in some places for agricultural purposes as well as for timber. Where this has occurred, any resulting secondary which develop are more like the Pine-Oak-Liquidambar forest, regardless of which forest type was originally disturbed. The increased complexity of the Montane Rain forest as compared to the Pine-Oak-Liquidambar forest suggests that the former forest is re-established with greater difficulty than the latter. As a result, it appears that disturbance to the two forests enchances the re-estabilishment of the Pine-Oak-Liquidambar forest and may actually cause it to spread and expand its range, but inhibits redevelopment of the Montane Rain forest.

This might be explained in part by noting that the climatic factors of the Montane Rain forest in the study area are just under the line, so to speak, of the environmental requirements for rain forest structure and composition. Thus, any slight alteration in the forest structure, such as cutting or burning, alters the microclimate of the forest area to the extent that the Montane Rain forest establisher under the altered climatic conditions.

The Pine-Oak-Liquidambar forest, on the other hand, has less exacting climatic factors for its structure and development and as a result cannot only-reestablish in situ but can also spread into a disturbed Montane Rain forest site and re-establish there because of the altered microclimate.

The critical factors then, which appear to be responsible for the relatively close proximity of the tropical Montane Rain forest to the temperate-like Pine-Oak-Liquidambar forest are: the rain shadow effect of topography of the area; the resultant differences in climate the above topographical feature produces; the differences in plant structure and composition caused by the difference in climate of the two forests.

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Plate 1. A panoramic view looking northward along the Jicotol Ridge, Chiapas, Mexico. Montane Rain forest can be seen extending the total length of the crest. All of the forest in the valley to the left of the ridge is of the Pine-Oak-Liquidambar type. Arrow indicates the study area. Photograph taken by Elwin Norton, November, 1970.

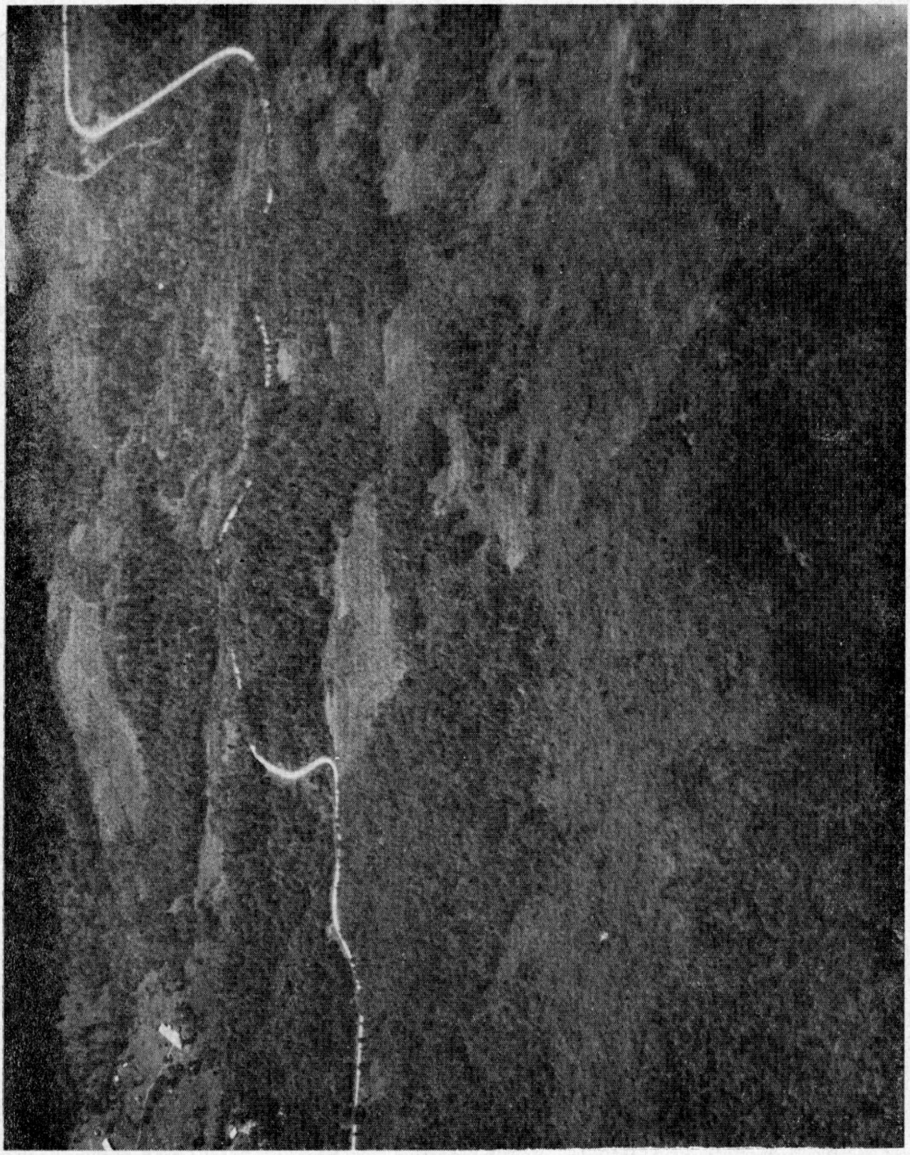

Plate 2. Aerial view of the study sites showing the Montane Rain forest in the immediate foreground on NE facing slopes and the Pine-Oak-Liquidambar forest in the background on SW slopes. Photograph taken by Elwin Norton, November, 1970.

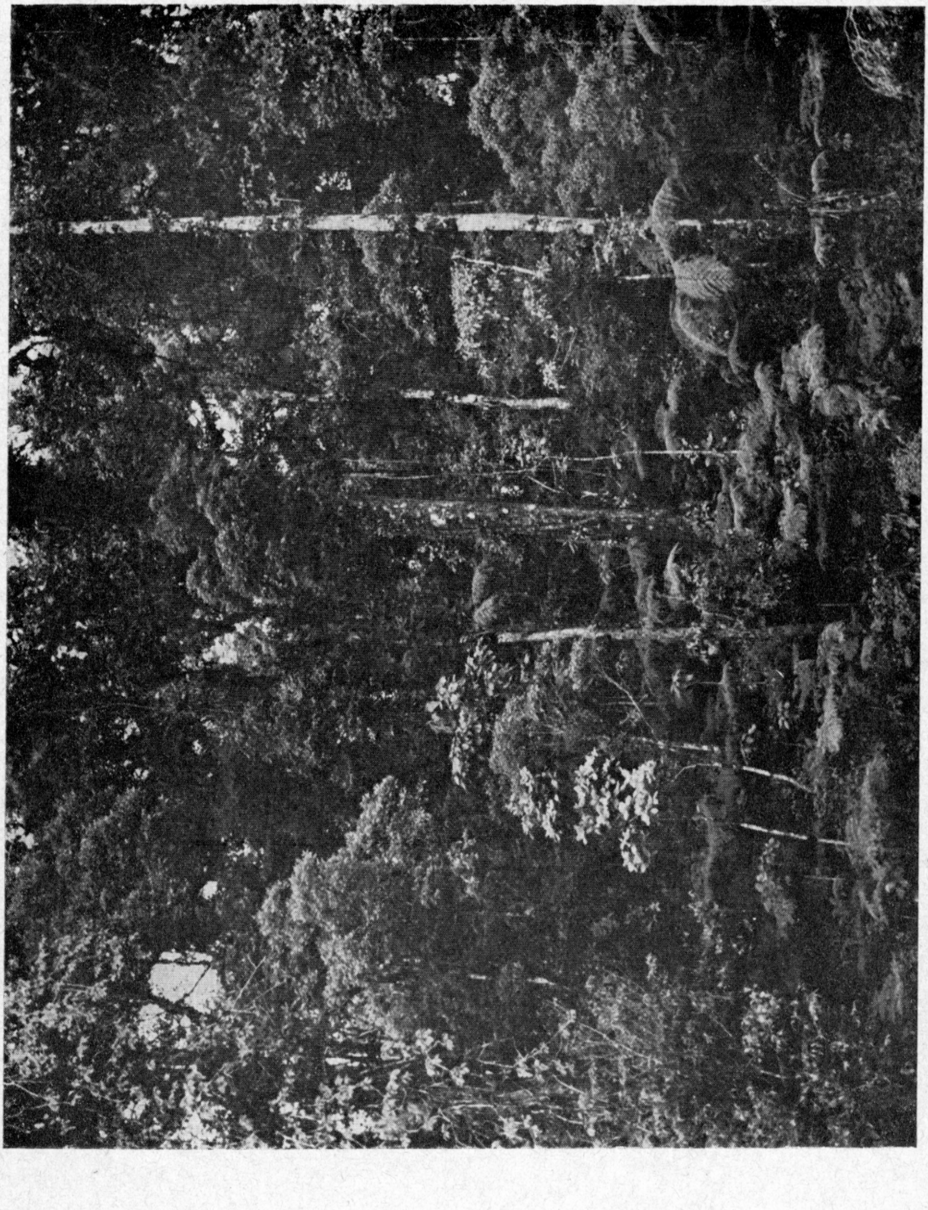

Plate 3. View of the Montane Rain forest study site showing diverse tree species including *Podocarpus matudae, Quercus acantenangensis* and *Magnolia sharpii.*

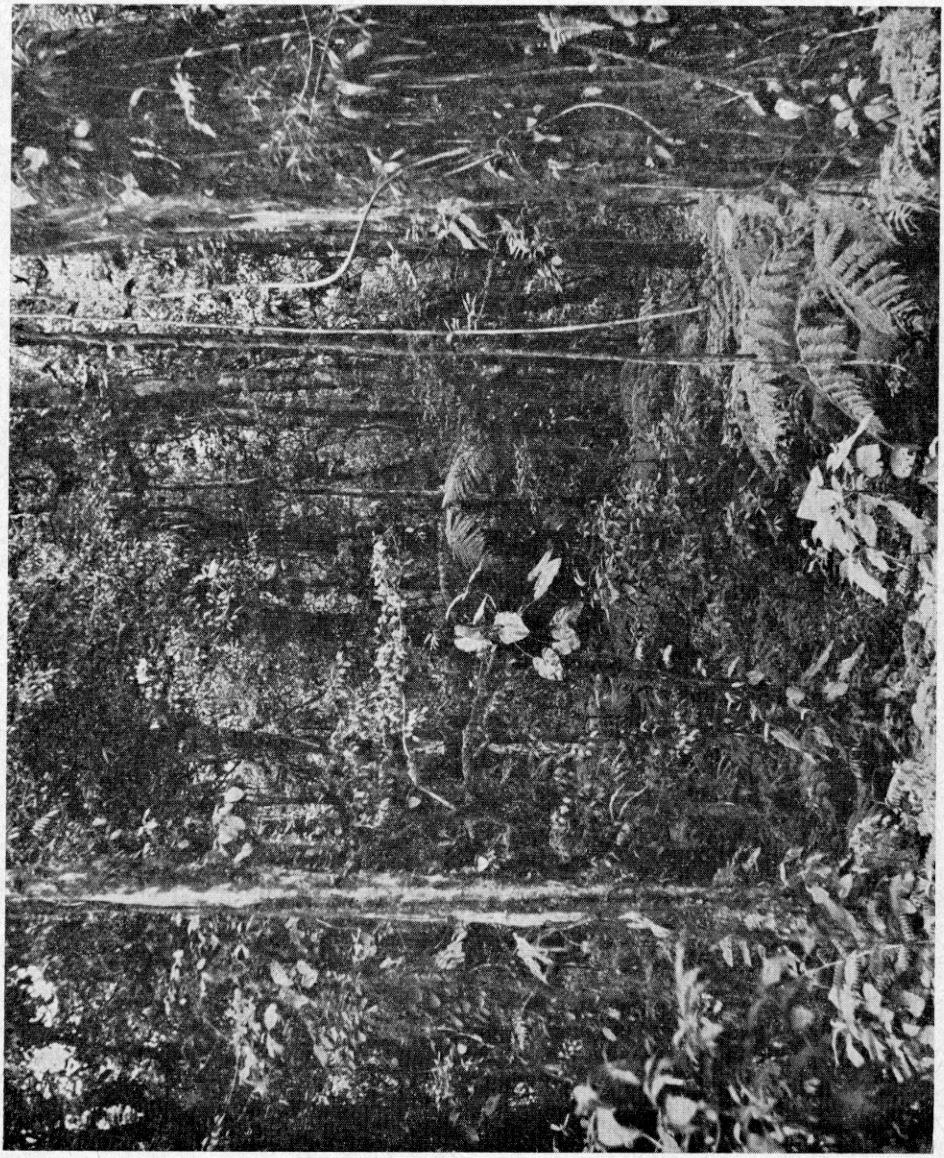

Plate 4. Montane Rain forest study site showing ground ferns and palms, lianas and epiphytes.

Plate 5. View of the Pine-Oak-Liquidambar forest showing typical dominant pines and oaks.

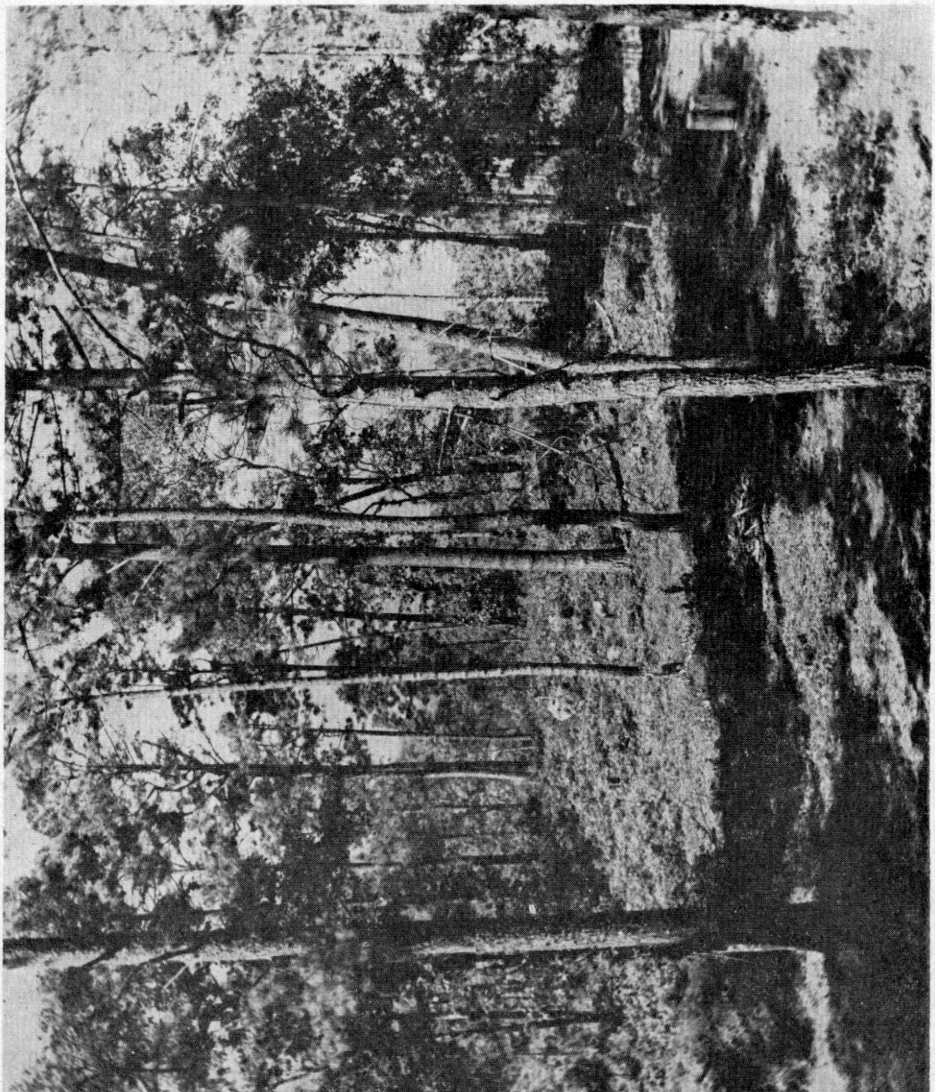

Plate 6. Pine-Oak-Liquidambar forest showing typica l disturbance in the vicinity of settled areas.

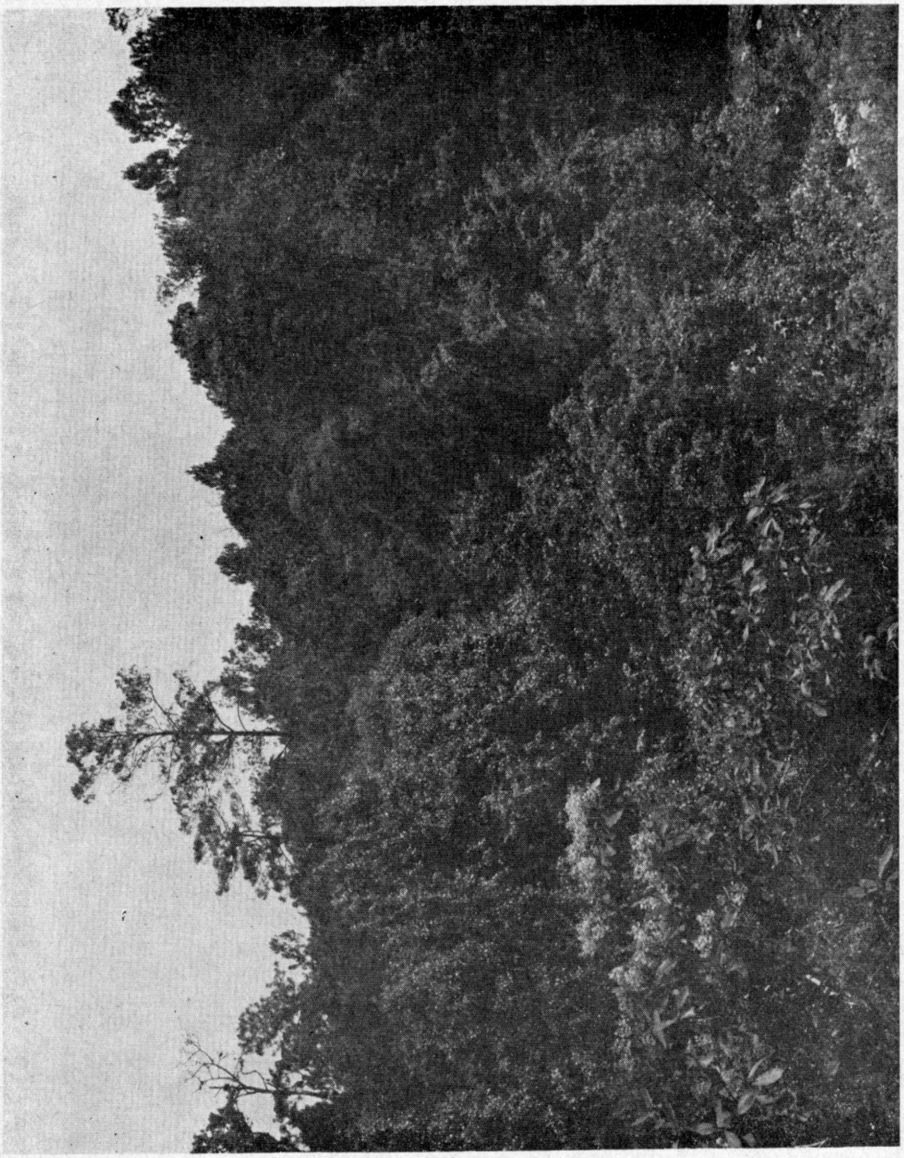

Plate 7. Typical view of the Pine-Oak-Liquidambar forest study site showing characteristic second growth along trains and cut over areas.

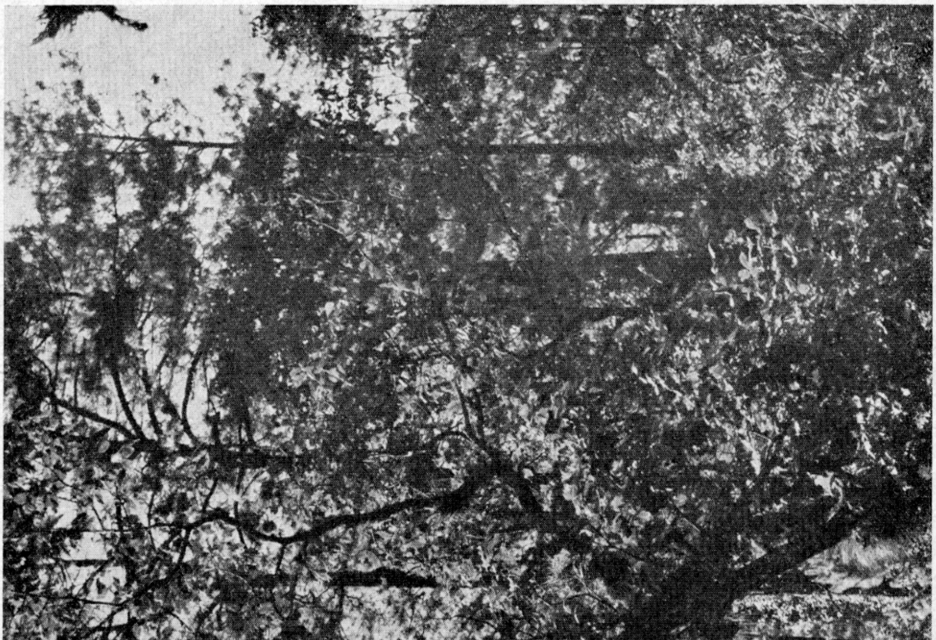

Plate 8. Pine-Oak-Liquidambar forest study site showing typical epiphytes and oppenness of the forest.