

U.S. Army Tropic Test, Fort Clayton, Canal Zone

Semiannual Report No. 3

ENVIRONMENTAL DATA BASE FOR REGIONAL

STUDIES IN THE HUMID TROPICS

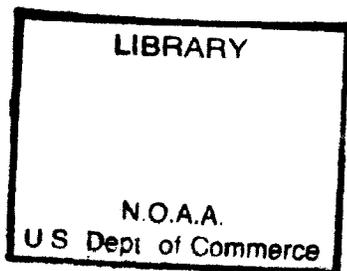
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FOREWORD

This summary report, the third of a series to be issued semiannually, covers the progress and status of the Environmental Data Base for Regional Studies in the Humid Tropics. The project is sponsored by the Office, Secretary of Defense, Advanced Research Projects Agency (ARPA), Directorate of Remote Area Conflict, and by the Department of Army, Office of Chief of Research and Development, Army Research Office (ARO).

The study reported herein is being conducted under the guidance and with the direct participation of the Research Division of the US Army Tropic Test Center. The Commanding Officer during the report period was Colonel Pedro R. FlorCruz. The Commanding Officer, at time of publication, is Colonel John Zakel, Jr. The research program is carried out under the supervision of Dr. Guy N. Parmenter, Chief of the Division. Staff members of the Division have been responsible for the preparation of the individual study papers comprising the body of this report, as noted herein. Compilation and arrangement of the report has been done by Mr. Edward E. Garrett, Physical Environmental Scientist of the Division.

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SUMMARY

This report, the third in a series of semiannual progress reports of the Environmental Data Base Project, presents a resume of Project objectives and methods and descriptions of the operational sites.

The Climate section (Part IV) shows the data collected and instrumentation used with a description of automatic instrumentation planned. Analyses of daily temperature variations and a discussion of soil-surface temperature determination are presented.

The Soils and Hydrology section (Part V) presents analyses of soil-moisture profiles and soil-strength profiles and their interrelationships. Detailed information on soil profiles and physical characteristics is presented in an appendix.

The Vegetation section (Part VI) presents analyses of forest litter accumulation. Information on seedling characteristics and seed germination, and a revised vegetation inventory and plot for the Albrook Forest site are given in appendices.

The section dealing with Microbiology and Chemistry of the Atmosphere contains papers on: (a) airborne and surface deposited microorganisms; (b) observations of microbial populations of the forest soil; and (c) a discussion of atmospheric particulate matter.

ENVIRONMENTAL DATA BASE FOR REGIONAL STUDIES IN THE HUMID TROPICS

PART I. INTRODUCTION

Background

This report, covering the period 1 September 1966 through 28 February 1967, is the third in a series of semiannual reports on the progress of the Environmental Data Base for Regional Studies in the Humid Tropics (USATECOM Project No. 9-4-0013-01). It presents a review of project activities during the reporting period along with selected technical data and analyses. Additional technical information will be found in the periodic Data Summaries to be issued under project auspices.

The project is sponsored jointly by the Advanced Research Projects Agency, Office of the Secretary of Defense, and by the Army Research Office, Office of the Chief of Research and Development, Hqs., Dept. of the Army. Work is carried out by the US Army Tropic Test Center, US Army Test and Evaluation Command, Army Materiel Command, with contracted support of Weather Engineers of Panama, Corp. Additional scientific support was received during the reporting period through co-operative arrangements with the National Center for Atmospheric Research, and with several individual scientists.

The project is an interdisciplinary investigation of the humid tropical environments of the Canal Zone and the Rio Hato military training reservation. These environments include a high rainfall region on the Caribbean slope of the Isthmus where tropical evergreen broadleaf forest prevail, a less wet region on the Pacific slope where tropical semideciduous forests predominate, and the still drier Rio Hato region where a typical savanna association is found. The latter two areas are characterized by a pronounced dry season (though the Caribbean, or Atlantic, site has a relatively dry season, it is not so well marked). These areas are analogous to environments in regions of tropical monsoon and tropical savanna climates (Koeppen Am and Aw) in southeast Asia and other parts of the tropics.

Objectives

The overall objective of the Data Base project is to provide increased knowledge concerning the militarily significant environmental factors of humid tropical environments. The project is designed to provide a bank of information and analyses derived from observations of selected physical and biological conditions at representative sites in the three natural environments mentioned above. A specific objective of the US Army Tropic Test Center is to obtain detailed information concerning the environments in which its tests are conducted, which information will be of direct value in the planning and accomplishment of tests as well as in the development of tropical test techniques and methods. The project will establish, at the sites chosen as representative of the three specified environmental

regimes, the spatial and temporal variations of a number of natural conditions that affect the durability and operability of materiel as well as such factors as movement, communication, visibility, and the physical performance of troops.

Description of Project

Tasks

The basic program for the Data Base project provides for investigations in the following fields: (1) Climate, specifically its microaspects, or the meteorological phenomena manifested between the ground surface and a height of approximately 50 meters; (2) Soils and hydrology, with emphasis on factors related to soil trafficability and ground water; (3) Vegetation, with emphasis currently being placed on taxonomy, foliage canopy, and the ground accumulation of forest debris (litter); (4) Microbiology, with emphasis on numbers and kinds of bacteria and fungi and their transportation and deposition; (5) Macrofauna, currently limited to selected arthropods; and (6) Atmospheric chemistry, i.e., chemical and physical contaminants of the air.

Detailed study plans providing guidance for various aspects of each project task have been prepared in the form of Project Memoranda. These memoranda are periodically reviewed and revised to accord with current practice and to reflect experience gained in operation of the project.

Observational Approach

In order to obtain as much information as possible on the interrelationships between various environmental factors, investigations are carried out simultaneously at selected sites. Manpower limitations and the cost of instrumentation have dictated that the full range of observations be limited to a few main observational sites. Two are in operation; three others are planned. "Main" sites are established where a broad range of environmental elements will be observed over a relatively long period of time. Additional "satellite" sites will be, and have been, established in the same general area, at places with different physical and biological conditions where restricted data are observed.

The project plan calls for establishing two main observational sites in each of the two major environmental types found in the Canal Zone. A fifth site is planned for the Rio Hato military reservation where the third principal local variation of the tropical environment is found. The two observational sites in the semideciduous forest environment on the Pacific side of the Canal Zone are now in operation. One is within the forest, the other in a large clearing nearby. A similar pair of sites is planned for the tropical evergreen broadleaf forest environment on the wetter Caribbean side of the Canal Zone. The paired sites are necessary in order to fully characterize conditions in each of the two environments. Both cleared land and forest are extensive throughout the humid tropics and military

operations are not confined to one or the other, yet each imposes significantly different environmental conditions affecting movement, visibility, deterioration of materiel, etc.

Some of the observations are made by Tropic Test Center personnel; however, most of the routine observations are made under contract by the Weather Engineers of Panama Corp., following guidance provided in the Project Memoranda. Project scientists on the Tropic Test Center staff monitor all work and provide additional guidance as necessary. The frequency of observation varies with the nature of the parameter, ranging from the continuous reading of some meteorological instruments to the one-time observation of some soil factors. The high frequency of many observations requires manning of the main sites on a 24-hour basis.

PART II. OBSERVATION SITES

Site Locations

General

The selection of sites within the Canal Zone which are representative of the generalization, "Humid Tropics", is complicated by the scarcity of land that is not significantly subjected to influences stemming from cultural or industrial activities and at the same time is available for continued use (for one to two years) by military agencies for research purposes. The sites must be readily accessible to the personnel required for performing the necessary observations and maintenance. Physical security to preclude molestation must be provided for the costly instrumentation. The requirement for electric power necessitates close access by road, or nearness to power lines. Furthermore the sites should, as nearly as practicable, represent the extreme developments of the range of environmental variation that occur within the area. The variational range within the isthmian region is, indeed, large for its comparatively small size, but is not by any means inclusive of all variations for the world's humid tropics. All of these considerations limit site selection and may force some compromise to be made in their choice.

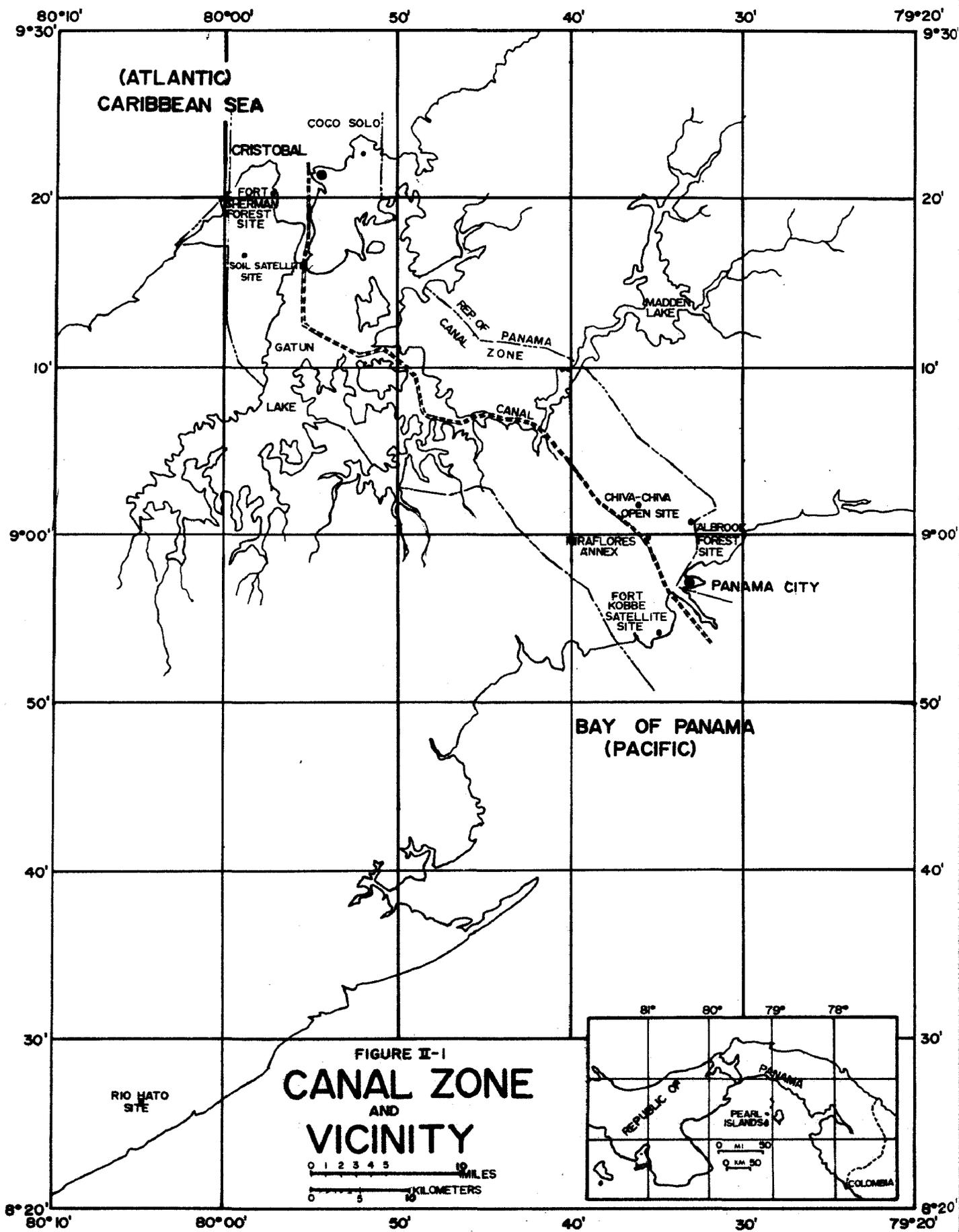
Established Sites

Two main observational sites have been established to date. These are located on the Pacific side of the Canal Zone, which is characterized by moderate precipitation (an average annual rainfall of approximately 70 inches) with a pronounced wet and dry season, and semideciduous forest vegetation. The two sites are located in the Albrook Forest and at Chiva Chiva (see Figure II-1). The latter is in an open grass-covered area, four kilometers (2-1/2 miles) from the former, which is located within a forest with a relatively dense canopy about 10 meters thick and extending to about 27 meters above the ground and with an understory of shrubs and vines with greatest density at about 2 meters height.

Three satellite sites are currently being utilized for observation of soils and meteorological data. These are sites for which significant bodies of data had been gathered before the institution of the Data Base project, and at which instrumentation was already installed. Consequently it was considered desirable to maintain the sites under reduced observation schedules. Their locations are described below.

Proposed Sites

The establishment of paired sites is planned for the Atlantic side of the Canal Zone, where the significantly higher annual rainfall (130 in. average) with a less pronounced dry season produces vegetation with evergreen characteristics and forests with higher and denser canopies than on



the Pacific side. Two areas are under consideration: one in the vicinity of Fort Sherman, (military grid PV 144324), and the other in the Coco Solo Naval Ordnance Annex (military grid PV 245365).

The fifth main observational site has been planned for location on the Rio Hato Military reservation (approximate grid location, NV 970283) about 80 kilometers southwest of the Albrook sites (see Figure II-1). This is within a savanna (grassland) area with an annual rainfall of approximately 40 in. appreciably less than that at the Albrook area. Observations of some climatic factors were started at a location near the proposed site in 1965. These include rainfall, temperature, relative humidity, and wind speed and direction.

Site Descriptions

Albrook Forest Site

This site is located in the northeastern portion of the Albrook Air Force Base immediately adjacent to the Fort Clayton Military Reservation (military grid PV 602964). Elevations at the site range from 30 to 33 meters above sea level. (See Grid Orientor Map in Appendix C). The ground slopes very gently, approximately 4%, to the southeast. The nearly-level surface is broken only by a one-half to two-meter deep channel of an ephemeral stream running southerly across the eastern side of the test site. This stream enters the Rio Curundu which follows a southerly course, natural here in the upper stretches but canalized several kilometers downstream. The regional topography is characterized by rounded hills, with elevations up to 130 meters. The nearest lie about 400 meters to the east, and others 600 meters to the NW, the latter being part of a generally NE-SW trending line, with slopes ranging from about 10% to 50%. The site is located on a low, erosional terrace. The soil is a residual clay oxisol with a light-textured surface rich in organic matter. The parent material is an agglomeratic tuff (a pyroclastic rock with a fine grained matrix of volcanic ash with phenoclasts up to 1 cm in diameter).

The vegetation consists of many species of trees, shrubs, and vines, many of which are deciduous. The upper surface of the tree canopy occurs at 26 to 28 meters. The forest extends for several kilometers on all sides, except to the east of Rio Curundu where the large vegetation has been cleared. A gravel road provides access to a paved highway three kilometers distant. Figure II-2 is a view over the forest as seen from 30 meters above ground.

A walk-up tower, 46 meters high, fabricated from aluminum tubing, is located at the center of the site. Figure II-3 is a diagrammatic sketch of the towers showing the instrumentation array as generally followed at both main sites. Figure II-4 is a photographic view of the below-canopy portion of the tower.



FIGURE II-2. ALBROOK FOREST, WESTWARD FROM TOWER AT 30 METERS

Two generators of 30 kw capacity provide the power required to operate the electrical instrumentation (see Figure II-5). They are located at the site entrance within a wire-protected enclosure. A concrete, air conditioned building for use of the round-the-clock observers, and in which the central components of the data acquisition and recording systems are located, is positioned on the perimeter of the site. (Figure II-5).

Figure II-6 shows the relative locations of the principal installations of the site, including the meteorological, soils, and biological instruments and devices. To minimize disturbance of the existing vegetation and soil surfaces, wooden walk-ways have been installed.

Chiva Chiva Open Site

This site is located in the northwestern section of the Fort Clayton Army Reservation (at PV 562979) approximately four kilometers west-northwest of the Albrook Forest Site. The location is in an open grass-covered area at approximately 30 meters elevation. The clearing extends about one-half kilometer to the northeast and in other directions for nearly one kilometer. Beyond the cleared area, a forest, like that at the Albrook site, prevails. The surface is nearly level, with a slight incline toward the southwest. Clay, oxisolic, residual soils, very sticky and plastic, comprise the surface mantle. The parent material, an agglomerate, is generally similar to that at the forest site. A tower, identical in structure to that at Albrook, is centrally positioned on the site. This tower carries a somewhat smaller number of instruments than the one at the Albrook Forest site (see Figure II-3). Two air conditioned vans are provided for the observers and the central components of instrumental recording systems. Electricity is supplied to the site by commercial line power. Figure II-7 is a plot of the principal installations at the site. Figure II-8 shows views of the tower and the vans at Chiva Chiva. Due to the open nature of the site,

ALBROOK FOREST SITE

CHIVA CHIVA OPEN SITE

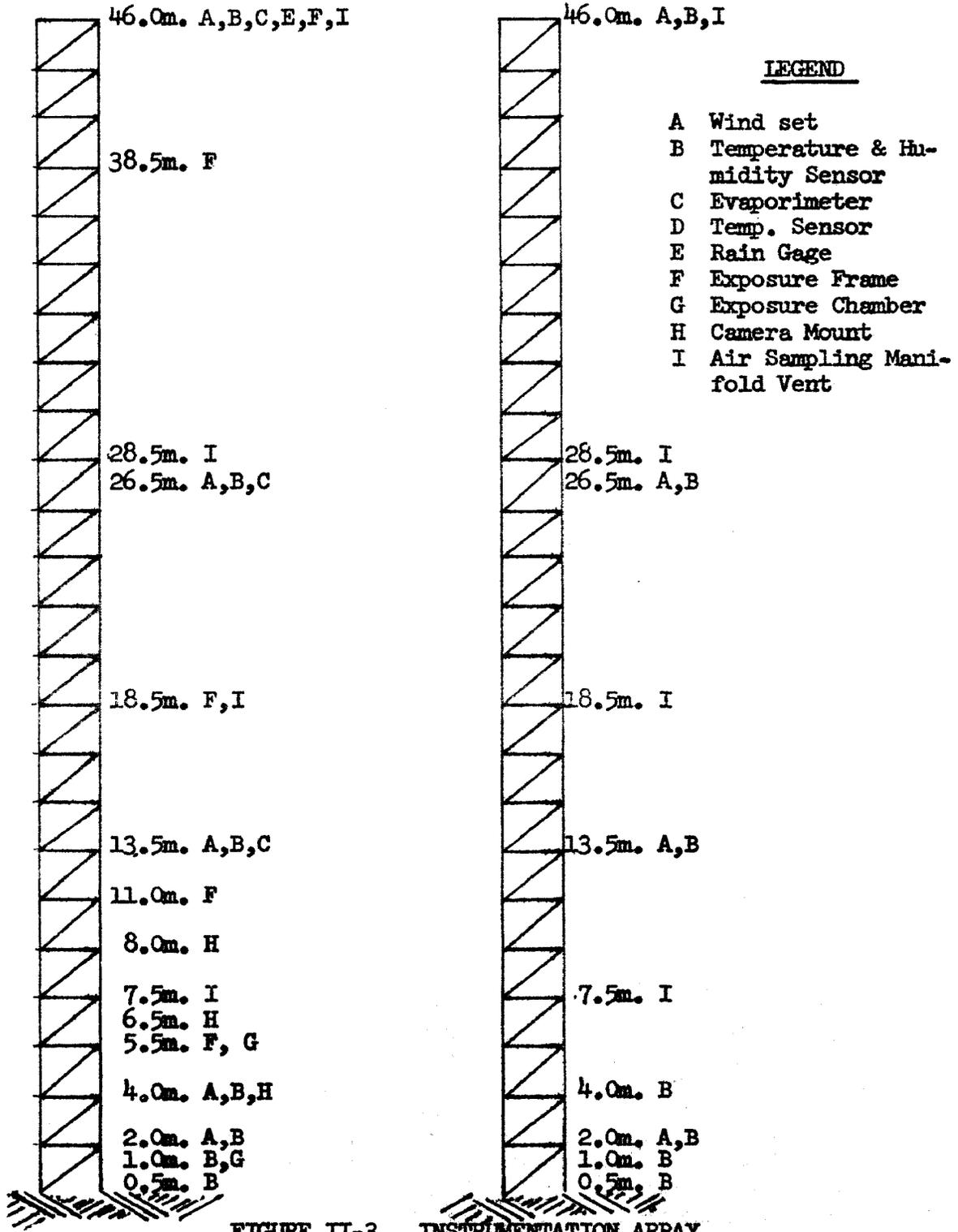


FIGURE II-3. INSTRUMENTATION ARRAY ON OBSERVATION TOWERS

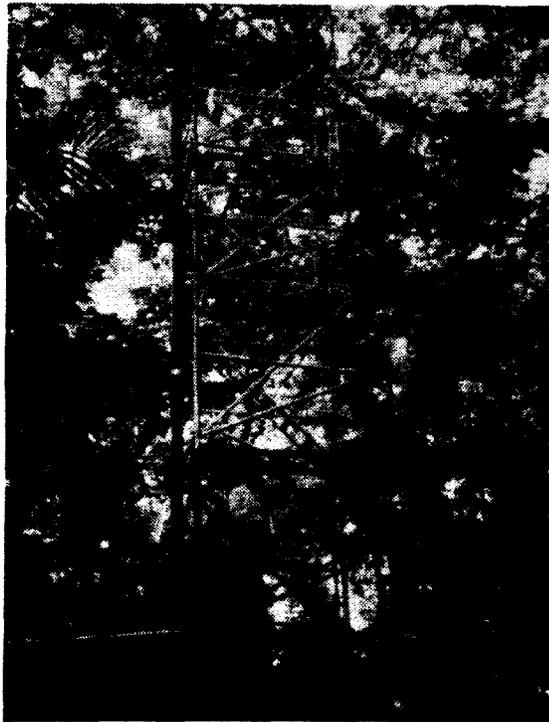
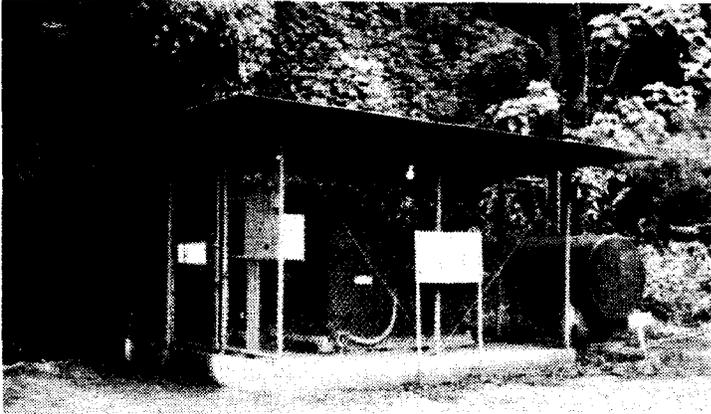
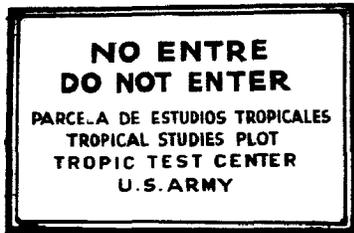


FIGURE II-4. TOWER AT
ALBROOK FOREST SITE



Generator Shelter
at Entrance to Site



Observer and Recording
System Building

FIGURE II-5. INSTALLATIONS AT THE ALBROOK FOREST SITE

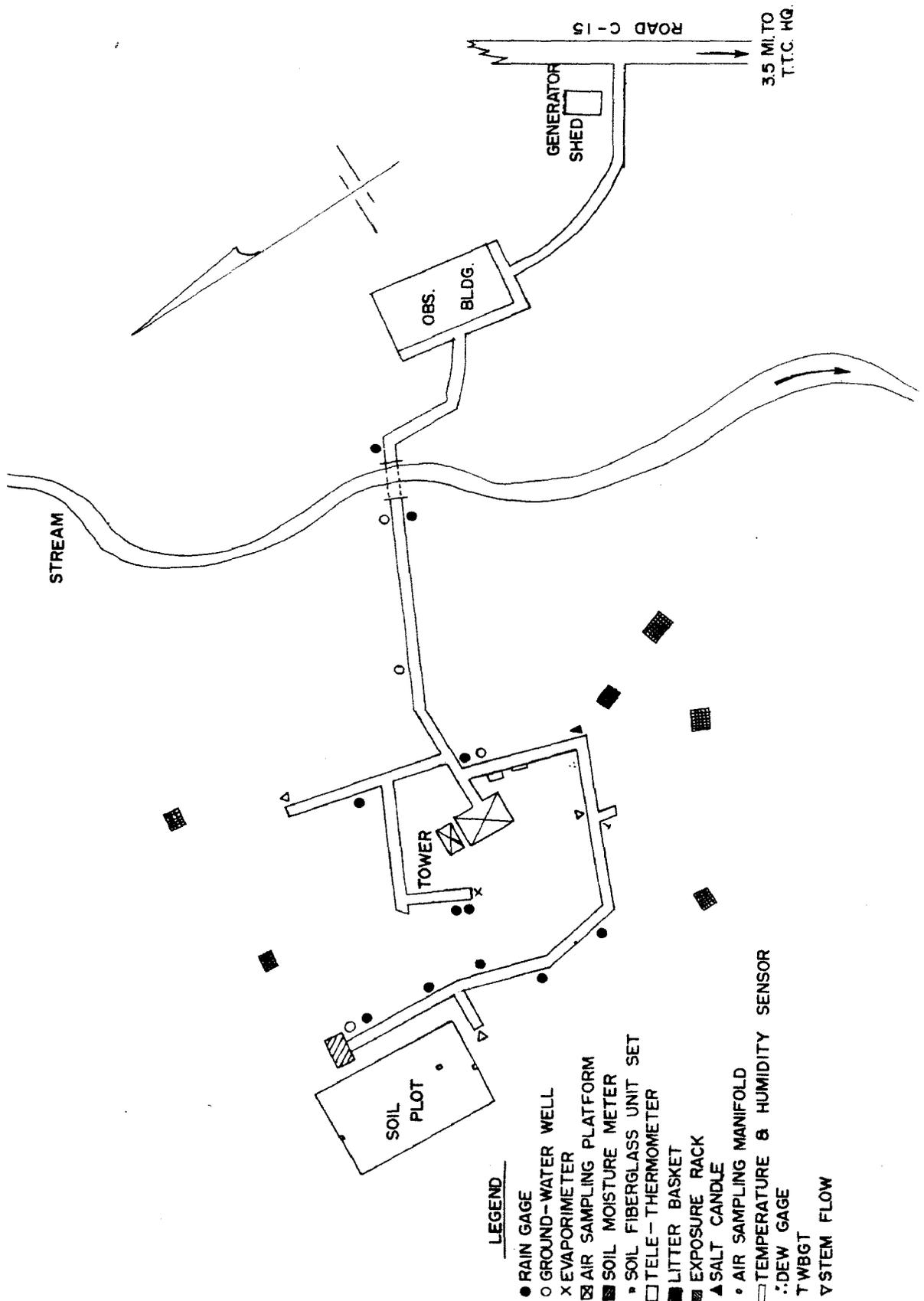
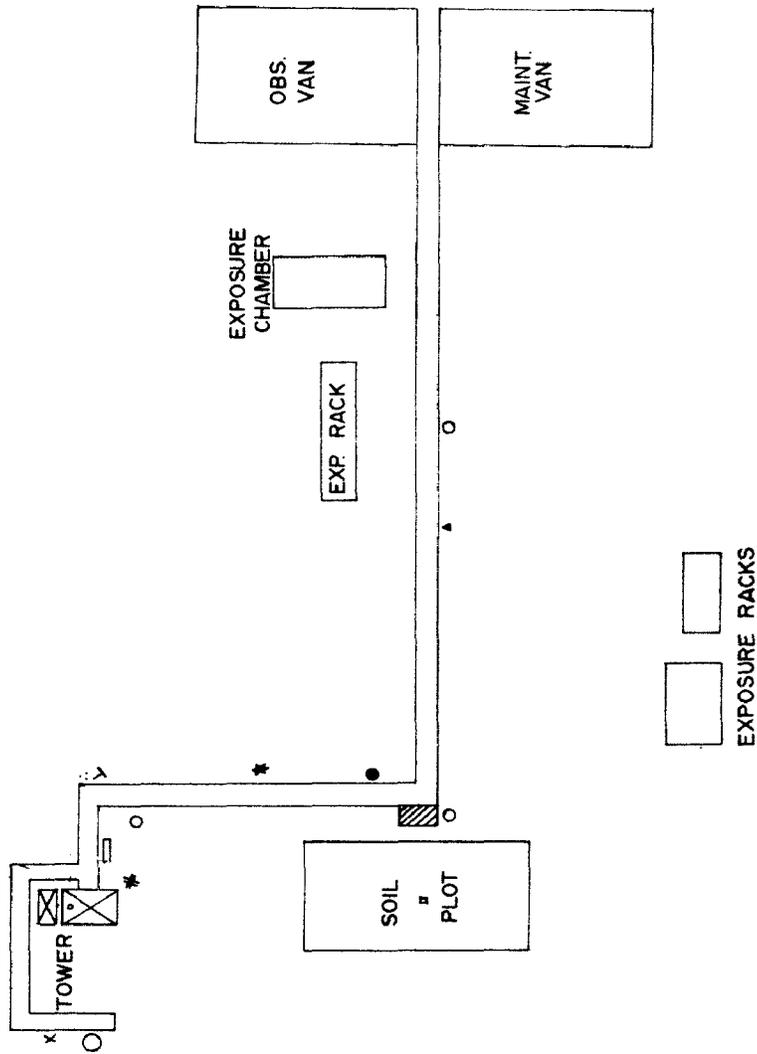


FIGURE 11-6. ALBROOK FOREST SITE. GENERALIZED PLOT



- LEGEND**
- RAIN GAGE
 - GROUND-WATER WELL
 - EVAPORATION PAN
 - × EVAPORIMETER
 - ★ GRASS MINIMUM THERMOMETER
 - ▲ SALT CANDLE
 - ∴ DEW GAGE
 - ▨ SOIL MOISTURE METER
 - ▣ SOIL FIBERGLASS UNITS SET
 - AIR SAMPLING MANIFOLD
 - TEMPERATURE & HUMIDITY SENSOR
 - ◻ INFRARED THERMOMETER
 - ⊠ AIR SAMPLING PLATFORM
 - T WBGT

FIGURE II-7. CHIVA CHIVA SITE. GENERALIZED PLOT

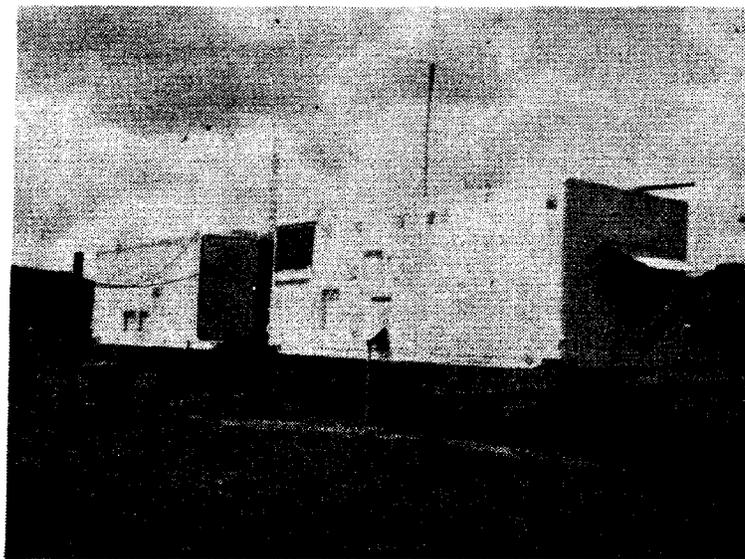
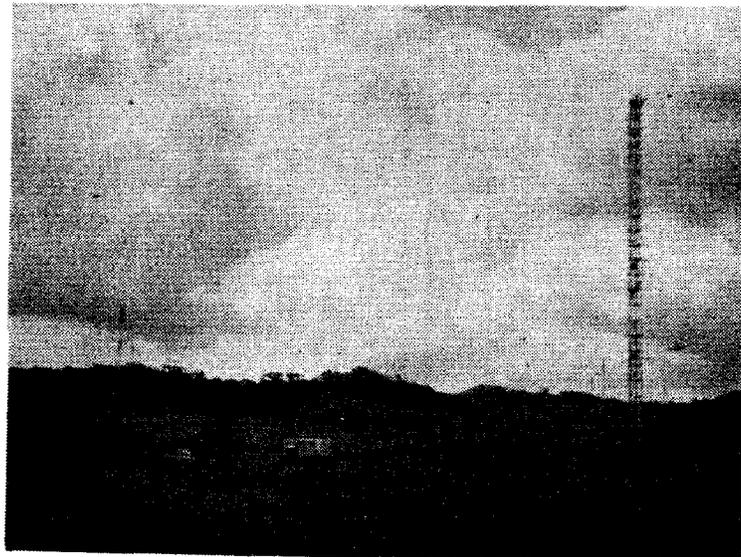


FIGURE II-8. CHIVA CHIVA SITE, OBSERVATION TOWER AND VANS

biological observations are not carried out as extensively as at the Albrook site. As at Albrook, wooden walk-ways are provided to prevent disturbance of natural conditions.

Albrook Satellite Site (Soil)

The Albrook soil satellite site is located approximately 400 meters southwest of the Albrook Forest site at PV 600960. The soil is a well-drained clay. The physical environment and topographic setting is similar to that of the main Albrook site. A cased ground-water well, with a water-level recorder, a hygrothermograph, and two recording rain gages (one in the open and another under the canopy) comprise the permanently installed equipment at this site.

Fort Kobbe Satellite Site (Soil)

The Fort Kobbe soil satellite site at PV 569848 (location shown on Figure II-1) is at an elevation of approximately 20 meters. The soil is a dark clay, very sticky and plastic. The topography is nearly flat, with slopes less than 2%. The vegetation is of secondary growth, with trees reaching a maximum height of about nine meters. Two rain gages, in the open and under the canopy; a hygrothermograph; and a cased water-well with a level recorder are installed at the site. Figure II-9 is a view of the site.

Fort Sherman Satellite Site (Soil)

This site is located within the Fort Sherman Army Reservation on the Atlantic side of the Canal Zone at PV 117261 (see Figure II-1), at an elevation of approximately 80 meters. The generally broken terrain slopes at about 40%. Soils are reddish brown, oxisolic clays, very sticky and plastic. The site is covered by a mature forest, with evergreen broadleaf species predominating. The same meteorological equipment is installed as at the other satellite sites.



FIGURE II-9. FORT KOBBE SOIL SATELLITE SITE

PART III. PROJECT ACCOMPLISHMENTS

General

During the reporting period observations have continued in the five study areas comprising the project. Microclimatic observations continue to provide the major bulk of the recorded data, and information concerning macrofauna has not been developed to the level planned. Observations of soil and hydrology conditions are approaching completion for the sites established on the Pacific side of the Canal Zone, though further analysis of the data is still required. The biological staff has been reinforced significantly, but the additions came at, or shortly after, the conclusion of the report period. Results of the increased capability in this area will be reflected in future reports of project progress.

Dissemination of Data

Monthly Microclimatic Summary

The publication of a series of microclimatic abstracts for monthly release is currently under way. These summaries will contain the basic meteorological data compiled each month. They are designed to provide factual knowledge, as well as cognizance of the existence of the data, to interested governmental agencies. Extensive distribution will be made (approximately 100 will be distributed initially). Additional copies will be available at the Defense Documentation Center.

This publication, entitled "Monthly Microclimatic Summary", is being printed as a pamphlet of approximately 30 pages. It consists of a brief introduction followed by the tabulated data. Table III-1 is a listing of the meteorological elements presented in the publication. Figure III-1 is an example of one of the tabular forms incorporated in the pamphlet.

TABLE III-1. ELEMENTS REPORTED IN MONTHLY MICROCLIMATIC SUMMARY

Monthly Means of Air Temperature by Hour
 Monthly Ranges of Air Temperature by Hour
 Monthly Means of Relative Humidity by Hour
 Monthly Ranges of Relative Humidity by Hour
 Monthly Means of Soil Surface Temperature by Hour
 Monthly Means of Wet Bulb Temperature by Hour
 Monthly Means of Barometric Pressure by Hour
 Monthly Means of Precipitation by Hour
 Monthly Totals of Precipitation
 Monthly Ranges of Soil Surface Temperature by Hour
 Monthly Ranges of Wet Bulb Temperature by Hour
 Monthly Ranges of Barometric Pressure by Hour
 Monthly Ranges of Precipitation by Hour
 Monthly Means of Wind Speed by Hour
 Monthly Ranges of Wind Speed by Hour
 Relative Frequencies of Wind Directions (46 meters, Albrook)
 Relative Frequencies of Wind Directions (4 meters, Albrook)
 Relative Frequencies of Wind Directions (46 meters, Chiva Chiva)
 Relative Frequencies of Wind Directions (4 meters, Chiva Chiva)
 Summary of Elements with Non-Hourly Frequencies of Observation:
 WBGY - (Albrook)
 Evaporation - (Albrook)
 Precipitation - (Manual gage network, Albrook)
 Precipitation - (Stem Flow, Albrook)
 WBGY - (Chiva Chiva)
 Evaporation - (Chiva Chiva)
 Minimum Grass Temperature - (Chiva Chiva)
 Maximum Temperature - (Albrook Satellite site)
 Minimum Temperature - (Albrook Satellite site)
 Maximum Relative Humidity - (Albrook Satellite site)
 Minimum Relative Humidity - (Albrook Satellite site)
 Precipitation - (Albrook Satellite site)
 Maximum Temperature - (Fort Kobbe, Satellite site)
 Minimum Temperature - (Fort Kobbe, Satellite site)
 Maximum Relative Humidity - (Fort Kobbe, Satellite site)
 Minimum Relative Humidity - (Fort Kobbe, Satellite site)
 Precipitation - (Fort Kobbe, Satellite site)
 Maximum Temperature - (Fort Sherman, Satellite site)
 Minimum Temperature - (Fort Sherman, Satellite site)
 Maximum Relative Humidity - (Fort Sherman, Satellite site)
 Minimum Relative Humidity - (Fort Sherman, Satellite site)
 Precipitation - (Fort Sherman, Satellite site)

SUMMARY OF METEOROLOGICAL OBSERVATIONS
HOURLY DATA
NOVEMBER 1966

| Exposure | Monthly Means of Air Temperature by Hour (°F) | | | | | | | | | | | | | | | | | | | | | | | | Monthly Summary | | | | |
|--------------------------|--|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----------------|------|----------------|------|------|
| | Site | Level | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | No. of Obs. | Min. | Mean |
| Albrook (Forest site) | 46.0 m | 74.0 | 73.8 | 73.6 | 73.5 | 73.4 | 74.3 | 76.1 | 78.2 | 79.6 | 80.7 | 80.8 | 80.4 | 79.8 | 79.3 | 78.2 | 77.1 | 75.8 | 75.2 | 74.8 | 74.5 | 74.3 | 74.3 | 74.3 | 74.1 | 715 | 71.7 | 76.2 | 85.6 |
| | 28.5 m | 73.8 | 73.6 | 73.4 | 73.2 | 73.1 | 74.5 | 76.8 | 79.2 | 81.1 | 81.9 | 81.7 | 81.4 | 80.4 | 80.2 | 79.1 | 77.7 | 76.2 | 75.4 | 75.1 | 74.6 | 74.4 | 74.2 | 74.0 | 74.0 | 718 | 69.2 | 76.6 | 88.1 |
| | 26.5 m | 73.8 | 73.8 | 73.4 | 73.2 | 73.2 | 74.6 | 77.1 | 79.8 | 81.7 | 82.7 | 82.3 | 82.0 | 81.0 | 80.6 | 79.6 | 77.9 | 76.2 | 75.3 | 75.0 | 74.5 | 74.4 | 74.2 | 73.9 | 73.9 | 718 | 69.7 | 76.8 | 89.9 |
| | 13.5 m | 73.6 | 73.4 | 73.3 | 73.1 | 72.9 | 72.8 | 73.6 | 75.9 | 78.0 | 79.6 | 80.8 | 80.9 | 81.0 | 80.2 | 79.5 | 78.6 | 77.4 | 76.0 | 75.1 | 74.7 | 74.3 | 74.2 | 73.9 | 73.7 | 720 | 68.4 | 76.1 | 86.9 |
| | 8.0 m | 73.5 | 73.2 | 73.2 | 73.0 | 72.9 | 72.7 | 73.5 | 75.4 | 77.8 | 79.4 | 80.6 | 80.8 | 80.8 | 80.1 | 79.4 | 78.5 | 77.3 | 76.0 | 74.9 | 74.6 | 74.2 | 74.0 | 73.8 | 73.5 | 720 | 69.9 | 76.0 | 86.3 |
| | 4.0 m | 73.1 | 72.9 | 72.9 | 72.6 | 72.5 | 72.3 | 73.2 | 75.6 | 77.5 | 79.1 | 80.3 | 80.5 | 80.2 | 79.4 | 78.7 | 77.8 | 76.8 | 75.5 | 74.5 | 74.2 | 73.8 | 73.6 | 73.4 | 73.2 | 718 | 69.5 | 75.6 | 85.2 |
| 2.0 m | 73.1 | 73.0 | 72.9 | 72.6 | 72.5 | 72.3 | 73.2 | 75.3 | 77.2 | 78.8 | 79.9 | 80.1 | 79.9 | 79.3 | 78.7 | 77.8 | 76.7 | 75.5 | 74.5 | 74.2 | 73.8 | 73.6 | 73.5 | 73.2 | 718 | 69.5 | 75.5 | 85.0 | |
| 1.0 m | 73.4 | 73.3 | 73.1 | 73.0 | 72.8 | 72.6 | 73.2 | 75.1 | 77.0 | 78.3 | 79.4 | 79.6 | 79.6 | 79.5 | 78.8 | 77.7 | 76.7 | 75.5 | 74.6 | 74.6 | 74.1 | 73.9 | 73.7 | 73.5 | 720 | 70.0 | 75.6 | 85.0 | |
| 0.5 m | 73.5 | 73.4 | 73.3 | 73.2 | 73.0 | 72.9 | 73.3 | 74.8 | 76.5 | 77.7 | 78.6 | 78.9 | 79.0 | 78.7 | 78.5 | 77.5 | 76.8 | 75.8 | 74.9 | 74.6 | 74.2 | 74.0 | 73.8 | 73.6 | 720 | 69.8 | 75.4 | 83.5 | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------|------|------|------|------|------|------|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--|--|--|--|--|--|
| 46.0 m | 74.1 | 73.8 | 73.6 | 73.5 | 73.4 | 74.0 | 75.9 | 78.4 | 79.8 | 80.7 | 80.8 | 80.6 | 80.8 | 80.8 | 79.9 | 79.0 | 77.5 | 76.4 | 75.6 | 75.3 | 74.9 | 74.7 | 74.5 | 74.2 | 696 | 71.1 | 76.5 | 85.6 | | | | | | |
| 28.5 m | | | | | | | This level was not instrumented for air temperature at this time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26.5 m | 74.1 | 73.7 | 73.6 | 73.5 | 73.4 | 74.0 | 76.0 | 78.5 | 80.0 | 80.8 | 80.9 | 80.7 | 80.7 | 80.7 | 80.0 | 79.1 | 77.9 | 76.7 | 75.8 | 75.3 | 74.9 | 74.7 | 74.5 | 74.2 | 720 | 70.8 | 76.5 | 86.4 | | | | | | |
| 13.5 m | 73.9 | 73.6 | 73.4 | 73.3 | 73.2 | 73.8 | 76.2 | 78.7 | 80.4 | 81.3 | 81.4 | 81.2 | 81.0 | 80.3 | 79.4 | 78.0 | 76.8 | 75.8 | 75.3 | 74.9 | 74.6 | 74.4 | 74.0 | 716 | 70.6 | 76.6 | 87.5 | | | | | | | |
| 8.0 m | | | | | | | This level was not instrumented for air temperature at this time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.0 m | 73.3 | 73.2 | 72.9 | 72.9 | 72.9 | 73.0 | 74.4 | 77.1 | 80.0 | 81.6 | 82.3 | 82.5 | 82.0 | 81.8 | 81.3 | 80.2 | 78.4 | 76.7 | 75.7 | 75.1 | 74.7 | 74.2 | 74.0 | 73.5 | 715 | 69.0 | 76.8 | 88.8 | | | | | | |
| 2.0 m | 73.1 | 72.9 | 72.7 | 72.7 | 72.7 | 74.5 | 77.5 | 80.2 | 81.7 | 82.4 | 82.7 | 82.3 | 82.0 | 81.1 | 80.2 | 78.2 | 76.4 | 75.4 | 74.8 | 74.4 | 73.9 | 73.7 | 73.2 | 715 | 68.5 | 76.7 | 89.4 | | | | | | | |
| 1.0 m | 73.4 | 73.1 | 72.9 | 72.9 | 72.7 | 74.4 | 77.7 | 81.0 | 82.8 | 83.2 | 83.6 | 83.1 | 82.7 | 81.4 | 80.1 | 78.2 | 76.1 | 75.1 | 74.9 | 74.5 | 74.1 | 73.8 | 73.6 | 719 | 68.0 | 77.0 | 91.0 | | | | | | | |
| 0.5 m | 73.5 | 73.2 | 73.0 | 72.9 | 72.8 | 74.0 | 76.9 | 80.0 | 82.6 | 84.0 | 83.9 | 84.2 | 83.5 | 81.9 | 80.3 | 78.7 | 76.5 | 75.4 | 74.8 | 74.4 | 74.1 | 73.9 | 73.7 | 720 | 68.9 | 77.1 | 95.5 | | | | | | | |

FIGURE III-1. EXAMPLE OF TABULATED METEOROLOGICAL DATA
IN MONTHLY MICROCLIMATIC SUMMARY

PART IV. CLIMATE*

Introduction

This subtask of the Data Base project is designed to determine the microclimatic characteristics of the observation sites, with particular reference to other environmental studies being conducted concurrently. Measurements of climatic elements are made through the vertical profiles by exposing sensors at several selected levels on the 46-meter towers together with an array placed at the ground level at the two main sites, Albrook Forest and Chiva Chiva (see Figures II-2, -5, and -6). All determinations are made at scheduled time intervals, and like measurements are made simultaneously, at the forest and open sites. The simultaneity and continuity of measurements at the Data Base sites makes possible the definition in precise terms of the areal and temporal variations of the humid tropical climate as exhibited at the two sites.

Instruments used for data acquisition are selected on the basis of ability to withstand the severe tropical environment while producing reliable results. A continuing training program is conducted to obtain maximum efficiency from the observers.

Observations

Meteorological observations of the following elements have been made: Clouds, Dew, Evaporation, Humidity, Precipitation, Pressure, Special phenomena, Stem flow, Temperature, Visibility, Wet-bulb-globe temperature, Wind speed and Wind direction. Temperature, humidity, and wind measurements are taken at eight levels on the tower: 0.5, 2, 4, 8 meters, and at the levels of the base and top of the upper canopy, two meters above the canopy, and the top of the tower (46 meters). Precipitation is measured above the canopy and at the ground level at the forest site. The ground level measurements include both direct canopy penetration and stem flow. All other measurements, made at both sites, are made at the most advantageous exposures. Measurements of radiation and sunshine which have not been made to date, will begin with the installation of the Meteorological Data Acquisition and Recording Systems (MDARS), described below.

The full range of climatic elements has been observed at the two main sites, as nearly as possible, while only limited data were observed at the Rio Hato savanna site. Temperatures, humidities, and rainfall were measured at the three satellite soil sites. The types and frequencies of meteorological observations made at each site are summarized in Table IV-1.

* These introductory and descriptive sections of Part IV have been prepared by Mr. Michael A. Fradel, Meteorological Technician.

TABLE IV-1. LOCATION OF SENSORS AND FREQUENCY OF OBSERVATIONS

| Element | Height (meters) | | | | | | Frequency | | | | |
|---------------------|-----------------|-----|-----|-----|-----|-----|-----------|------|------|------|------------------------|
| | Sfc | 0.5 | 1.0 | 2.0 | 4.0 | 8.0 | | 13.5 | 26.5 | 28.5 | 46.0 |
| Temperature: | | | | | | | | | | | |
| Dry Bulb | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | Hourly*/Continuously |
| Wet Bulb | - | 2 | - | 2 | 2 | - | - | - | - | - | Hourly*/Continuously |
| Grass Minimum | 4 | - | - | - | - | - | - | - | - | - | Once Daily |
| WBGT Index | - | - | 2 | - | - | - | - | - | - | - | Hourly (0600-1900 EST) |
| Relative Humidity | - | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | Hourly*/Continuously |
| Barometric Pressure | - | - | 2 | - | - | - | - | - | - | - | Continuously |
| Evaporation | 2 | - | - | - | - | - | - | 3 | - | 3 | Once Daily |
| Precipitation: | | | | | | | | | | | |
| Recording Gage | - | - | 1 | - | - | - | - | - | - | 3 | Continuously |
| Manual Gage | - | - | 3 | - | - | - | - | - | - | - | 4 Times Daily |
| Stem Flow | - | - | 3 | - | - | - | - | - | - | - | 4 Times Daily |
| Wind: | | | | | | | | | | | |
| Direction | - | - | - | - | 5 | - | - | - | - | 2 | Continuously |
| Speed | - | - | - | 2** | 5 | - | 2** | 2** | - | 2 | Hourly**/Continuously |

* Observation made with sling psychrometer when recorders are inoperative.

** Hourly.

1. All sites
2. Albrook and Chiva Chiva
3. Albrook only
4. Chiva Chiva only
5. Main sites and Rio Hato

Instrumentation

Current Instrumentation

The instruments used for making the meteorological measurements have been largely of standardized types: (see previous Semiannual Report, (1)* pp. 17-19) standard rain gages for precipitation, various standard types of hygrothermographs and psychrometers for temperatures and humidities (see Figure IV-1), Belfort and GMQ/12 wind sets for winds, and a standard evaporation pan. Although the hygrothermographs and the wind sets are adequate instruments under normal conditions, their exposure to the tropical environment necessitates considerable maintenance effort in order to obtain data of maximum continuity and accuracy. This applies to any instrument employing the strip chart recording technique. To counteract these deficiencies in instrumentation, the MDARS was specifically designed to operate in the severe tropical environment. The strip chart recording technique has been eliminated; the active electronics are being placed in air-conditioned buildings, to the greatest extent possible; and the sensors are of advanced design to minimize effects of environmental exposure. Consequently, a higher degree of accuracy in the data can be attained and the maintenance effort greatly reduced.

To further improve techniques and instrumentation, infrared thermometers have been added to measure soil surface temperatures (Figure IV-2). An experimental evaporimeter consisting of a Livingston atmometer and a modified Piche evaporimeter (the edge of the disc has been sealed) was placed next to the standard evaporation pan (see Figure IV-3) to establish correlations between the various instruments. The rain gage network, for the measurement of rain penetration through the canopy, will be increased to improve the determination of the representative amount of rainfall reaching the forest floor. A detailed discussion of the experiment with infrared thermometers is presented in a following section. Results of the experiment with the evaporimeters will be presented in future reports.

Future Instrumentation

A contract was awarded on 21 December 1966 for the procurement of two complete and separate units of an automatic meteorological data acquisition and recording system (MDARS). Each system consists of meteorological sensors mounted on the observation towers, a means for converting the sensor output to measurable quantities, a measuring system, and a digital system which ultimately punches the quantified parameter on paper tape in the form of an eight-channel binary coded decimal code. To make their operation entirely automatic, timing and control devices will be incorporated in the systems. A control panel will permit all functions of the system to be controlled manually. Any sensory input can be selected, displayed, and/or recorded, individually.

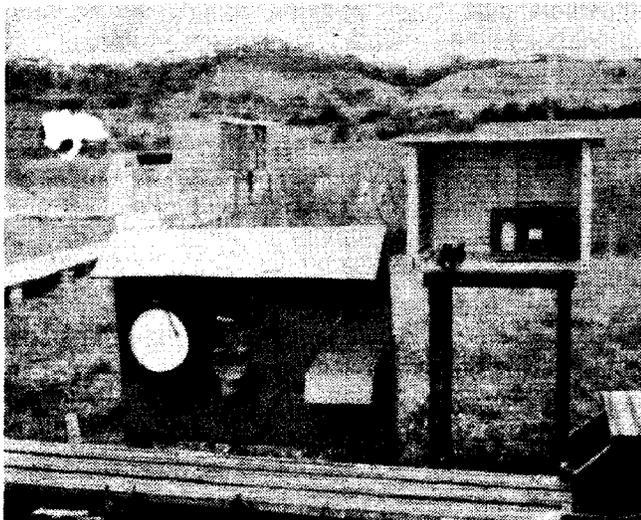
* References listed at the end of this report.



Weighing and Recording Rain Gage
at Chiva Chiva Site

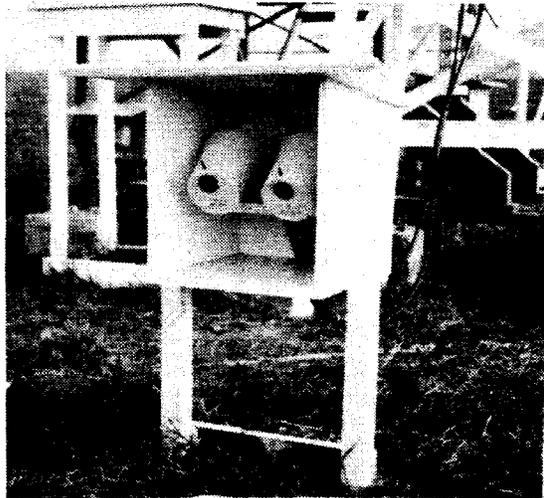


Manual Clear-Vu Rain Gage at
Albrook Forest Site

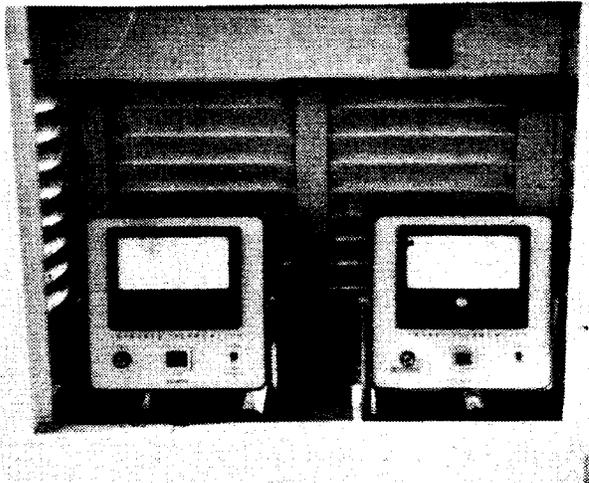


Honeywell-Brown and Bendix
Hygrothermographs and Bendix
Psychron at Chiva Chiva Site

FIGURE IV-1. VIEWS OF INSTALLED INSTRUMENTS

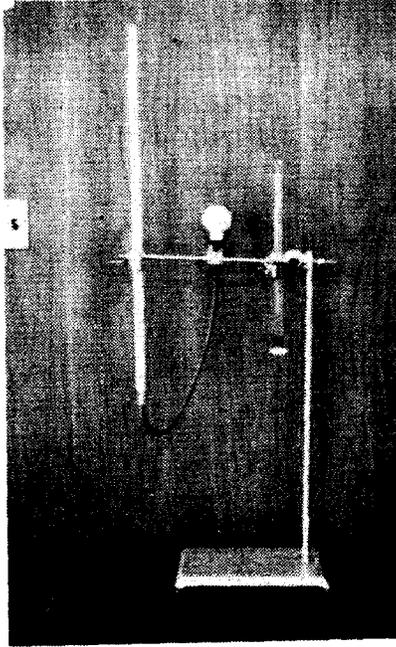


Infrared Thermometer Sensors

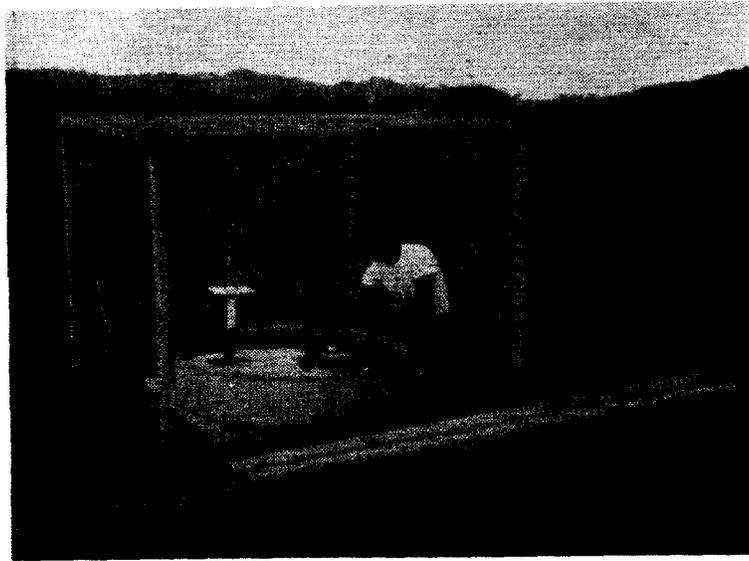


Infrared Thermometer Indicators

FIGURE IV-2. INFRARED THERMOMETERS



Livingston Atmometer and Modified Piche Evaporimeter



Standard Evaporation Pan with the Piche Evaporimeter on the Left

FIGURE IV-3. EVAPORATION MEASURING INSTRUMENTS

Each system provides five of each of the following sensors: wind speed, wind direction, dry bulb and wet bulb temperatures. The systems will employ circuitry of modular design so that additions may be made with minimum modification. At the time of field installation the addition of the following sensors is planned: sunshine, rain gage (tipping bucket), pyranometer, radiometer-net exchange, and radiometer-total hemispheric. A tape reader and automatic typewriter combination will be included as part of the system, which will serve the purpose of monitoring data at the site, as it is being received.

The systems are scheduled for delivery and installation in mid-1967. Figure IV-4 shows some of the components of the MDARS. Figure IV-5 gives a view of the internal circuitry of the wind transmitters. Figure IV-6 pictures some of the internal electronics of the digital registers. Figure IV-7 is a block diagram of the MDARS.

Special Maintenance Problems

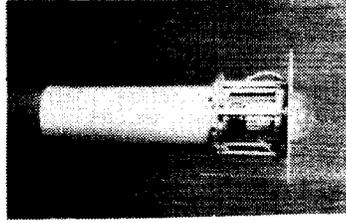
The maintenance and the calibration of instruments subjected to the degradational effects of the humid tropic environment continues to be a major problem in the operational continuity of the Data Base project.

To prolong the time between failure and to increase the service life of the recording-type instruments, all charts are exposed to the ambient atmosphere prior to use, pens are cleaned weekly, hair elements (of the hygromographs) are replaced frequently -- often weekly, the entire assembly is cleaned monthly, and the casings are repainted at least every six months. Calibration checks have been increased to five times per day. The wind measuring instruments require frequent overhaul. These instruments are completely disassembled and thoroughly cleaned at least once each month. The phenolic resin tube sockets supplied with the GMQ-12 wind sets deteriorate rapidly in the tropical environment; their replacement by ceramic sockets has prolonged the life of this component.

Another serious maintenance problem at the Albrook Forest site is created by the use of field-type generators as a power source. Many cases of generator failure have occurred in which the generator required field maintenance. This necessitates removal of the malfunctioning generator from the operating site to the maintenance shop and the installation of a replacement. Since two on-site generators are necessary to afford a continuous power supply (generators are alternated each 24 hours), the supply problem alone has proven difficult. Moreover, the ready availability of at least two additional generators is desirable in the event, which has often occurred, that both on-site generators become inoperative during the same period. This problem could be avoided by utilizing a commercial power line. However, the distance of the site from the nearest transformer facility precludes installation of a separate power line to the site because of fund limitations. A possible solution for the future would be the use of a commercial unit rather than the government issued field-type generator. This possibility is being investigated.



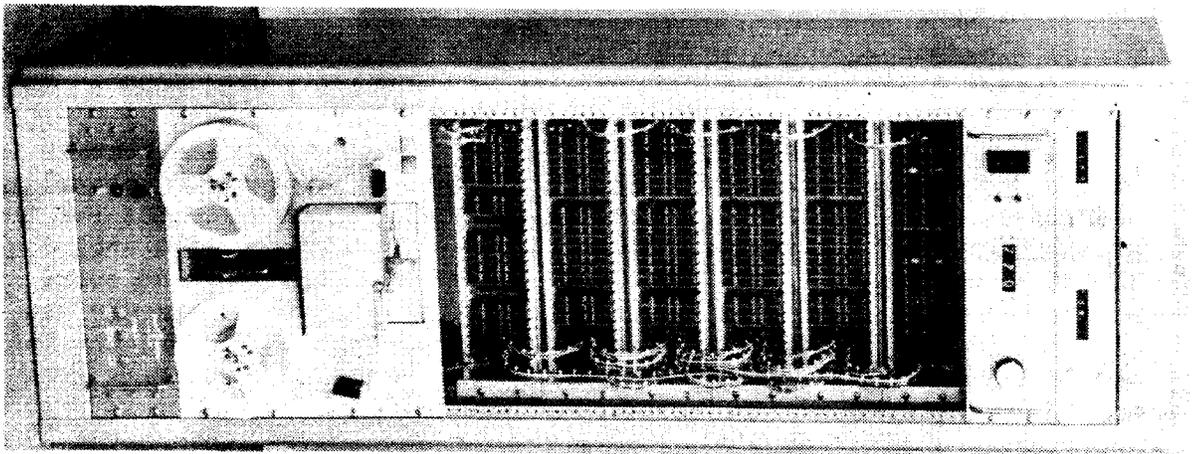
RADIOMETER



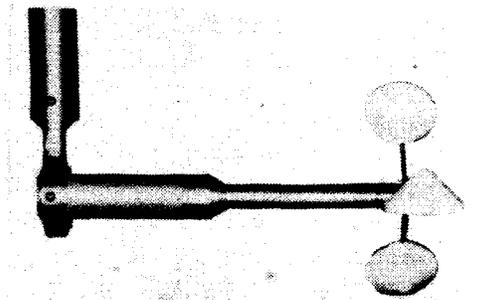
PYRANOMETER



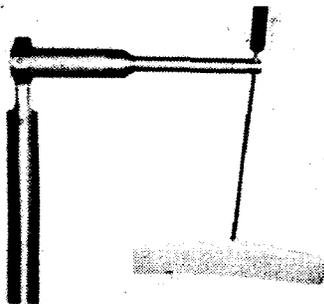
SUNSHINE SWITCH



DIGITAL RECORDER



ANEMOMETER

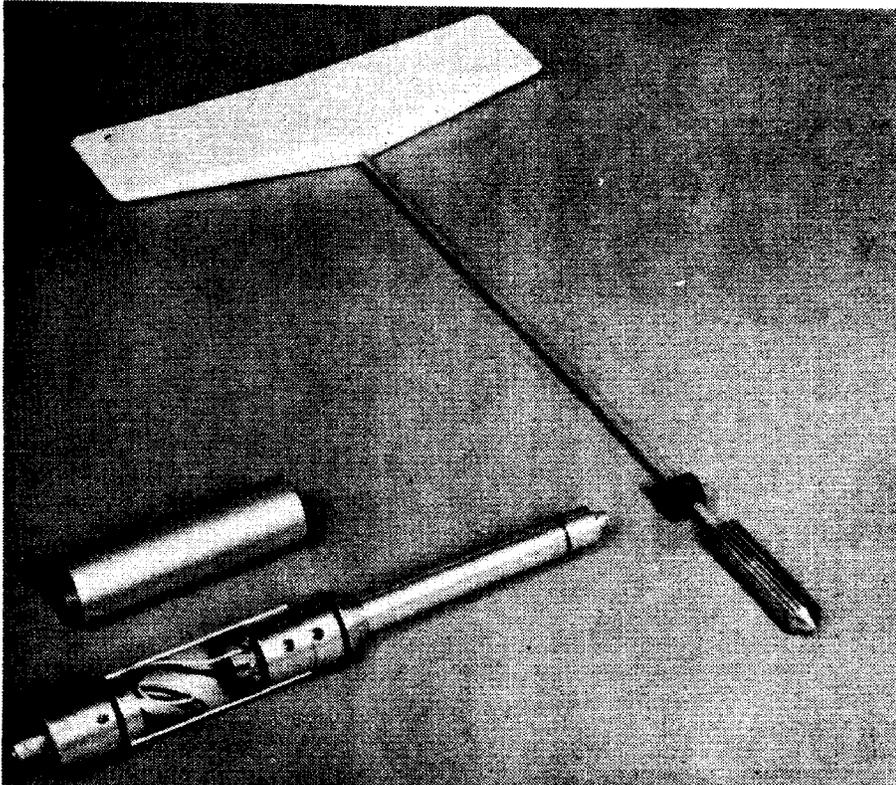


WIND VANE

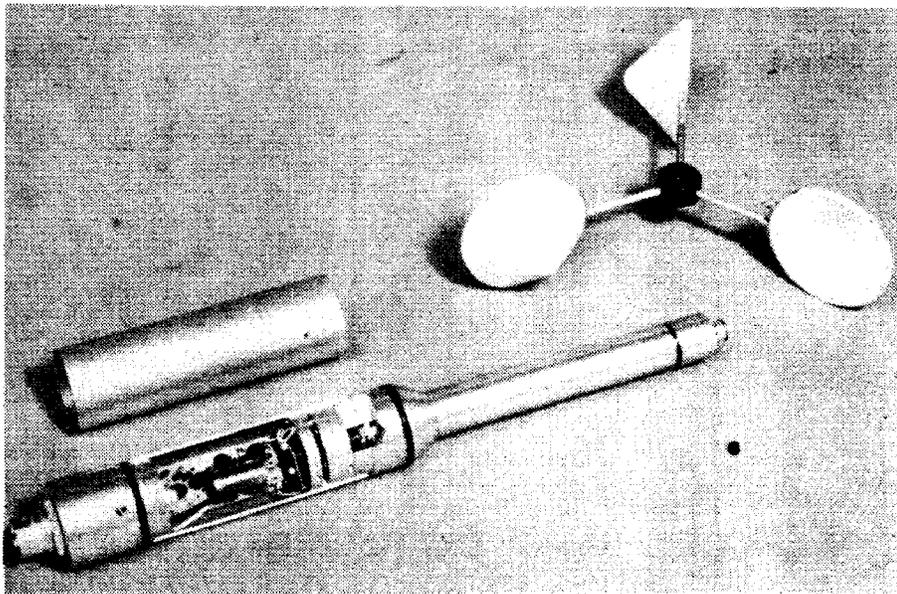


SHIELDED TEMPERATURE
SENSORS

FIGURE IV-4. SOME COMPONENTS OF THE METEOROLOGICAL DATA ACQUISITION AND RECORDING SYSTEMS



WIND DIRECTION TRANSMITTER



WIND SPEED TRANSMITTER

FIGURE IV-5. WIND SENSORS, SHOWING INTERNAL CIRCUITRY

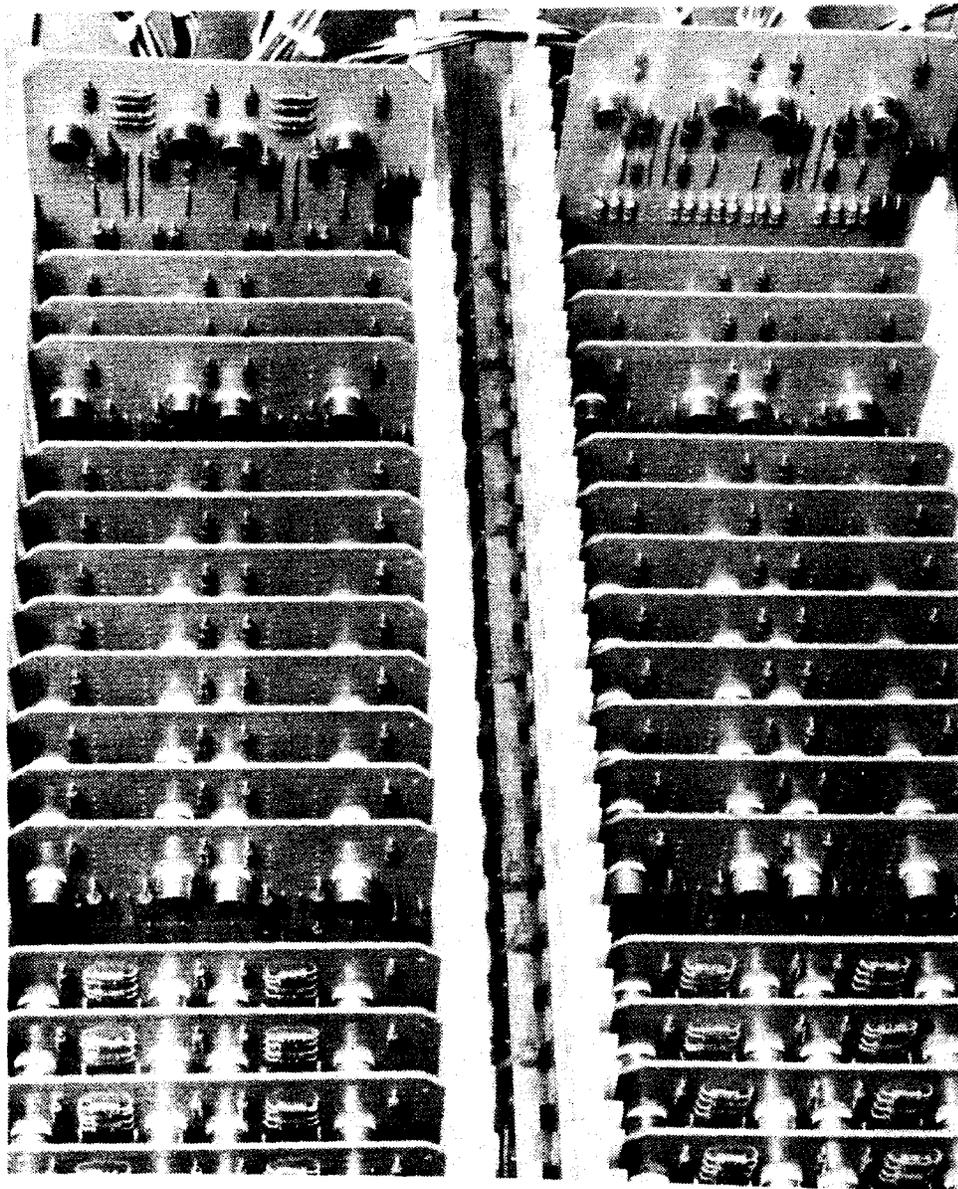


FIGURE IV-6. DIGITAL REGISTERS

FIGURE IV-6. DIGITAL REGISTERS

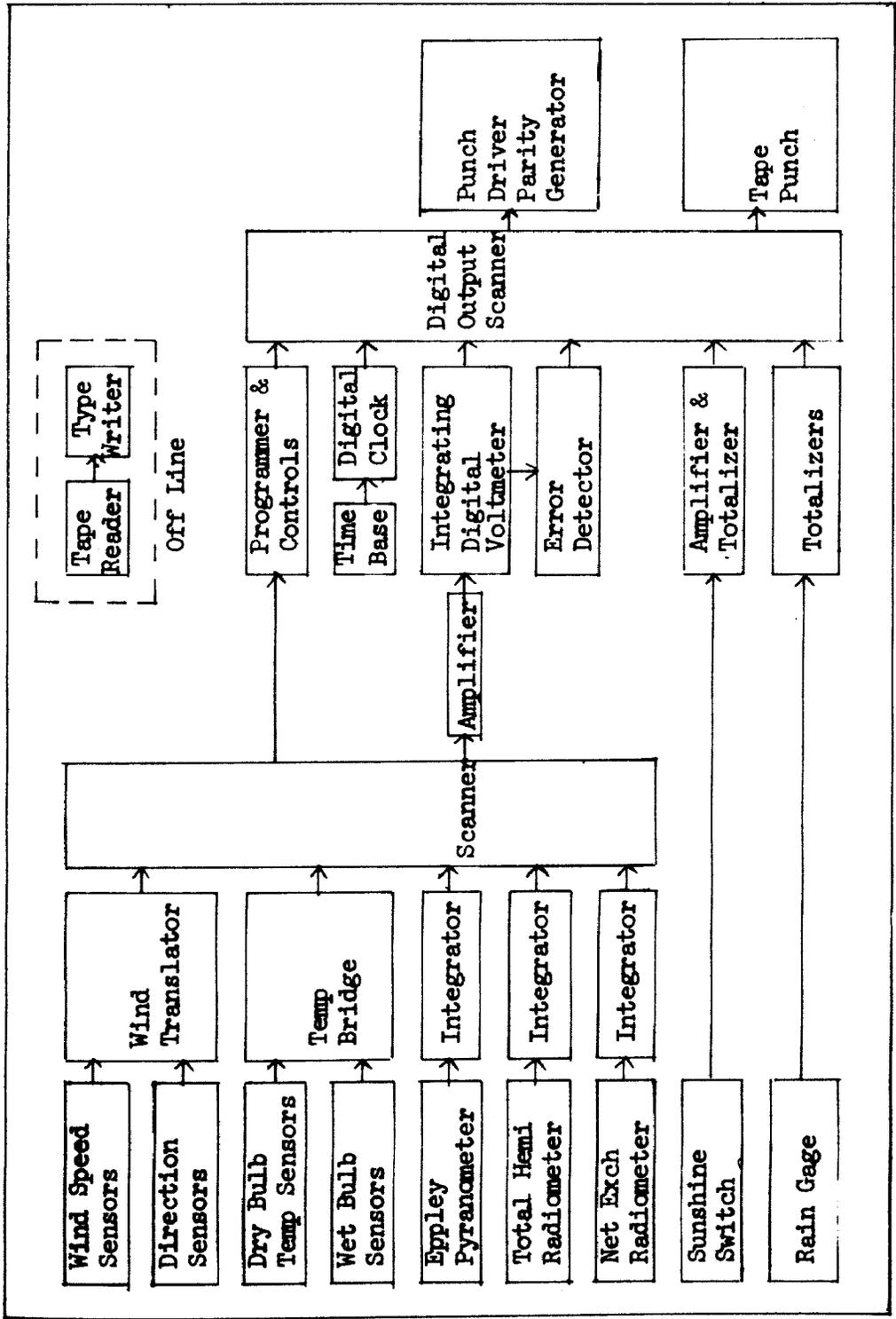


FIGURE IV-7. BLOCK DIAGRAM OF METEOROLOGICAL DATA AND RECORDING SYSTEM

Data Reduction and Storage

The data generated through the climate subtask represent the largest single body of data within the project. Approximately 64,000 observations are made each month. All of these observations, except wind direction and surface observations (approximately 25,000), have been entered on punch cards. Prior to entry on cards, the data are reduced to hourly values, as appropriate, from the data source forms; i.e., strip charts and log forms. The raw data are screened, verified for accuracy and validity, and then processed by a computer. The print-out exhibits the hourly values as well as the daily and monthly means and extremes. Examples of the data source forms and the monthly summaries derived from the computer print-outs may be seen in the previous Semiannual Report⁽¹⁾. The print-outs are used by the Tropic Test Center to make analyses of the various elements and correlations with other factors being observed. All punch cards, raw data, and data-source forms are stored in the Tropic Test Center Technical Library Annex at the Miraflores Laboratory. These data may be made available to any authorized agencies for analysis. As an example of such usage, the US Army Natick Laboratories is currently planning a rainfall study which will utilize specific types of data to be selectively retrieved from the data bank and presented on magnetic tape. Natick will be requested to provide the Tropic Test Center a duplicate of this tape and the results of the study.

The total number of individual meteorological observations recorded and stored during the reporting period, 1 September 1966 through 28 February 1967, is summarized in Table IV-2.

TABLE IV-2. TOTAL NUMBER OF METEOROLOGICAL OBSERVATIONS FOR PERIOD 1 SEPTEMBER 1966 THROUGH 28 FEBRUARY 1967

| | <u>Albrook</u> | <u>Chiya Chiya</u> | <u>Rio Hato,</u> | <u>Albrook</u> | <u>Ft. Kobbe</u> | <u>Ft. Sherman</u> | <u>TOTAL</u> |
|-----------------------|------------------|--------------------|------------------|------------------|------------------|--------------------|----------------|
| | <u>Soil Site</u> | <u>Soil Site</u> | <u>Soil Site</u> | <u>Soil Site</u> | <u>Soil Site</u> | <u>Soil Site</u> | |
| Dry Bulb Temperature | 42,638 | 34,768 | 4,227 | 292 | 346 | 336 | 82,607 |
| Wet Bulb Temperature | 13,032 | 12,948 | -- | - | - | - | 25,980 |
| Relative Humidity | 30,219 | 30,208 | 4,167 | 292 | 346 | 336 | 65,568 |
| Wind Speed | 15,731 | 21,178 | 680 | - | - | - | 37,589 |
| Wind Direction | 15,731 | 15,731 | 680 | - | - | - | 32,142 |
| Evaporation | 539 | 380 | -- | - | - | - | 919 |
| Rain Gage (Recording) | 17,207 | 4,341 | 4,344 | 4,472 | 7,304 | 6,776 | 44,444 |
| Rain Gage (Manual) | 5,820 | -- | -- | - | - | - | 5,820 |
| Stem Flow | 2,226 | -- | -- | - | - | - | 2,226 |
| Barometric Pressure | 4,344 | 4,344 | -- | - | - | - | 8,688 |
| WBG7 | 10,156 | 10,152 | -- | - | - | - | 20,308 |
| Surface Observations | -- | 56,940 | -- | - | - | - | 56,940 |
| TOTALS | 157,643 | 190,990 | 14,098 | 5,056 | 7,996 | 7,448 | 383,231 |

Data Analysis

Analyses of the meteorological data acquired under the project, as well as of the methodology for its acquisition, are carried out, as time permits, in order to increase the utility, significance, accuracy, and validity of the measurements. In line with this objective, the sections below are presented.

Diurnal Temperature Variation in Forest and Open Sites*

Introduction

Microclimatic data will be summarized by monthly averages and totals, as described on p. 16, for dissemination to interested agencies. The original raw data will also be available to research workers, either in punch card or tape form. The analysis presented here is an example of how the original data can be applied. Though temperature variations in the tropics are less pronounced than at higher latitudes, definite variational patterns do exist, and these are assumed to affect propagation of sound and radio waves and the dispersion of microorganisms, gases, and other materials. In this study two simple weather patterns, which occurred in September 1966, have been singled out for analysis: days without rain at both the open and forested sites; and days with rain at both sites. The analysis utilizes the readings taken each hour, on the hour.

Analytical Method

There were seven days in September 1966 without any rain at Chiva Chiva and Albroom, and ten days with rain at noon at both stations. Averages of such small samples are usually somewhat irregular because of incidental variations and non-systematic observational errors. To smooth the irregularities without eliminating significant details, the data were submitted to harmonic analysis, from which new sets of data were produced by summing the first harmonics. Since the temperature pattern of days with rain is rather complicated, the first eight harmonics were used for such days, while only the first four harmonics make up the smoothed data for the days without rain. In addition, the constituents of each harmonic were smoothed vertically by plotting the values of the same harmonic as obtained for each level on graph paper as a function of height over ground, and by drawing a smooth curve in such a way that the differences between the curve and the plotted values were reasonably small.

This procedure permits the computation of the temperatures for any desired time of the day and for any level between 50 cm and 46 m. However, with exception of the 8-meter level in Chiva Chiva (for which no records exist) the smoothed temperatures were computed only for the levels and the times (full hours) for which actual observations exist. No smoothing has

* This section has been prepared by Dr. Wilfried H. Portig, Research Meteorologist.

been applied in those cases in which all thirty days in the month have been considered.

Presentation

The entire bulk of data is presented in three different forms in Figures IV-8, -9, and -10. Each figure shows height above ground as the ordinate, which is plotted on a logarithmic scale in order to better show the relatively larger variations near the ground. While this seems to be the best way to present the data for the Chiva Chiva open site, there are unavoidable shortcomings with respect to the treetop level at the Albrook Forest site (26.5 m). To a certain extent the deficiencies of presentation at that level are justified by the fact that there are no other observations close to 26.5 m which might provide more details of the temperature distribution near the upper surface of the canopy. A wavy line in the Albrook graphs is to remind the reader that 26.5 m is just above the general treetop level.

Figure IV-8 shows the smoothed mean temperature of the days without rain at both stations (upper part of the figure), and those with rain around noon at both stations (lower part). The diagrams on the left side refer to Albrook Forest, those on the right to the Chiva Chiva open site.

Figure IV-9 has the same arrangement as Figure IV-8. It shows the changes of temperature from one hour to the next by means of isallotherms, i.e., lines of equal temperature change.

Figure IV-10 is another presentation of the same data displayed in the lower part of Figure IV-8. For selected hours the vertical distribution of temperatures is shown in form of curves. For legibility, the figure is broken down into the periods from midnight to noon, and from noon to midnight. The marginal curves of 2400 and 1200 appear in either part of the figure.

Discussion

General. The simple basic concept of the diurnal temperature variation, "warm at noon, cool at night", is modified in several aspects. Three parts of Figure IV-8 show that the highest temperatures occur approximately at noon (astronomical noon occurs at 12:10 in September), i.e., two or three hours earlier than seems to be normal in most of the world. This is the consequence of two effects which are merely different expressions for the same weather development. The first is the increase of cloudiness which begins at sunrise for low clouds, and at an earlier hour for total cloudiness. On those seven days without rain at both observation sites the total cloudiness increased from 0.6 at 0400 hours to 0.9 at 1000 and from there, after a slight dip to 0.8 at 1300, to 1.0 at 1700 hours. Such a strong cloud development necessarily decreases the amount of effective solar radiation. The other factor that prevents further rise of temperature after midday is the development and discharge of thunderstorms in the vicinity of,

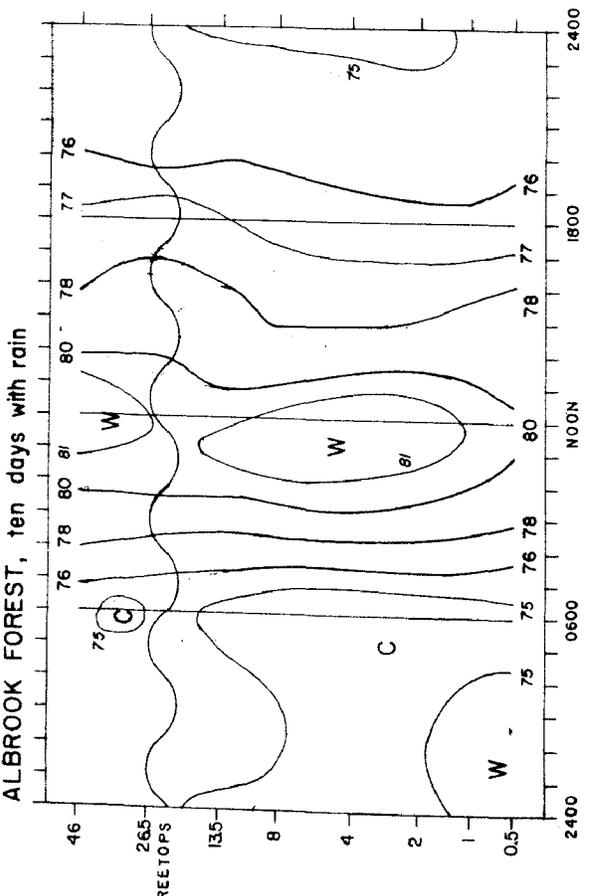
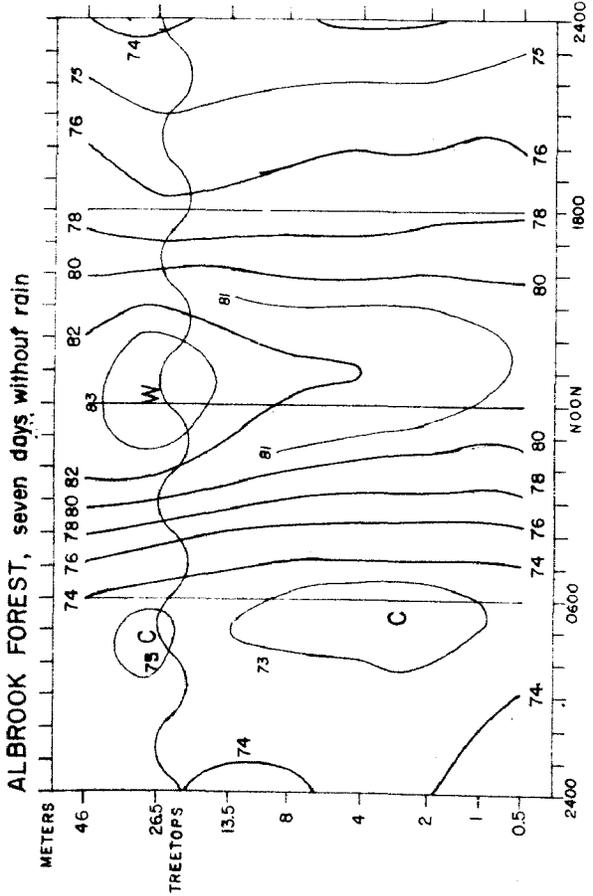
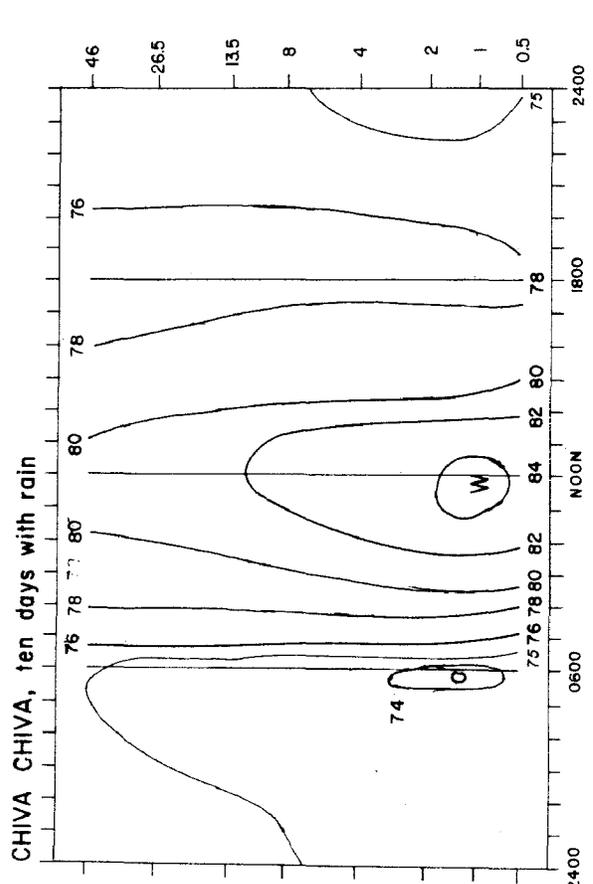
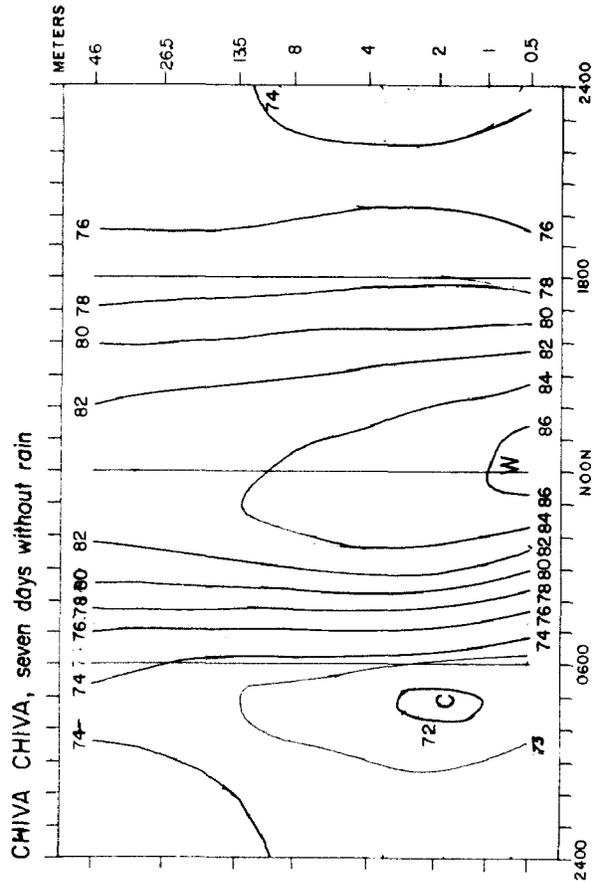


FIGURE IV-8 SMOOTHED MEAN TEMPERATURES (F)

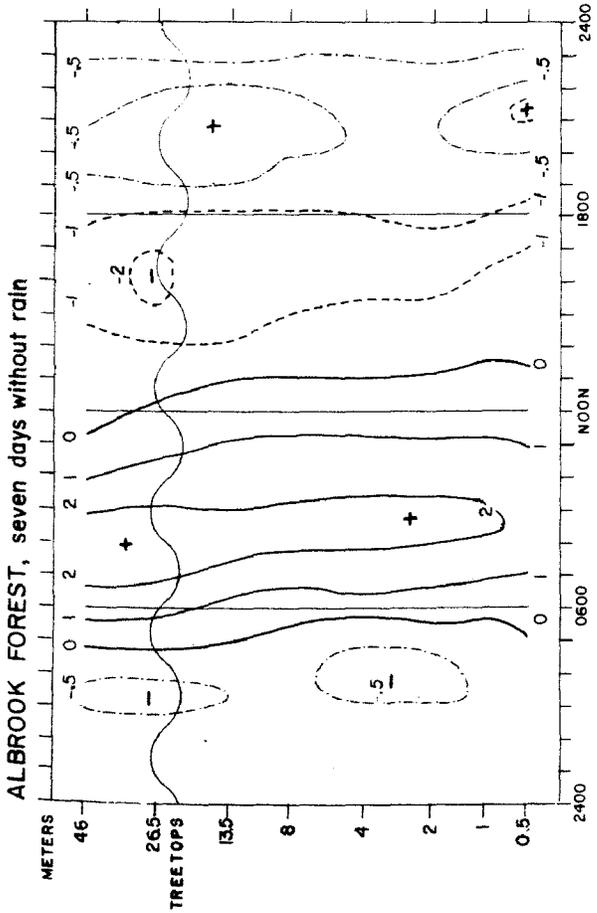
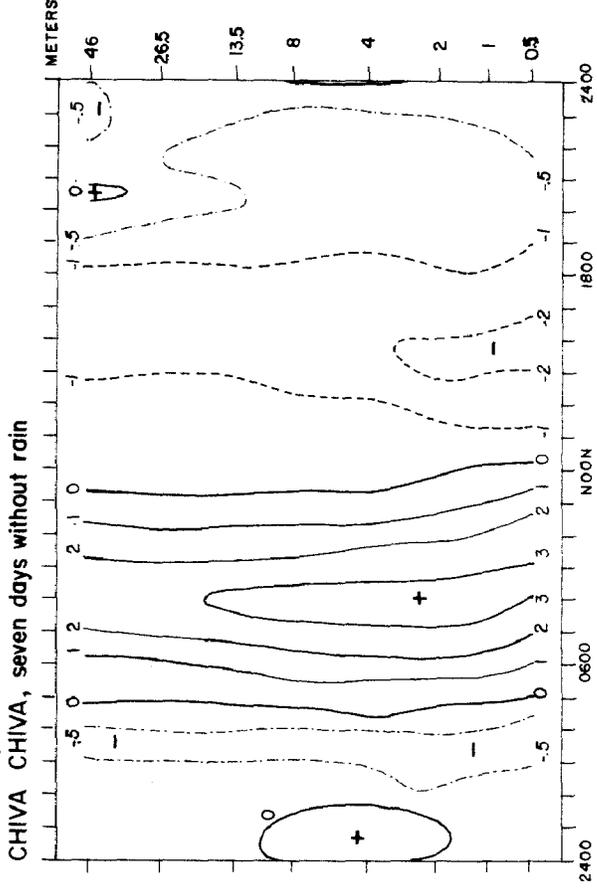


FIGURE IV-9. HOURLY TEMPERATURE CHANGES (F/hr)

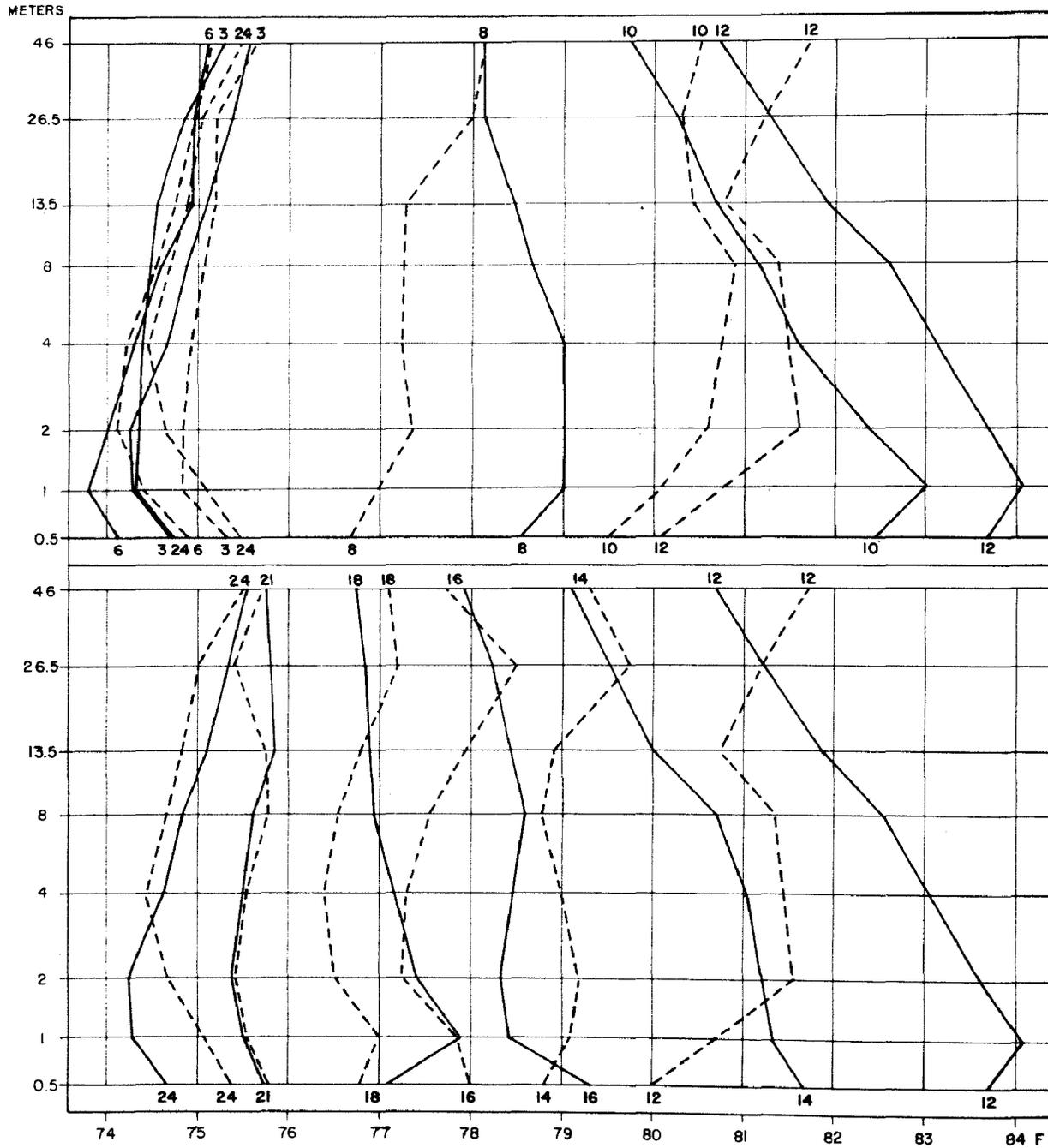


FIGURE IV-10. VERTICAL TEMPERATURE PROFILES,
MEAN OF 10 DAYS WITH RAIN AT NOON

SOLID LINES-CHIVA CHIVA

DASHED LINES-ALBROOK FOREST

NUMERALS-HOURS LOCAL TIME

FIGURE IV-10. VERTICAL TEMPERATURE PROFILES, MEAN OF 10 DAYS WITH RAIN AT NOON

but not over, the observation sites. On several of the days when no rain fell at the sites, the observer heard thunder, in one case even overhead. (This was on 23 September.) Only a few drops fell at Chiva Chiva and none at Albrook, but at both stations the temperature maximum at all levels occurred at the time when the first thunder was heard, or earlier. The temperature drop after the maximum was considerable, e.g., at the 2-m level Chiva Chiva showed 90.6 F at 1100 hours, 83.1 F at 1200 and 80.6 F at 1300. The changes at the other levels were of the same order of magnitude.

As expected the highest temperatures occurred near the ground at Chiva Chiva and near the treetops at Albrook. At both stations the lowest temperatures (near 72 F) were recorded at low levels and the highest, 83 F, just above the trees in Albrook, and 86 F in Chiva Chiva at the 50-cm level, the lowest for which observations are available.

The fact that the lowest temperature at Chiva Chiva did not occur at the lowest level but at two meters above ground was unexpected. However, this may be explained through the assumption that the nighttime cooling of the air is not only accomplished through contact with the cool ground but also through direct radiational loss of heat into space. This interpretation is supported by measurements made by Florida State University over the open Atlantic Ocean, as reported by Garstang⁽²⁾. It was found that the air temperature over the open water responds immediately to sunrise and sunset while the water temperature lags considerably. Thus, the air temperature before sunrise was lower than the water temperature but passed quickly above the latter after sunrise. The occurrence of ample dew at the Data Base observation sites provides some analogy with the conditions investigated by Florida State (although dew does not display the sizeable convection that is typical for open water bodies).

Table IV-3 compares some mean temperatures obtained in Chiva Chiva on days without rain, with mean temperatures obtained aboard the research vessel "Crawford" in August/September 1957 in the Atlantic off the Guiana coast at a latitude approximating that of the Canal Zone.

TABLE IV-3. MEAN TEMPERATURES AT SELECTED HOURS
IN THE CANAL ZONE AND OVER THE OPEN SEA

| Hour | <u>Chiva Chiva</u> | | <u>Open Sea</u> | | 6 meters water |
|------------|--------------------|------|-----------------|------|-------------------|
| | 0500 | 1000 | 0500 | 1000 | |
| 2 meters | 71.8 | 84.2 | 80.5 | 84.5 | |
| 1/2 meter | 72.4 | 83.3 | 83.4 | 84.1 | |
| Difference | -0.6 | +0.9 | -2.9 | +0.4 | |

The solid lines of Figure IV-10 and the portions of Figure IV-8 applicable to Chiva Chiva show that the described effect lasts until noon on days with rain, and until 1000 hours on days without rain. Although the magnitude of the described effect is small, it may assume considerable importance because the sign of the vertical temperature gradient is opposite to the "normal" during substantial parts of the day.

The publications of Garstang⁽²⁾ and Cachan⁽⁴⁾ are the only ones known to present temperature measurements from very low levels for average days. Instead, most writers have concentrated on selected clear days even in regions where such days occur with much lower frequency than cloudy days. From measurements taken on such clear days it has been concluded that the temperature of the very lowest layers of the atmosphere decreases substantially with height during hours of incoming radiation (day), and increases during the night when outgoing radiation prevails. During September 1966 this supposition has been contradicted at our stations:

64% of the time at Chiva Chiva on days without rain,
75% of the time in Albrook Forest on days without rain,
84% of the time at Chiva Chiva on days with rain, and
92% of the time in Albrook Forest on days with rain

It can be expected that within the short dry season the conditions would correspond better to the type of regime that is usually described. This subject will be taken up again below.

Unfortunately no reliable temperature measurements are available at heights below 50 cm or at the ground surface. Measurements of the soil surface temperature are extremely difficult. It appears that such measurements will be more reliable in future work of the Data Base Project.

Table IV-4 presents information on average temperature extremes observed at different levels at both sites. In this computation each day of September 1966 has been considered; means of this type are not sufficiently representative when they are based on only ten days or less. (The reader should consider that the extremes derived from a smoothed mean function, such as in Figure IV-14, are not the same as mean extremes taken from the daily curves before averaging.)

The hours at which the extremes were measured varied through any daytime hour for the maximum, and any night hour for the minimum. Frequently the temperature remained nearly constant for several hours. Usually the rise (or decline) to the maximum (or minimum) was rather gradual, while the drop (or rise) after the maximum (or minimum) was abrupt. The period of high temperatures was generally abruptly terminated by rain, either at the station or nearby; and the period of low temperature was usually abruptly terminated by the rising sun, even when the sun was hidden by clouds.

Little difference exists between the mean temperature minima at the open site and forest. At no level is the deviation from the common mean,

TABLE IV-4. MEAN TEMPERATURE EXTREMES DURING SEPTEMBER 1966

| | <u>Maxima</u> | | <u>Minima</u> | |
|-----------|----------------|--------------------|----------------|--------------------|
| | <u>Albrook</u> | <u>Chiva Chiva</u> | <u>Albrook</u> | <u>Chiva Chiva</u> |
| 46 meters | 84.8 | 84.7 | 74.1 | 73.4 |
| 26.5 | 86.1 | 85.6 | 73.1 | 73.3 |
| 13.5 | 84.2 | 85.8 | 73.3 | 73.5 |
| 8 | 83.7 | -- | 73.1 | -- |
| 4 | 83.4 | 87.0 | 73.1 | 72.5 |
| 2 | 83.2 | 87.6 | 73.2 | 72.5 |
| 1 | 82.8 | 87.8 | 73.7 | 72.7 |
| 0.50 | 81.7 | 87.4 | 73.8 | 73.1 |

73.2, greater than 0.9 F.

Except for the lowest layer the temperature maxima at Chiva Chiva decreased with height. The absolute maximum was recorded at 1 meter above ground (94.2 F). In contrast to this, the maximum temperatures in the forest show a slight increase from the ground up to the crowns of the trees. There it rises considerably and has its highest value at 26.5 meters. Also the absolute maximum (90.8 F) was recorded at that level. As expected the mean maximum temperature decreases above the treetop level. Since the mean minimum temperatures are almost equal at all levels, this variation of the maximum temperatures means that the temperature spread between minimum and maximum temperatures is greatest in Chiva Chiva at the 2-m level (15.2 F) from where it decreases upward and downward. At Albrook the maximum spread is measured at the upper side of the canopy (13.0 F). At either station the decrease of spread from the 1- to the 0.5-m level is surprisingly large.

It seems to be natural that at Chiva Chiva very high and very low temperatures occurred on the same days, namely on days with reduced cloudiness ("radiation days"). Surprisingly this happened also in the forest. At 8 meters, for example, the lowest temperature was 69.8 F and occurred on 2 September. The temperature maximum on the same day at this level was 86.4 F. Only two other days of that month had higher temperatures (86.8 F on both). This obvious reaction of inside-forest temperatures to sky conditions accords with the experience that the small variations of temperature traces occur at practically the same time at all levels. This shows that short-time irregularities of the temperature above the canopy are rapidly translated, though with reduced amplitudes, to lower layers.

Temperature Variation with Time. Figure IV-9 presents the temperature changes from one hour to the next for the seven days without rain at either station and for the ten days with rain at both sites. The general situation is, of course, of temperatures rising from sunrise to noon, and falling during the remainder of the day. The deviations from this simple pattern are discussed in the following paragraphs.

Days without Rain at either Station. Typically, the open site shows the greatest temperature change near the ground, the forest station near the treetops. As discussed before, the open station does not exhibit the fastest temperature rise directly at the ground, but some meters above. At both stations the changes lag with height. The strongest rise occurs first in the higher layers and spreads towards the ground; this is also true for the temperature drop in the forest. In the open site the most pronounced fall is first observed at the lowest layer and spreads upward. In each case the lag is from one-half to one hour. There are indications that the lagging is reversed at the very highest layer. This effect, however, is not strong enough to be ascertained.

Days with Rain at Noon at Both Stations. The cooling produced by the rain becomes more obvious in Figure IV-9 than in Figure IV-8 and renders the graph for Chiva Chiva difficult to interpret. Nevertheless, it can

be seen that the soil tends to have a smoothing effect: neither the temperature drop in the early afternoon nor the rise a few hours before are as strong at the ground as they are a few meters above it. In contrast to days without rain, the temperature drop in the afternoon occurs in two steps rather than gradually, the first of which is initiated by the rain, the second by the approaching night.

Irregularity of Temperature Drop at Night. Newton's law of cooling requires the undisturbed temperature drop to follow an exponential curve. As a matter of fact, this has frequently been found to be the case in dry conditions without, or with only a few, clouds. Conditions are not that simple in the Canal Zone. The portions of Figure IV-9 referring to nighttime conditions show deviations from Newton's law by the inclusion of periods of warming and periods of diminished rate of cooling, or by having the strongest cooling at the very end of the cooling period. Comparison of the four graphs suggests that these deviations always occur at the same times. Encouraged by this preliminary finding, and in order to work on a broader statistical basis, the average of all 30 days was considered.

Figure IV-11 shows the average hourly cooling rate of the 4-meter level for both sites, taken for all 30 days, as well as the theoretical rate that corresponds to Newton's law. It is obvious that both the forest site and the open site exhibit slower cooling rates at the same times, from 2100 to 2200 hours and from 0200 to 0300 hours, than would have been expected. Between these periods the cooling rate at both locations is more than Newton's law suggests (October and November show a very similar pattern). The very lowest layer (not presented here) shows the same effect at both stations approximately one hour later than does the 4-meter level.

Attempts to correlate the irregularities of the cooling rate with the periods of low or total cloudiness failed. While the total cloudiness decreases at an almost constant rate until 0400 hours, the low cloudiness remains almost constant with slight variations that do not coincide with the variations of the cooling rate. No attempts have been made to correlate the cooling rate with the moisture of the air, dew formation, or wind.

Temperature Variation with Height. The vertical variation of air temperatures is of great importance for propagation of sound and radio waves, as well as for the transport of gases and particulate matter such as liquid water, bacteria, spores, dust, etc. In macrometeorology the actual temperature variation with height is compared with the adiabatic lapse rate, which is 10 C per kilometer or 0.018 F per meter. Since we deal with heights of not more than 46 meters, the adiabatic temperature difference cannot be more than 0.8 F. Because we concentrate on narrower layers the adiabatic lapse rate may be disregarded. With this simplification temperature decreases with height will denote super-adiabatic conditions, and temperature increases (inversions), sub-adiabatic conditions.

From the temperature distribution shown by Figure IV-8 discussed above, considerable divergence may be expected between the current

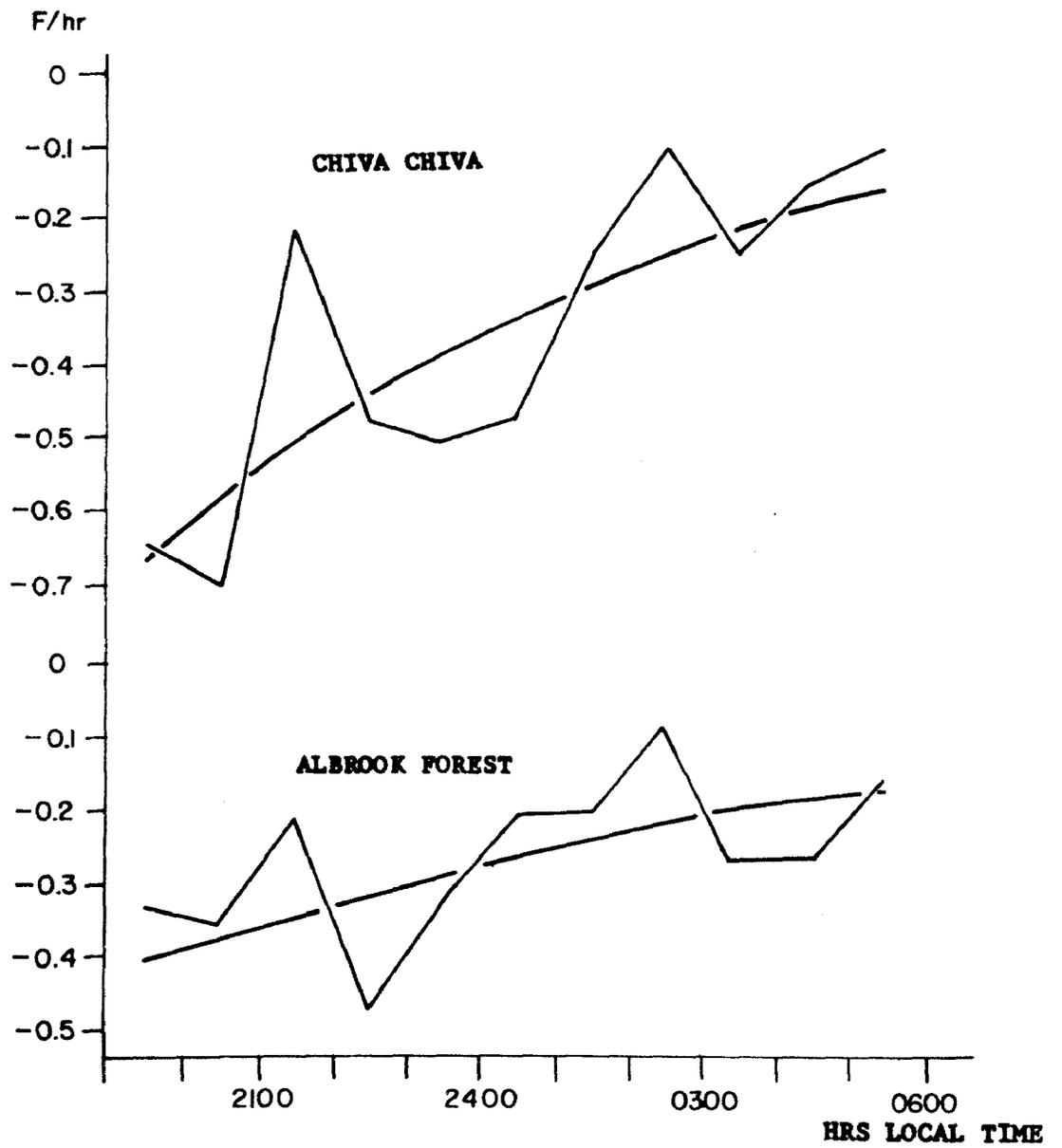


FIGURE IV-11. COOLING RATES AT 4 M ABOVE GROUND DURING SEPTEMBER 1966

**Rugged curves - actual data
Smooth curves - Newton's law of cooling**

measurements and the "textbook scheme". Figure IV-12 shows, in its upper part, vertical temperature variations during 24 hours as they can be derived from measurements made at the Laboratory of Climatology in Seabrook, N. J. and quoted in Geiger's textbook⁽³⁾. They display temperature decreases with height during most of the daytime, and increases (inversions) during the night.

The lower part of Figure IV-12 presents the corresponding data of Chiva Chiva for "days with rain" and "days without rain" combined (almost the same figure results from using all 30 days without smoothing). In the uppermost layer, 4-8 meters, both parts of Figure IV-12 coincide reasonably well. However, in the lowest layers they are substantially different. Hence, the phenomena influenced by temperature stratification, such as propagation of electro-magnetic waves, and transport of atmospheric contaminants, may show diurnal variations that are different from those that can be derived from "idealized" data published so far. Data for "undisturbed" days, as those published for Seabrook, can hardly be applied to the Canal Zone, because undisturbed days are rare in the short dry season and non-existent during the nine-month rainy season.

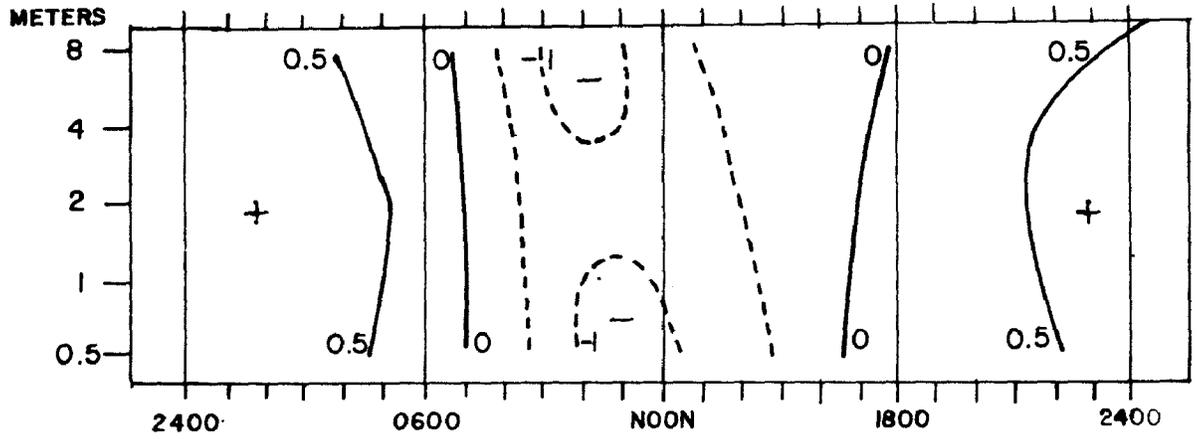
The dislocation of temperature extremes at the open site has the strange consequence that the lapse rate of the lower layer has a double diurnal wave. Table IV-5 (which partly overlaps with Table IV-3) shows the temperatures at the 50-cm and 4-m levels of Chiva Chiva at the hours of greatest elongation. Other layers, sites, or weather exhibit this effect only in a lesser degree or not at all.

TABLE IV-5. MEAN TEMPERATURES (F) AT CHIVA CHIVA
ON SEVEN DAYS WITHOUT RAIN AT EITHER SITE

| Hour | 0000 | 0800 | 1300 | 1900 | 2000 |
|------------|------|------|------|------|------|
| 4 meters | 73.2 | 79.0 | 84.6 | 76.8 | 76.0 |
| 50 cm | 73.7 | 77.3 | 86.2 | 76.5 | 75.7 |
| Difference | -0.5 | +1.7 | -1.6 | +0.3 | +0.3 |

In a study of a forest environment near Abidjan, Ivory Coast, Cachan⁽⁴⁾ found such a double wave between the layers over and below the canopy, i.e., between the 46- and 11-m levels. In this respect there is no similarity between Cachan's data and those of the Canal Zone. His well expressed maxima of vertical temperature differences were found for the same hours where the Albrook data have indistinct minima. Cachan's maxima rise 8 F over the minima, the maxima in the Canal Zone only 1 F. At the present stage of investigation no explanation for this discrepancy can be given. (It is not evident from Cachan's publications^(4, 5, 6) whether this

SEABROOK, N.J.



CHIVA CHIVA, C.Z.

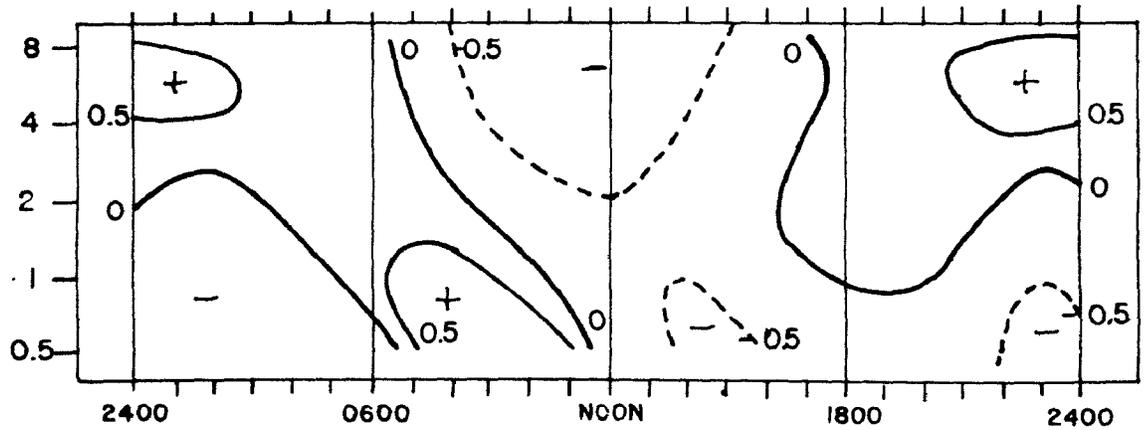


FIGURE IV-12. VERTICAL TEMPERATURE DIFFERENCES (F)
BETWEEN THE LEVELS INDICATED AT THE LEFT MARGIN

Solid lines = increase of temperature with height = inversion

phenomenon occurs regularly or only under special conditions.)

Figure IV-10, derived from the lower part of Figure IV-8, compares the vertical temperature stratification of both Canal Zone sites for the same days and the same hours. At the time of the lowest temperature, 0600 hours, both stations show the same type of temperature stratification near the ground, though expressed somewhat better at the open site than in the forest. Before 0800 hours the temperature has risen much more rapidly in the lower layers of the open site than in the forest, but at 46 meters the temperatures at both sites are identical. At both stations the rate of temperature rise at the lowest level is less than at some meters above, which produces a shallow but well marked inversion. The forested site shows in addition a second inversion through and above the treetops. Both inversions are still present at 1200 hours, and, in the forest, until sunset. This is true in spite of the fact that the temperatures are decreasing as a consequence of the rain.

At 1400, and, not quite as well expressed, at 1600 hours, the temperatures for Chiva Chiva finally show a vertical distribution which corresponds to what one might have expected: -straight cooling from the ground to 46 meters.

Comparison of the curves for 1800, 2100, 0300, and 0600 hours at Chiva Chiva demonstrates how the middle layers cool off more rapidly than the lowest or the highest layers. In this way an inversion develops that does not begin at the ground as would be normal in a typical radiation regime.

The temperatures and their variations with time and height are generally less extreme than one could expect from measurements made at higher latitudes. Apparently the long night and the high moisture content of the air tend to equalize the radiative and convective processes. It is regrettable that Cachan's⁽⁴⁾ data are not summarized in the form of averages for particular hours. It would be interesting to compare his data, obtained in a typical monsoon climate in an old, dense forest with that of the current study, obtained at the downstream end of a trade wind climate in a relatively young forest.

Determination of Temperature at the Soil Surface*

Introduction and Discussion of Problem

Soil surface temperatures are important for many reasons. They affect everything in contact with the ground as, for example, vehicle tires, personnel on foot, animals, and also the air with suspended microorganisms. Seedlings pass through the soil surface; fruits, seeds, and spores fall onto the ground. Little is known of the manner in which the temperature of the soil surface furthers or impedes life and the propagation of life, mainly because the temperatures are not well known. In addition to the direct effects produced by contact with the soil, there are remote effects through radiation from it.

For centuries one principle has been used for measurement of temperatures. That is to equalize the temperature of a thermometer with that of the body whose temperature is required, after which the former is read. The difficulty of achieving the necessary equality of temperatures is well known, and requires special, but not always adequate, provisions for the purpose. For example, when measuring the temperature of air, the thermometer must be ventilated, yet simultaneously protected against radiation, even against that of the observer's own body.

The sensing part of a thermometer will adopt the temperature of a body when it is completely submerged in it for enough time. It is not difficult to measure the temperature within a body of soil. Because of the stable thermal properties of soil, its inner temperature will not change rapidly, and even if the thermometer is not in complete contact with the soil the sensor will adopt the soil temperature with a high degree of accuracy.

The situation is, however, completely different at the soil surface. There the temperature is a compromise between the energy of incoming and outgoing radiation, the heat capacity of the soil and of the overlying air, the heat conduction (molecular as well as turbulent) of the air, and the heat conduction of the soil. The temperature can further be substantially modified through evaporation, dew formation, or precipitation.

The complex thermal conditions at the surface juxtaposed to stable and inert conditions within the soil permit marked temperature differences between the surface and the interior of the soil. Until now it has very rarely been possible to measure them with the desirable accuracy. One may conclude, from several sets of observations from various sources, that temperature changes of approximately 6 C in the uppermost centimeter of soil are not uncommon. This gradient diminishes rapidly with depth, and the same difference, 6 C, has been found as a maximum between 5 and 20 cm depth.

* This section has been prepared by Dr. Wilfried H. Portig, Research Meteorologist.

Method and Principles of Instrumentation

It is clear that, when the temperature changes on the order of magnitude of 0.6 C within one millimeter, the sensor of a thermometer must be extremely thin. Furthermore it must respond to all types of conduction and radiation in exactly the same way as the soil. It is doubtful that such a thermometer exists. Since the problem of measuring the temperature of the surface of the soil cannot be solved with traditional direct means, indirect measurements seem to be more promising. Hoffmann wrote in the appendix of Geiger's book "Possibly the measurements of the soil surface temperature will soon be basically improved through utilizing the radiation emitted from the soil. Engineers already measure surface temperatures by means of this principle".

An infrared thermometer is an instrument for sensing certain radiation emitted from the surface of any body, and experiments (described below) seem to indicate that it will provide the means of measuring the soil surface temperature. The Research Division of the Tropic Test Center possesses two such instruments*, the operating principles of which are discussed in the following.

The surface of any body emits electromagnetic radiation over a wide spectrum. The amount of emitted energy depends on the surface temperature to the fourth power and on the emissivity of the body. The spectral spread depends on the temperature and on the emissivity which may change with temperature and with wave length. The conditions in the receiver are correspondingly complicated. Considering the multiple feedback of the temperature, one cannot say, a priori, how the received energy may be interpreted in terms of temperature.

Basically the instrument is entered only by radiation in the infrared part of the spectrum, and this incoming radiation is internally compared with a radiation source of constant temperature within the instrument. The difference between the internal and external energy sources is indicated on a dial in degrees of temperature, though the actual and indicated temperatures are different, as shown below.

The fundamental question was the unknown and possibly varying emissivity of the soil. The radiative energy entering the instrument is represented by the equation: $E = e k T^4$, where e is the emissivity of the observed surface, T is temperature (absolute), and k is a constant. By definition, e may vary between 0 and 1; a body with emissivity $e = 1$, is called black. It has been known that soils have emissivities close to unity, but just how close was not known. The manufacturer stated that e is between 0.9 and 1. This means that a soil sample of $e = 0.9$ and 300 abs. would give the same instrument reading as a sample of $e = 1$ and 292 abs. This error would have

* Infrared Thermometer. IT-3E; manufactured by Barnes Engineering Co., Stamford, Conn.

been too large. It was shown through a series of calibrations with different kinds of soil that the error is actually much smaller, i.e., that the emissivity in the used wave lengths and at realistic temperatures differ very little. Details of the measurements are given below.

Another problem is the loss of energy between the emitting surface and the sensor. This is of no concern when the distance is short but must be considered when measurements over longer distances are planned.

The infrared instrument contains as stated above, a radiation source which serves as a base line for the incoming radiation. The mechanism of the instrument brings part of this radiation out of the instrument where it can have two effects. First, it may be reflected back into the instrument, which is not capable of distinguishing between the radiation it is supposed to measure and the additional reflected light. Second, the outgoing radiation may heat up the tested surface precisely at the place where the measurement is taken. The reflection effect can be almost completely eliminated by avoiding a perpendicular orientation of the instrument to the tested surface. This is not important as long as soil is measured, but in cases of high reflectivity, as typical for metals or water, the axis of the instrument must not be perpendicular to the tested surface. In testing the instrument on polished metal objects it was found that the temperature reading increased by as much as 20 C, or more, precisely as the 90° orientation was reached. The second effect, the heating of the tested surface by the instrument, may be considered as negligible in most cases, since the emitted energy is rather small so that no significant heating can occur, and also the radiation from the instrument must hit the surface for some time before it can accumulate to a measurable increment of temperature. However, in cases of stationary installations, e.g., for the permanent recording of a surface temperature, the heating effect must be checked to avoid modification of conditions under investigation.

Another effect that may reduce the usefulness of the infrared thermometer is the temperature of the instrument. The reference radiation inside the instrument is produced by heating a "black body" to a certain temperature at which it is maintained by a sensitive thermostat. This process, however, can work only as long as the instrument as a whole is cooler than the standard reference (approximately 60 C). Since the temperature of a body exposed to the tropical sun may become as high or higher than the reference temperature, the infrared instrument must be appropriately shielded when used in the open.

Two disadvantages of the instrument may be of importance in some kinds of application. First, the instrument needs a power source. Our instrument works only with 110 volts AC. A new type just announced, operates with batteries. It is however, very difficult to use dry batteries in a humid tropical environment satisfactorily, where high moisture and delayed supply routes introduce problems. Second, the sensor and the indicator portions of the instrument are connected by a 20-conductor cable, which offers considerable mechanical resistance to movement. Consequently two

persons are required to handle the device, one for aiming and one for reading. This difficulty is overcome in a stationary installation, as for the Data Base project, where routine measurements of the soil surface temperature are made concomitant with the other measurements made at fixed intervals and locations.

Calibration Measurements

Calibration of instruments is accomplished through comparison of the reaction to the same measureable characteristics of two instruments, one being investigated and the other known to be accurate. In this case the indication of the infrared thermometer must be compared with the actual temperature of the soil surface. The problem is to know the latter. The uppermost layer of the soil is known to change its temperature rapidly in response to varying conditions. Therefore it was necessary to maintain the soil samples under constant thermal conditions long enough for the internal and external temperatures to equalize. When this was accomplished, the internal temperature (now equal to the surface temperature) could be readily determined with a common mercury-in-glass thermometer. Because the internal soil temperature changes very slowly, it was necessary to spread the calibration measurements over several weeks.

Such measurements were carried out with different soil samples typical for this part of Panama: natural bare soil, as found at the Chiva Chiva site; the same soil with short grass; the same with moisture removed and volume compressed; and red clay prepared in the same way. Surprisingly and encouragingly, the infrared thermometer reacted in the same way to all the samples. This meant that the emissivity of the samples was equal, within the limits of accuracy with which the instrument can be read. This is also true for different degrees of wetness of the soil.

Measurements were made at three temperatures: in a normal storeroom of 26-27 C and high relative humidity of the air, in a climatized storeroom of 39-41 C with dry air, and in an oven at 52-54 C. The readings under the first two conditions were simple and unambiguous. In the oven the instrument readings were frequently unstable, and sometimes unexplained large differences were observed between the oven and the soil temperatures.

Figure IV-13 shows all 28 calibration measurements. They can be approximated by a straight line (not shown in the figure) of the equation: $t = 1.262 (s - 39.2) + 35.7$ with a rms error of ± 0.73 where t = temperature in C, and s = indication of the infrared thermometer. The deviations between the measurements and the straight line are not randomly distributed, but suggest a slight bending of the calibration curve. Trying a second degree approximation, the method of the least squares yields the parabola:

$t = 46.1 + 14.52\sqrt{s - 7.2}$ with a rms error of ± 0.66
and distribution of the errors seems to be random. The line in Figure IV-13 is this parabola, by means of which each instrument reading can be converted into temperature.

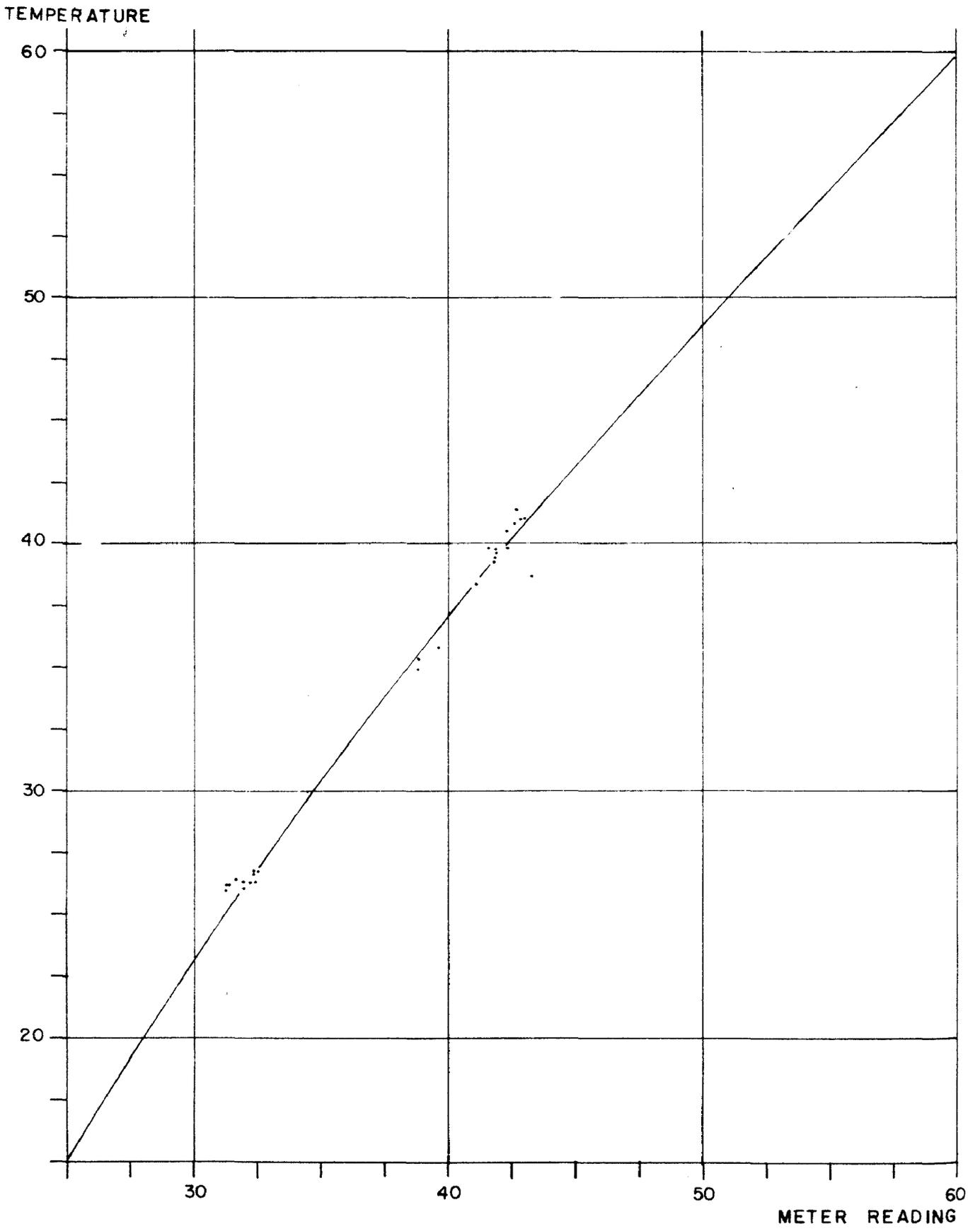


FIGURE IV-13. READING OF THE INFRARED THERMOMETER VS. TEMPERATURE (°C)

Summary

It has been shown that, with some restrictions, the Barnes infrared thermometer is an adequate instrument for measuring the soil surface temperature on a routine basis. The scale printed on the instrument must, however, be substantially modified in temperature ranges below 50 C. The different soils tested yielded equal temperature readings within the range of 25-54 C that was checked. Only dark soils (with and without grass), but no beach sand, were examined. Because of the encouraging results soil-surface temperatures are routinely measured with a Barnes infrared thermometer at the Chiva Chiva open site. Figure IV-2 shows views of the sensor and the indicator, respectively, together with the calibrated instrument which is being used as a check on the other. The indications of the "identical" instruments are substantially different (10 F) in lower temperature ranges; the difference is time-constant and reproducible. Further investigations are planned on the possibility of using the second instrument on the upper part of the Albrook tower to measure the temperature of the upper side of the forest canopy.

PART V. SOILS AND HYDROLOGY*

Introduction

The soils and hydrology task of the Data Base Project encompasses four integrated data-gathering phases connected with studies of soil trafficability: (1) soil strength measurements, (2) soil sample measurements, (3) soil temperature and moisture measurements, and (4) ground water level measurements. Data are gathered at the Albrook Forest and Chiva Chiva main sites and at the satellite sites located at Fort Kobbe, Fort Sherman, and near the Albrook Forest site. Table V-1 summarizes the types of data collected and their scheduling at the various sites.

The data presented in this section constitute a continuation and an expansion of those reported in the previous Semianual Report⁽¹⁾ detailed information on the three satellite sites is presented for the first time.

The one-time determination of bulk density and water tension samples was accomplished during this reporting period. Detailed descriptions of the soil profile for the two main and three satellite sites were prepared, and bulk samples for physical and chemical analysis were collected from each genetic horizon as well as from each three-inch increment layer, down to 18 inches.

Data Collection

Procedures and-operational techniques outlined in the previous report have been followed in collecting the currently described information. The soil strength data, as measured by cone index and remolding index, were collected with the 0.5 and 0.2-square-inch cone penetrometers and remolding equipment developed by the US Army Engineer Waterways Experiment Station (WES). When soil conditions permitted, soil moisture and density samples were obtained with the trafficability sampler. Otherwise, an Oakfield punch or soil auger was used to obtain moisture samples only. The San Dimas sampler was employed for securing soil cores for bulk density and water tension determinations at 0 and 0.06 atmospheres. Tension determinations at 0.06 atmospheres were performed with the tension table developed by Leamer and Shaw⁽⁷⁾ using double blotters as the porous medium and subjecting the samples to a constant tension of 60 cm of water for a 24-hour period after being thoroughly saturated for 36 hours. Other tension determinations were performed with the pressure membrane apparatus.

Bulk samples, to be used for physical and chemical analyses were collected from pits approximately one meter long, one-half meter wide, and one and one-half meters deep. The pits were dug to permit detailed description

* This section was prepared by Mr. Ricardo Ah Chu, Soils Scientist.

TABLE V-1. SOIL DATA COLLECTION SCHEDULE

| Sites | Strength | | | Type of Data and Frequency | | | Soil Sampling | | Soil Temperature & Moisture | | Groundwater Level | |
|--------------------|----------------------|----------------------|----------------------------|----------------------------|--|-------------------|---------------------------------|----------------------------|-----------------------------|--------|-------------------|--|
| | Cone Index | Remolding Index | Moisture Content & Density | Bulk Density | Chemical & Physical Analysis* | Tension | Bulk Density & Moisture | Electrical Resistance | Telemetry | Manual | Automatic | |
| Albrook (Forest) | 6/week 0-18" | 3/week 6-12" | 6/week 0-18" | One time 0-18" | One time plus general layers (8 depths) | One time 0-18" | Hourly (two tiers) 4-100 cm. | None | 4/day | None | None | |
| Chiva Chiva (Open) | 6/week 0-18" | 3/week 6-12" | 6/week 0-18" | One time 0-18" | One time plus general layers (8 depths) | One time 0-18" | Hourly (one tier) 4-100 cm. | 24/day (Sfc to 1 meter) | 4/day | None | None | |
| Satellite** | 2/two weeks 0-18" | 2/two weeks 6-12" | 2/two weeks 0-12" | One time 0-18" | plus general layers | One time 0-18" | None | None | None | None | Continuous | |

* Physical Analyses

Atterberg limits
Specific gravity
Water tension at 3 and 15 atmospheres
Grain size distribution

* Chemical Analyses

Nitrogen
Phosphorous
Potassium
Calcium
Minor Elements
Base exchange capacity
Organic matter content

** Satellite Sites

Albrook
Fort Kobbe
Fort Sherman

of the soil profile following procedures and techniques developed by the US Department of Agriculture.⁽⁸⁾ Each genetic horizon was described on basis of the following characteristics: depth, color (Munsell numerical notation), texture, structure, consistency at different moisture levels, amount of roots, boundary and thickness of horizons, mottling conditions, and other characteristics deemed significant in the characterization of the horizon. After completion of the soil profile description a three or four pound bulk sample of each horizon was collected. These samples were processed and used in physical and chemical analyses. Detailed descriptions of soil profiles and summary tables of some of the physical characteristics determined in the laboratory are shown in Appendix A.

The fiberglass units and the soil moisture meter developed by Coleman and Hendrix⁽⁹⁾ are used to obtain soil moisture information in-situ. A field calibration curve prepared for each unit is used to convert the readings obtained with the meter into approximately equivalent values of soil moisture content. Soil temperature is determined by the use of telethermometer probes at the Chiva Chiva site. Since additional probes were not available, the thermistors incorporated in the fiberglass units were utilized for this purpose at the Albrook site. The results obtained with these thermistors have not been satisfactory, however, and their use has been discontinued.

Fluctuation of the groundwater level is measured manually at the main environmental sites by inserting a graduated wooden rod in the cased well. Water-level measurements at the three satellite sites are automatically recorded.

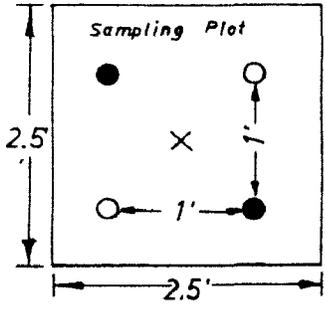
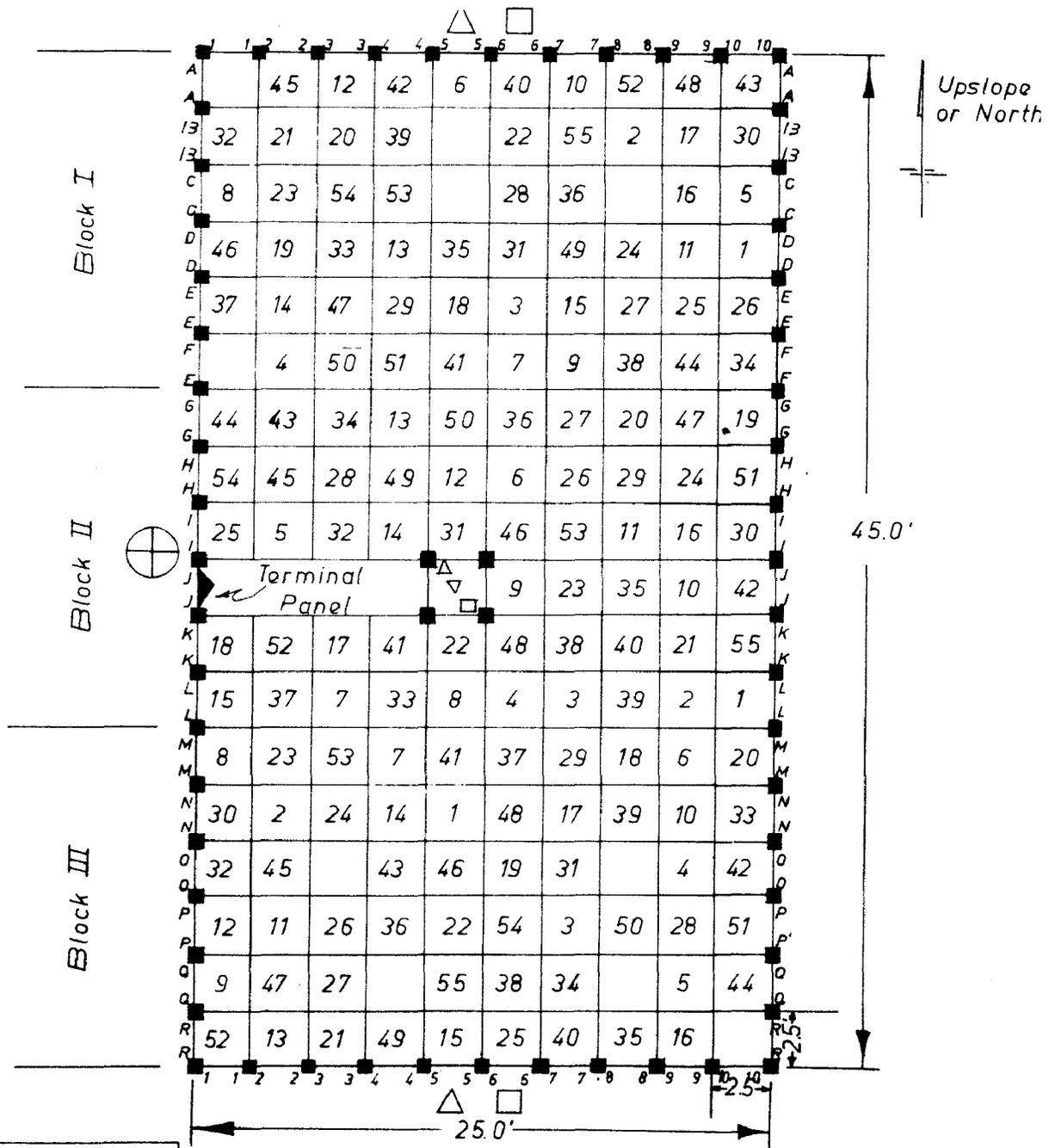
Analysis of Data

Data obtained from each site are presented below, together with a partial graphic analysis showing some of the relationships observed between the various soil parameters. The collection of soil information from a plot at each of the main sites similar to the one depicted in Figure V-1 has been completed and is available for statistical analysis. The data reported here for the two main sites pertains to these plots. A new plot has since been established at each main site and collection of the same general type of information has continued. Moisture-strength-density summary tables are contained in Appendix A for each site; the analysis that follows is based on these data.

Soil Moisture Profiles

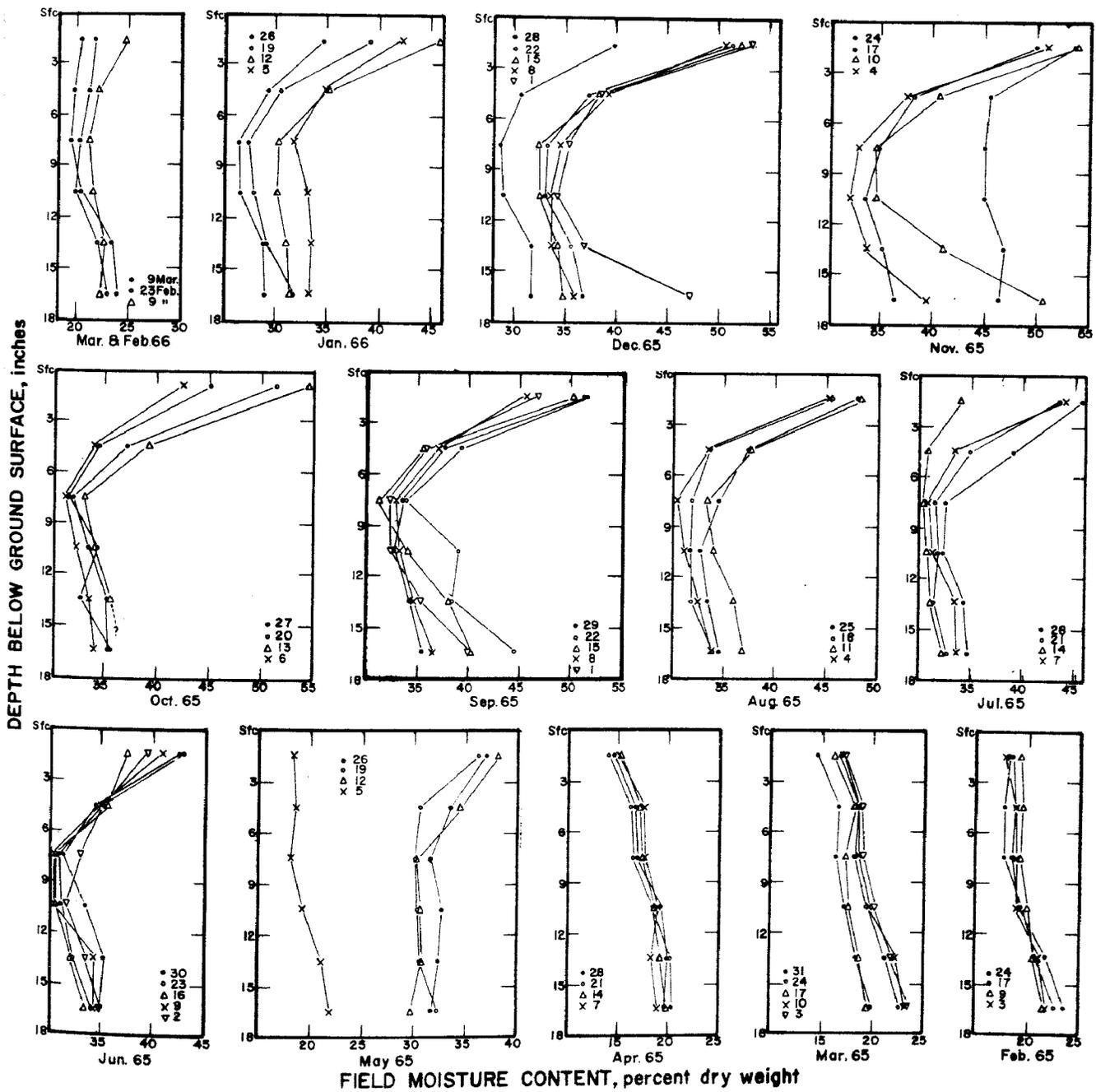
Moisture profiles from the Chiva Chiva and Albrook sites are presented in Figures V-2 and V-3 respectively. These profiles are plotted down to 18 inches at 3-inch increments and are shown by sampling date. Points on the profiles represent the average value derived from samples collected in pairs from three randomly chosen blocks (6 samples in all) within the soil plot at each site. Moisture contents were determined by weighing the

NOTE: Numbers in plots indicate sampling sequence by visit number.



- △ Bulk & Soil-profile sample
- Core sample
- × Remolding sample
- Moisture sample
- Cone penetrometer
- Wood stake
- Well
- ⊕ Fiberglass units

FIGURE V-1. LAYOUT OF SAMPLING PLOT AT THE CHIVA CHIVA AND ALBROOK FOREST SITES. (MODIFIED AFTER WES, 1962)



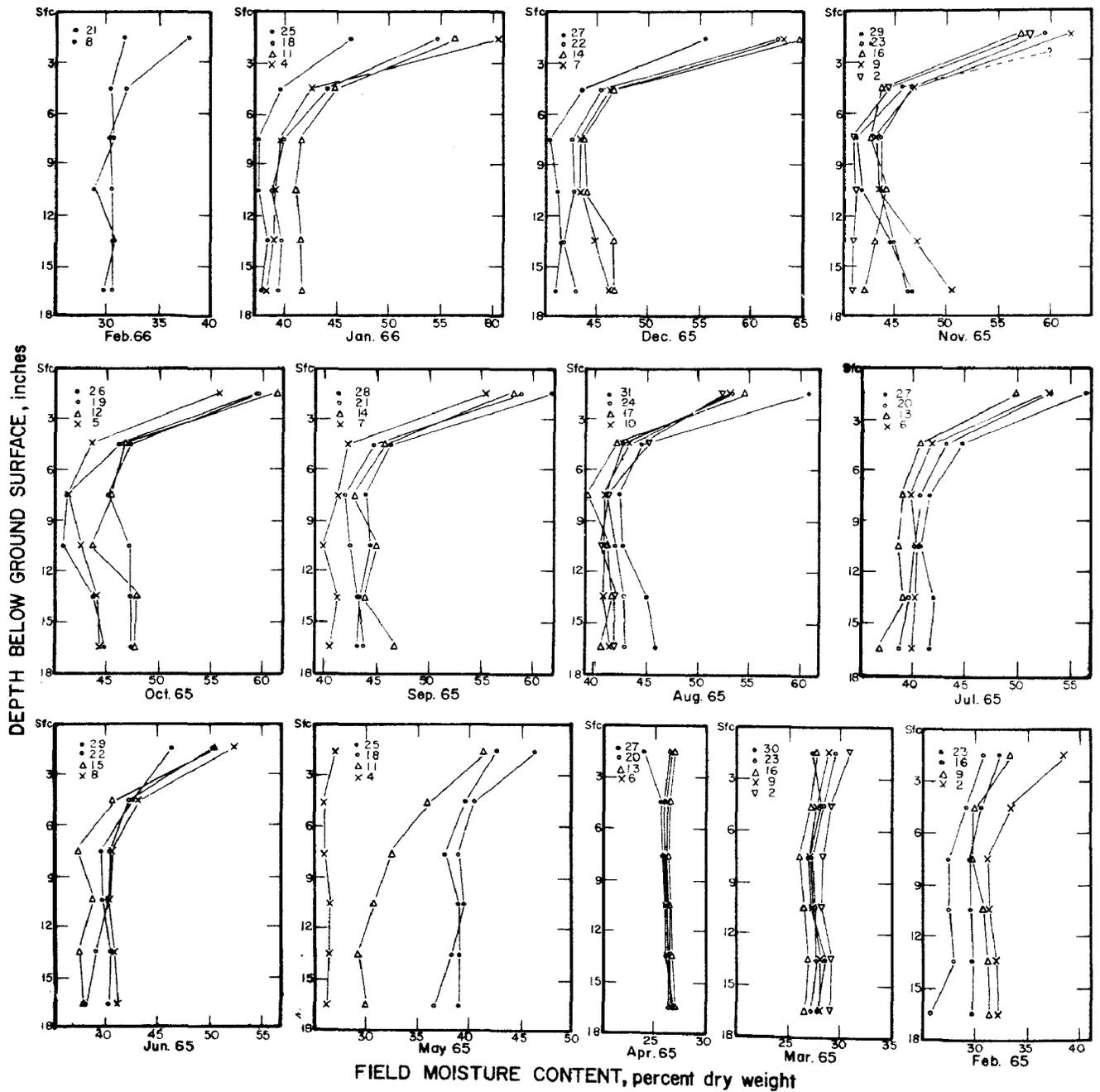


FIGURE V-3. MONTHLY VARIATION OF NATURAL FIELD MOISTURE CONTENT WITH DEPTH, ALBROOK FOREST SITE.

FIGURE V-3. MONTHLY VARIATION OF NATURAL FIELD MOISTURE CONTENT WITH DEPTH, ALBROOK FOREST SITE

samples before and after oven-drying. The results are expressed as a percentage based on the oven-dried weight of the soil.

A composite of all the moisture profiles has been grouped in Figure V-4 for overall comparison between the Chiva Chiva and Albrook sites. Moisture contents, as expected, are highest at both sites for the uppermost layers where the general physical conditions of the soils are more conducive to water retention during the wet season; bulk density, for example, averaged 0.87 and 0.99 grams per cc for the 3- and 6-inch depths respectively at lower depths it averaged as high as 1.17 grams per cc. Groundwater appears to be influential on the moisture regime of the soil between the 9- and 12-inch depths at the two main sites and increasingly so with advancement of the wet season as suggested by the sudden change in direction of the curves at this level. On the other hand, the groundwater level at both sites fluctuated most frequently between 10 and 20 inch depths during the wettest portion of the rainy season. (See Figures V-13 and V-14 of previous Semiannual Report⁽¹⁾.) The curves for the driest months (February, March, and April) show greater moisture differences between levels at Chiva Chiva than at Albrook, where moisture remained relatively constant from the 4.5-inch depth downward, although moisture content at all depths and at both sites decreased gradually as the dry season advanced. It is interesting to note that moisture at the surface, i.e., the 0- to 3-inch layer, at the forest site, usually remained higher throughout the dry season, except for two instances when it dropped below that of the deeper layers. The low rate of moisture loss at the 0- to 3-inch layer where evaporative mechanisms exert greater influence, suggests, in part at least, that possibly the relative humidity within the soil about equalizes that of the outside environment in such a way that no significant gradient between the two exists. It is also possible that the rather thick mat of dry litter over the ground exerts a shielding effect which greatly reduced the evaporation of moisture from the soil surface. The litter study being conducted under the Data Base Project may eventually clarify this question.

Soil Strength Profiles

Figures V-5 and V-6 present soil strength profiles for the Chiva Chiva and Albrook Forest sites, respectively. The profiles are constructed from cone indices recorded by sampling date. The curves were derived from the average of six samples, obtained in pairs from three randomly selected blocks from the soil plot. Figure V-7 shows a composite of all the curves for both sites. In general, all the curves show a normal strength profile whereby soil strength augments with depth. Dry, wet, and intermediate season conditions readily show up on the composite graphs. However, data for the dry season from Chiva Chiva is not plotted because the firmness of the soil during the dry season impeded penetration of the instrument into the ground. Tables V-2 and V-3 for the Chiva Chiva and Albrook sites display distributions of cone indices by class interval, for each layer, for the period covered by the data. Table V-4 presents the range of cone indices at the two sites for each of the layers measured by seasons.

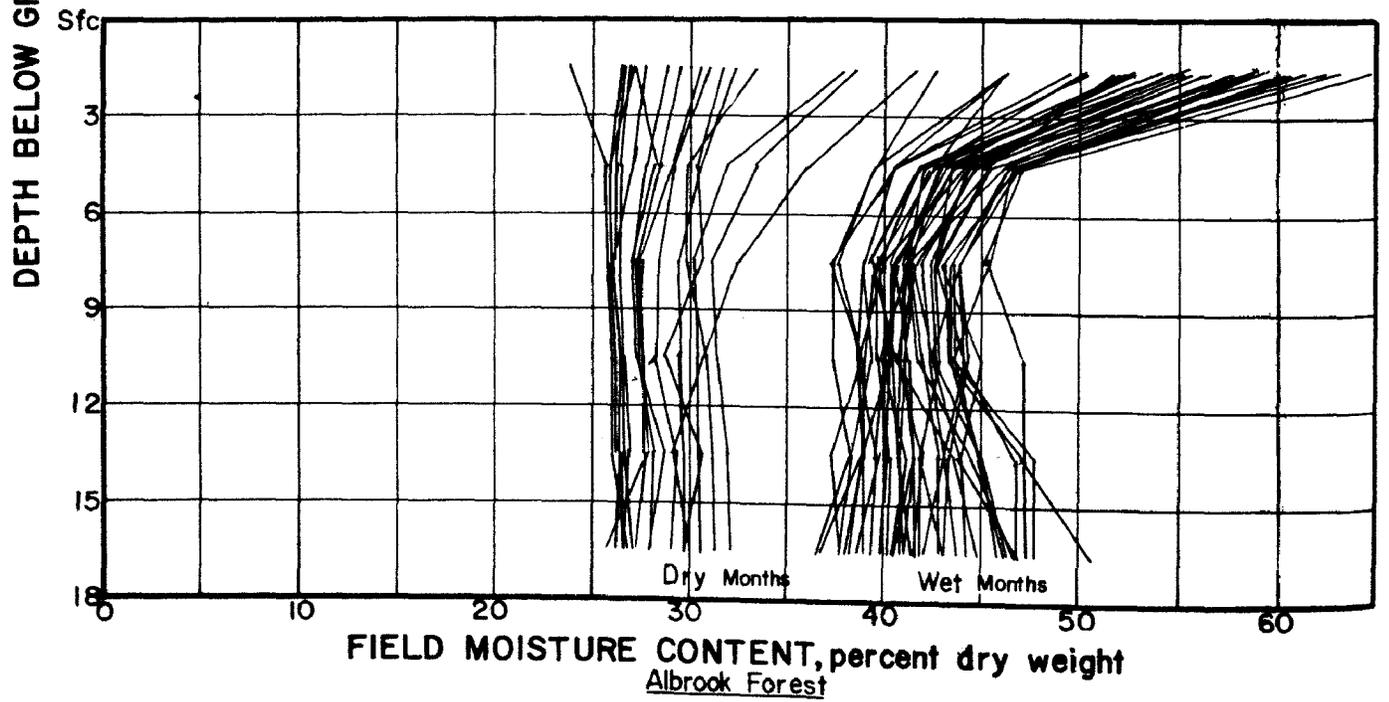
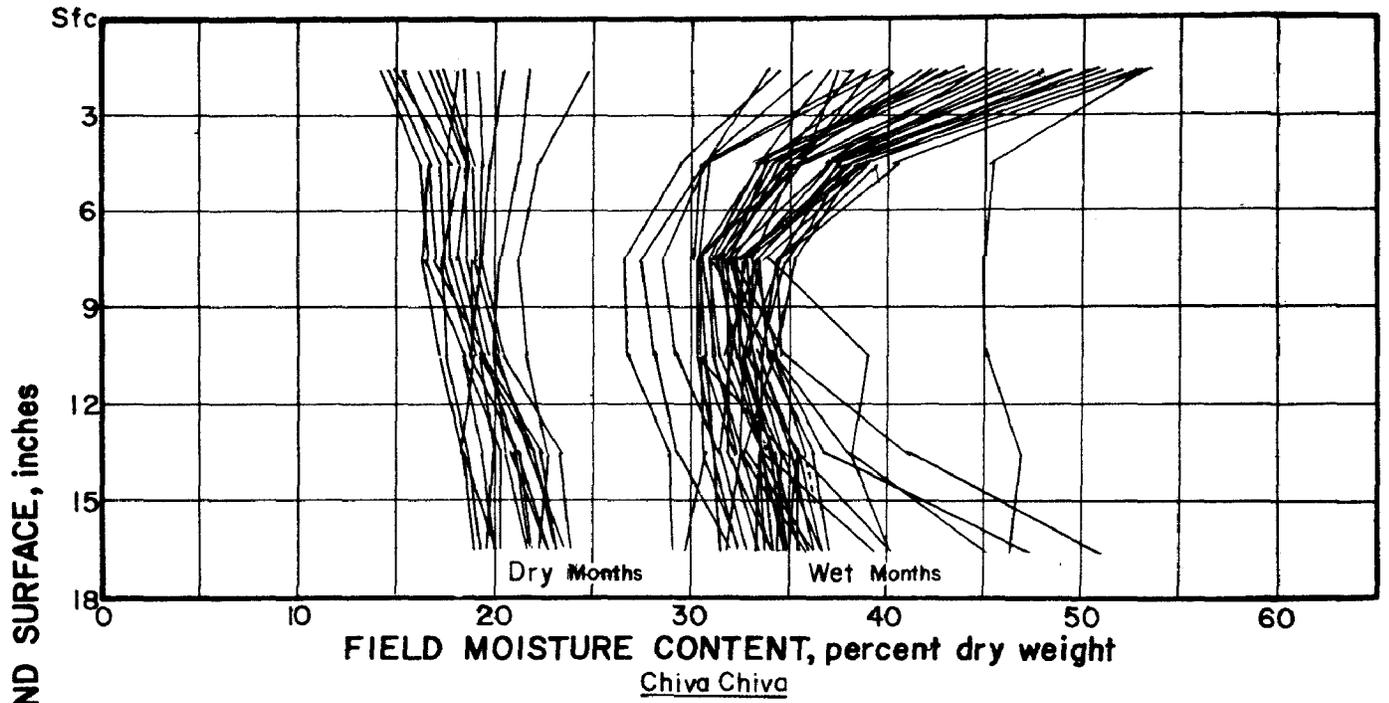


FIGURE V-4. COMPOSITE OF ALL SOIL MOISTURE PROFILES, CHIVA CHIVA AND ALBROOK FOREST SITES.

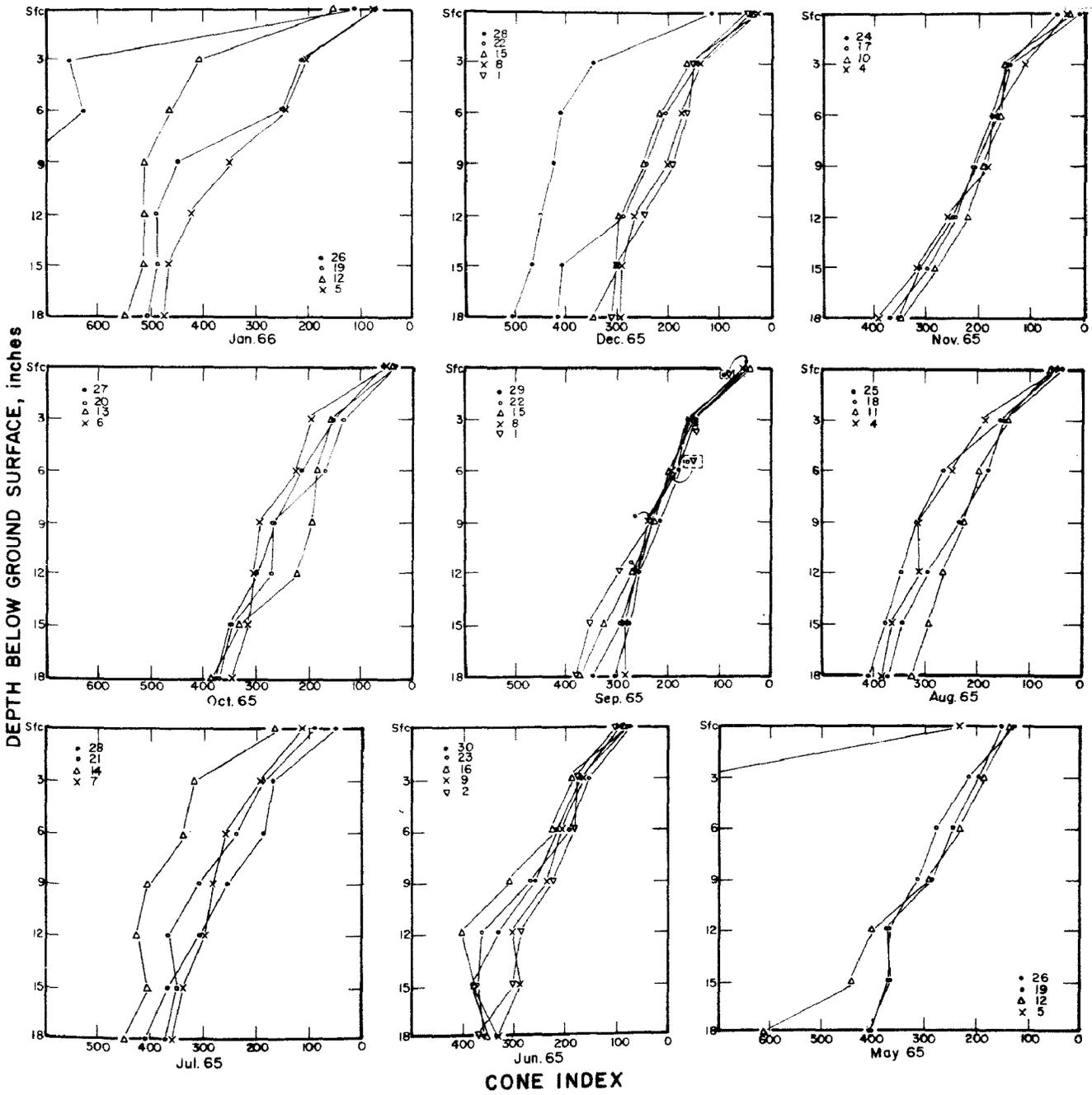


FIGURE V-5. MONTHLY VARIATION OF CONE INDEX WITH DEPTH, CHIVA CHIVA SITE

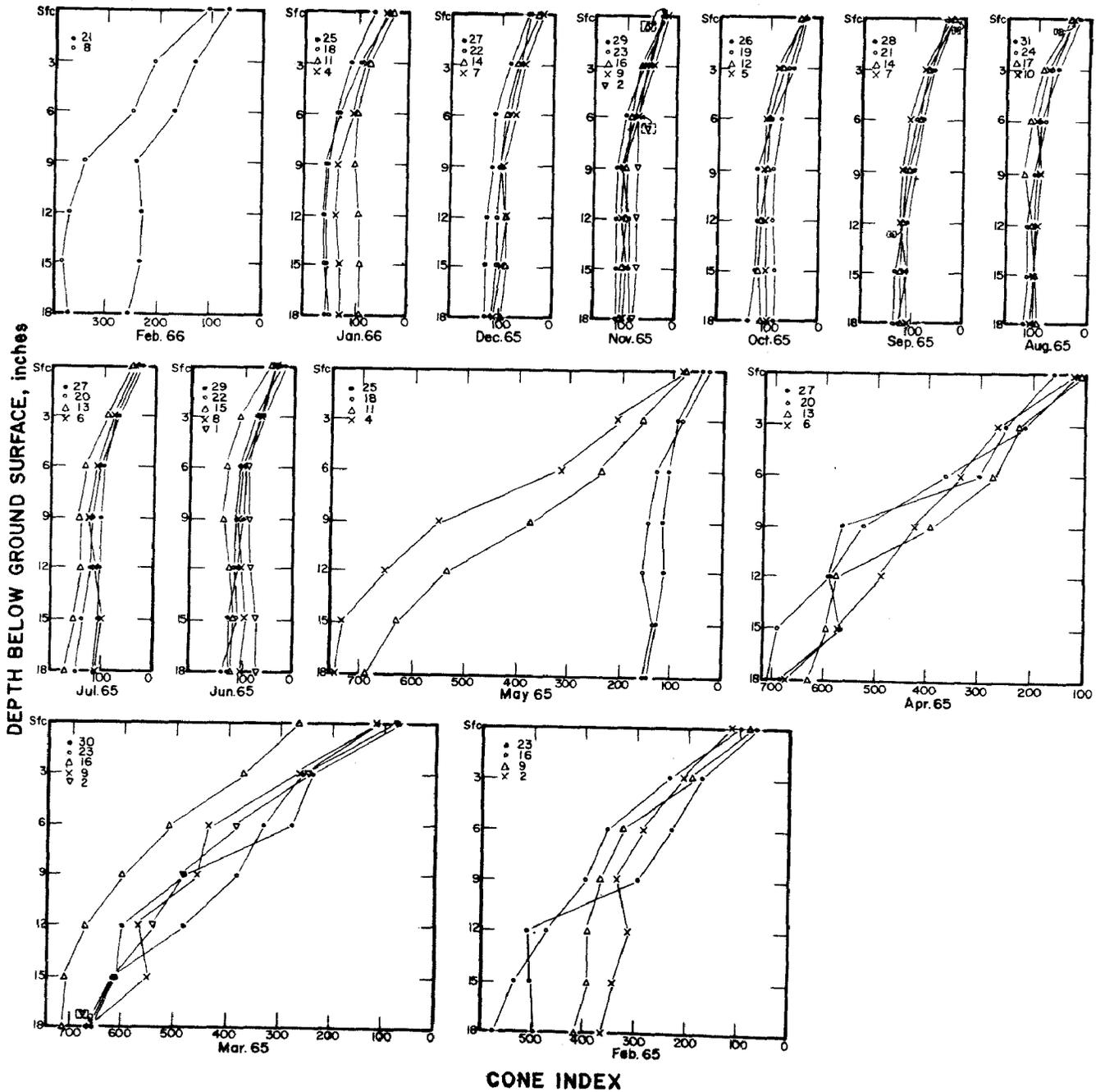


FIGURE V-6. MONTHLY VARIATION OF CONE INDEX WITH DEPTH, ALBROOK FOREST SITE

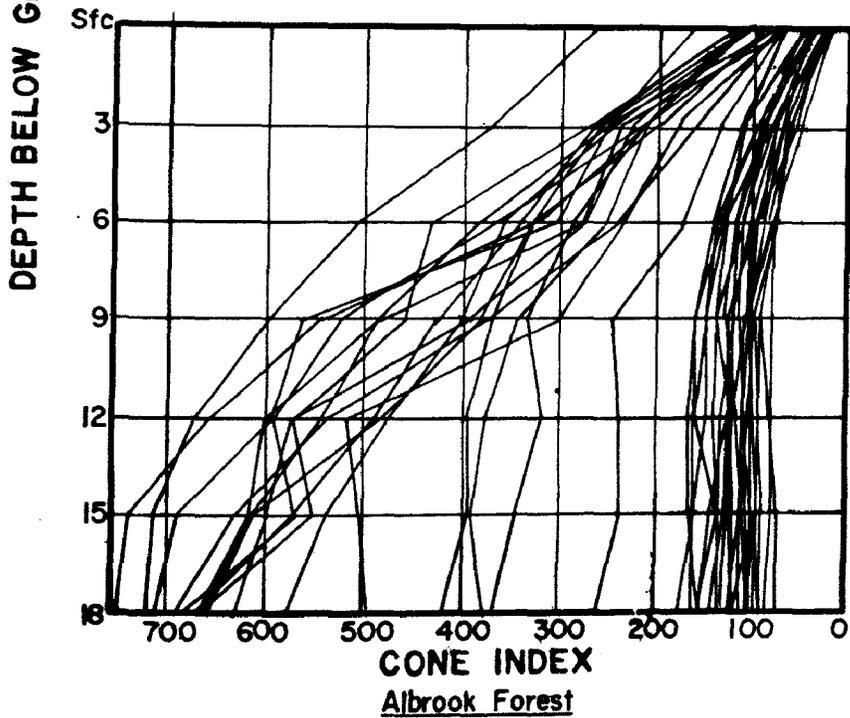
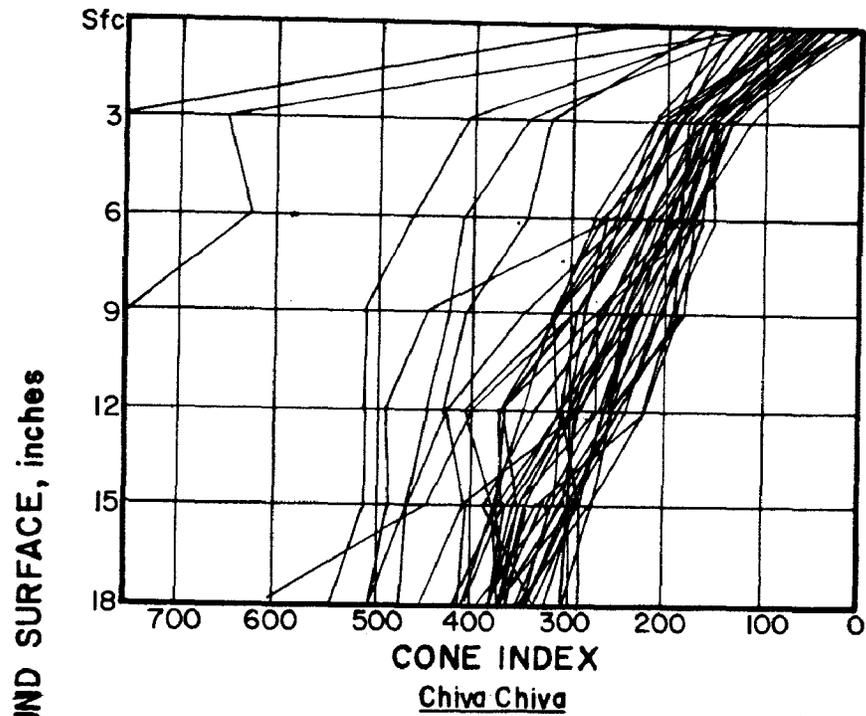


FIGURE V-7. COMPOSITE OF ALL CONE INDEX PROFILES, CHIVA CHIVA AND ALBROOM FOREST SITES.

TABLE V-2. DISTRIBUTION OF INDIVIDUAL FIELD CONE INDEX READINGS
BY CLASS INTERVALS AT THE CHIVA CHIVA SITE*

| Class Intervals in Cone Index Units | Sfc | 3 | 6 | 9 | 12 | 15 | 18 |
|--|-----|----|-----|-----|-----|-----|-----|
| 0 - 24 | 10 | - | - | - | - | - | - |
| 25 - 49 | 69 | - | - | - | - | - | - |
| 50 - 74 | 67 | - | 1 | - | - | - | 1 |
| 75 - 99 | 33 | 4 | - | - | - | - | - |
| 100 - 124 | 22 | 9 | 1 | 2 | 1 | - | - |
| 125 - 149 | 16 | 48 | 13 | - | 1 | - | - |
| 150 - 174 | 14 | 70 | 37 | 14 | - | - | - |
| 175 - 199 | 14 | 34 | 46 | 26 | 8 | 4 | 1 |
| 200 - 224 | 14 | 27 | 36 | 36 | 22 | 12 | 4 |
| 225 - 249 | 10 | 13 | 33 | 28 | 25 | 13 | 10 |
| 250 - 274 | 16 | 2 | 21 | 32 | 27 | 23 | 18 |
| 275 - 299 | 8 | 3 | 12 | 20 | 23 | 14 | 10 |
| 300 - 324 | 3 | - | 3 | 11 | 18 | 20 | 15 |
| 325 - 349 | - | 1 | 3 | 8 | 12 | 19 | 12 |
| 350 - 374 | 1 | 1 | 1 | 8 | 24 | 26 | 26 |
| 375 - 399 | - | - | 4 | 5 | 13 | 20 | 22 |
| 400 - 424 | - | 4 | 4 | 9 | 18 | 21 | 34 |
| 425 - 449 | - | 4 | 4 | 5 | 3 | 18 | 13 |
| 450 - 474 | 4 | 2 | - | 12 | 12 | 9 | 18 |
| 475 - 499 | - | - | 1 | 2 | 5 | 8 | 11 |
| 500 - 524 | 1 | - | - | 1 | 6 | 6 | 5 |
| 525 - 549 | 1 | 2 | 2 | 2 | 1 | 3 | 3 |
| 550 - 574 | 8 | 1 | 1 | 1 | 1 | 3 | 7 |
| 575 - 599 | 1 | 1 | 3 | - | 2 | - | 2 |
| 600 - 624 | 1 | - | 2 | - | - | 2 | 4 |
| 625 - 649 | 2 | 1 | - | 1 | - | - | 2 |
| 650 - 674 | 1 | 2 | - | - | - | 2 | 1 |
| 675 - 699 | 1 | 2 | - | - | 1 | - | 2 |
| 700 - 724 | - | - | - | - | - | - | - |
| 725 - 749 | - | - | - | 2 | - | - | - |
| 750 + | 13 | 99 | 102 | 105 | 107 | 107 | 106 |

* Individual field cone indices were used in making the distributions, contrasted to the use of average indices as shown on the strength profiles of the previous figures.

TABLE V-3. DISTRIBUTION OF INDIVIDUAL FIELD CONE INDEX READINGS
BY CLASS INTERVALS AT THE ALBROOK FOREST SITE*

| <u>Class Intervals in Cone Index Units</u> | <u>Sfc</u> | <u>3</u> | <u>6</u> | <u>9</u> | <u>12</u> | <u>15</u> | <u>18</u> |
|--|------------|----------|----------|----------|-----------|-----------|-----------|
| 0 - 24 | 55 | - | - | - | - | - | - |
| 25 - 49 | 144 | 23 | - | 1 | 1 | 1 | 1 |
| 50 - 74 | 49 | 93 | 27 | 6 | 8 | 10 | 9 |
| 75 - 99 | 22 | 81 | 86 | 59 | 66 | 65 | 43 |
| 100 - 124 | 25 | 26 | 80 | 91 | 76 | 74 | 86 |
| 125 - 149 | 7 | 14 | 20 | 44 | 53 | 45 | 54 |
| 150 - 174 | 8 | 15 | 9 | 16 | 14 | 18 | 19 |
| 175 - 199 | 4 | 11 | 8 | 6 | 6 | 7 | 5 |
| 200 - 224 | 1 | 22 | 20 | 8 | 2 | 3 | 4 |
| 225 - 249 | 1 | 13 | 7 | 6 | 3 | 4 | 4 |
| 250 - 274 | 1 | 8 | 14 | 6 | 4 | - | 1 |
| 275 - 299 | - | 2 | 3 | 3 | 1 | 3 | 1 |
| 300 - 324 | 2 | 1 | 9 | 2 | 3 | 1 | 4 |
| 325 - 349 | - | 1 | 2 | - | 3 | - | 1 |
| 350 - 374 | - | 1 | 5 | 6 | 4 | 7 | 1 |
| 375 - 399 | - | 1 | 1 | 3 | 3 | 3 | 2 |
| 400 - 424 | - | 2 | 10 | 13 | 6 | 2 | 5 |
| 425 - 449 | - | - | 1 | 3 | 1 | 2 | 1 |
| 450 - 474 | 1 | 1 | 2 | 7 | 6 | 10 | - |
| 475 - 499 | - | - | 5 | 4 | 6 | 1 | 4 |
| 500 - 524 | - | - | 2 | 10 | 7 | 5 | 8 |
| 525 - 549 | - | 2 | 2 | - | 2 | 4 | - |
| 550 - 574 | - | - | 1 | 11 | 8 | 6 | 7 |
| 575 - 599 | - | - | - | 4 | 1 | 4 | 3 |
| 600 - 624 | - | 1 | 2 | 3 | 14 | 9 | 6 |
| 625 - 649 | - | - | 1 | - | 1 | 3 | 2 |
| 650 - 674 | - | - | 1 | 2 | 10 | 4 | 6 |
| 675 - 699 | - | - | - | 3 | 3 | 3 | 3 |
| 700 - 724 | - | - | - | - | - | - | - |
| 725 - 749 | - | - | - | - | - | - | - |
| 750 + | - | 2 | 2 | 3 | 9 | 26 | 9 |

* Individual field cone indices were used in making the distributions. contrasted to the use of average indices as shown on the strength profiles of the previous figures.

TABLE V-4. RANGE OF CONE INDICES

| | | C H I V A | | | A L B R O O K | | | F O R E S T | | | |
|--------|--|---|----------|---------|---------------|--------|---------|---|--------|-----|-----|
| | | Most Frequently Occurring Range (80% or more) | | | Natural Range | | | Most Frequently Occurring Range (80% or more) | | | |
| | | Seasons | | | Seasons | | | Seasons | | | |
| | | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry |
| Sfc | | 20-575 | 50-750+ | 25-200 | 100-300+ | 15-125 | 20-475 | 15-75 | 25-175 | | |
| 3 in. | | 75-450 | 150-750+ | 100-250 | 750+ | 25-275 | 50-750+ | 25-125 | 50-275 | | |
| 6 in. | | 100-600 | 200-750+ | 125-300 | 750+ | 50-500 | 75-750+ | 50-150 | 75-425 | | |
| 9 in. | | 200-475 | 250-750+ | 200-475 | 750+ | 25-700 | 75-750+ | 50-175 | 75-575 | | |
| 12 in. | | 200-550 | 350-750+ | 200-475 | 750+ | 25-700 | 75-750+ | 50-175 | 75-675 | | |
| 15 in. | | 200-675 | 400-750+ | 200-475 | 750+ | 25-675 | 50-750+ | 50-200 | 75-675 | | |
| 18 in. | | 200-700 | 400-750+ | 200-500 | | 25-700 | 75-750+ | 50-225 | 75-675 | | |

Moisture Content-Soil Strength Relations

The natural field strength of soils is measured in terms of the soil trafficability indices developed by WES: cone index, remolding index, and rating cone index. The cone penetrometer is used to measure the shearing resistance of the soil expressed as the cone index (CI). The gain or loss of soil strength to be expected under traffic is measured with the remolding equipment as described in Reference 10; the remolding index (RI) is the ratio of the remolded soil strength to its original strength as measured with the cone penetrometer. The cone index readings of undisturbed soil are multiplied by the remolding index to obtain the "rating cone index" (RCI) which is the strength rating of the soil under sustained traffic. All the curves plotted in this section of the report have been drawn in by eye, in order to emphasize the general trend. Therefore, they should not be considered as the final best-fit curves.

Moisture Content vs. Cone Index. Figure V-8 shows the cone index and moisture content data by 6-inch incremental layers for the two main sites. It is observed that lower soil strength is found at Albrook; the range of the most frequently occurring cone indices for each 3-inch incremental layer for the wet and dry seasons was pointed out previously in Table V-4. The graphs also show the greater strength exhibited by the soils with increasing depth. In general, the spread of the data about the trend line is less for the 0- to 6-inch layer, and the widest spread occurs in the 12- to 18-inch layer. The wider spread observed in the data at greater depths can be attributed in part to instrument and/or operator deficiencies. Figure V-9 combines cone index and soil moisture data for the 0- to 6-inch and 6- to 12-inch layers from the three satellite sites with those of the two main sites. The deviation of the Fort Sherman site data on the Atlantic side from those plotted for the sites on the Pacific side is clearly shown by these curves, however soil strength at the Fort Sherman site follows the same trend as at the other sites, but at higher soil moisture values. It is interesting to note the remarkable uniformity of the cone index and soil moisture data obtained for all the sites on the Pacific side of the Canal Zone where the data from the four sites plotted along the same general curve for both the 0- to 6- and 6- to 12-inch layers.

Moisture Content vs. Remolding Index. Figure V-10 graphically shows the apparent relationship between remolding index and moisture content for the 6- to 12-inch layer for the sites. Remolding tests were restricted to the 6- to 12-inch layer since that is considered the most critical for soil trafficability considerations. Figure V-11 shows a more significant plot of the data in which the relationship derived for each of the sites has been combined into a single composite graph. This graph demonstrates the inconsistent relationship between remolding index and moisture content, which does not follow any constant trend. A slight response of remolded soil strength to moisture content at the two main sites appears on the drier side of the graph. The significance of this is not great since remolding of the soil at low moisture content is not a limiting factor for soil trafficability. On the other hand, the soils at all sites

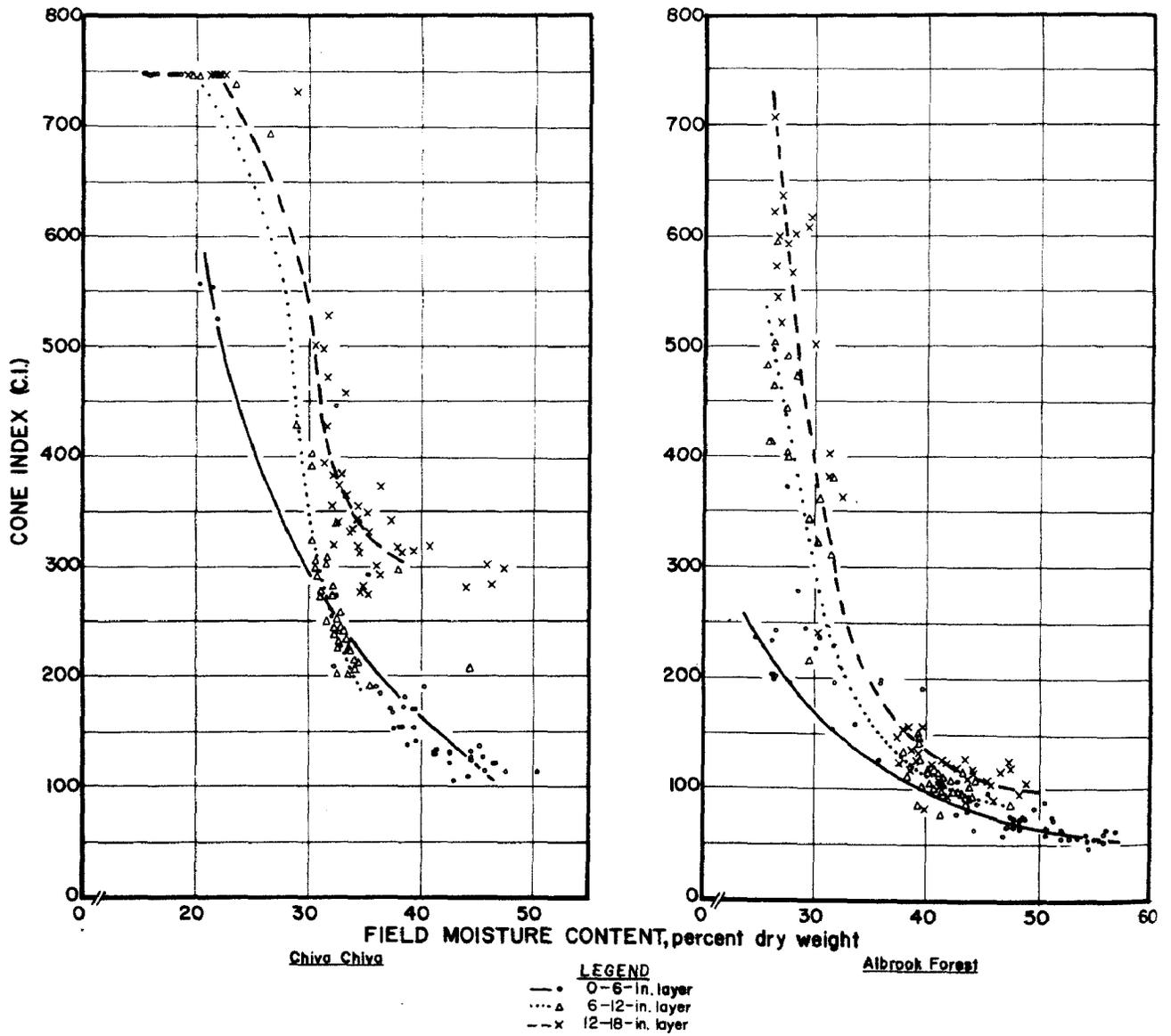


FIGURE V-8. CONE INDEX - SOIL MOISTURE RELATIONSHIP BY 6-INCH LAYERS, CHIVA CHIVA AND ALBROOK

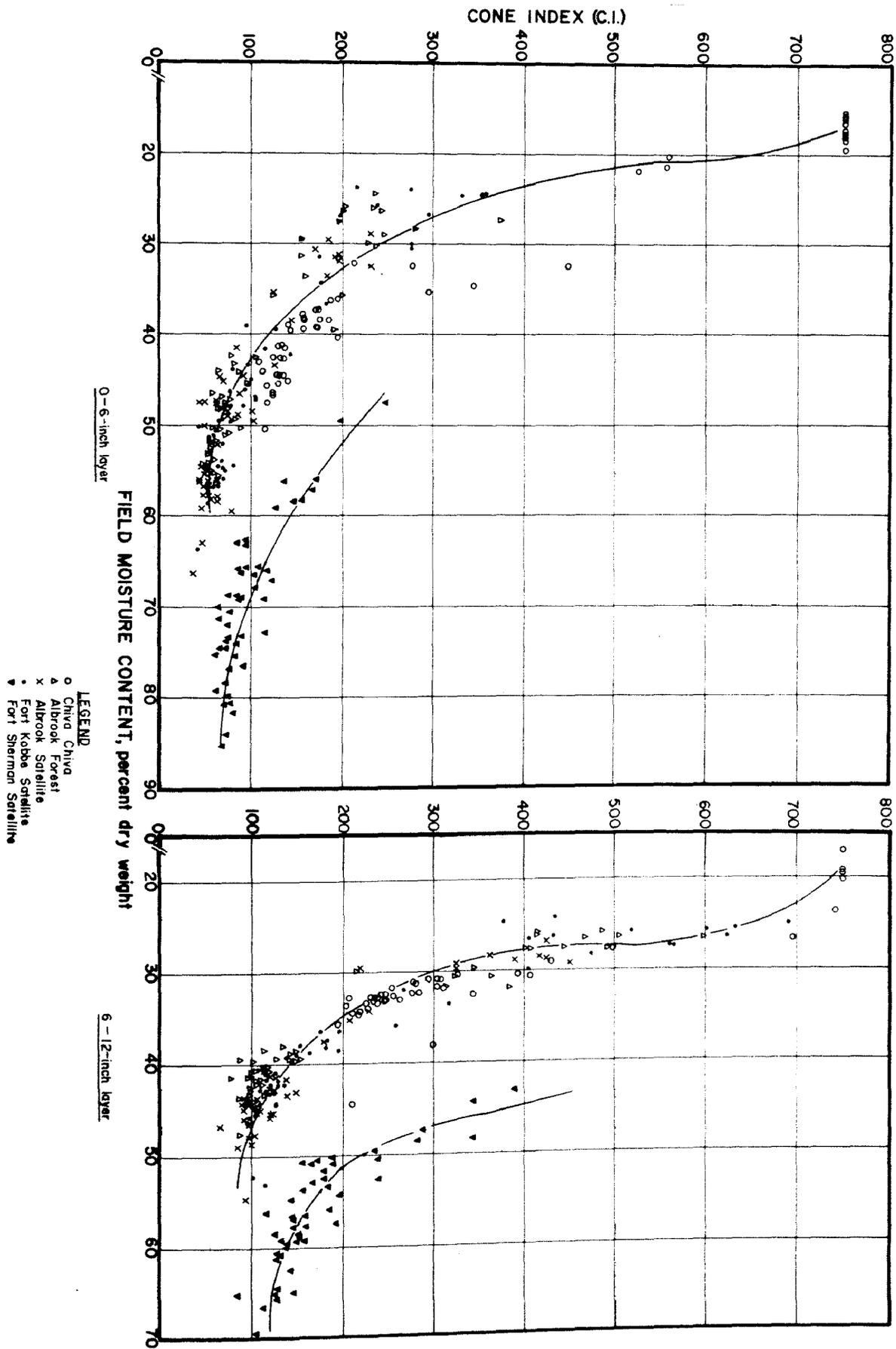


FIGURE V-9. COMBINED CONE INDEX - SOIL MOISTURE RELATIONSHIP FOR ALL SITES, 0 TO 6 AND 6 TO 12-INCH LAYERS.

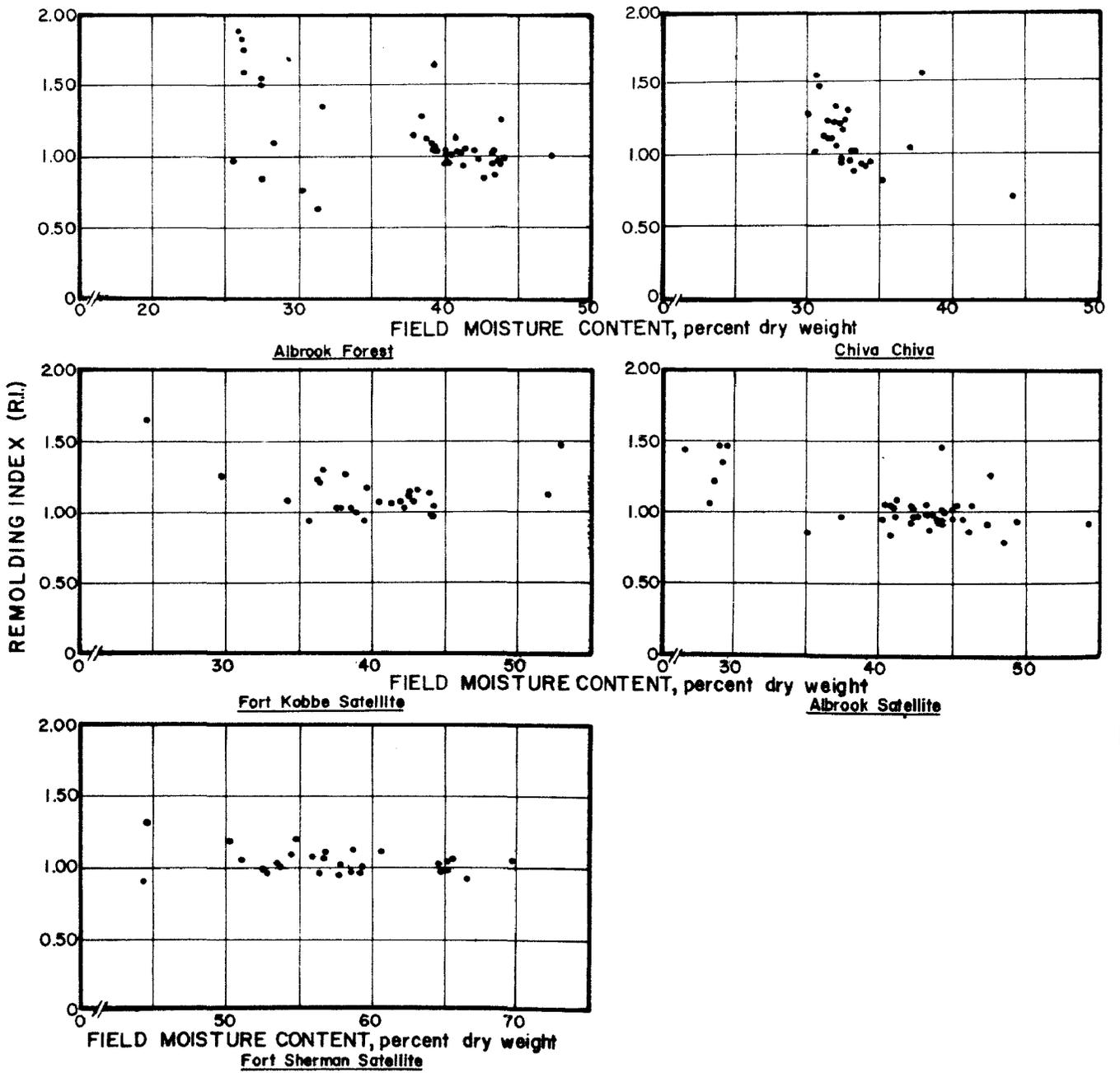


FIGURE V-10. REMOLDING INDEX - SOIL MOISTURE RELATIONSHIP FOR ALL SITES, 6 TO 12-INCH LAYER

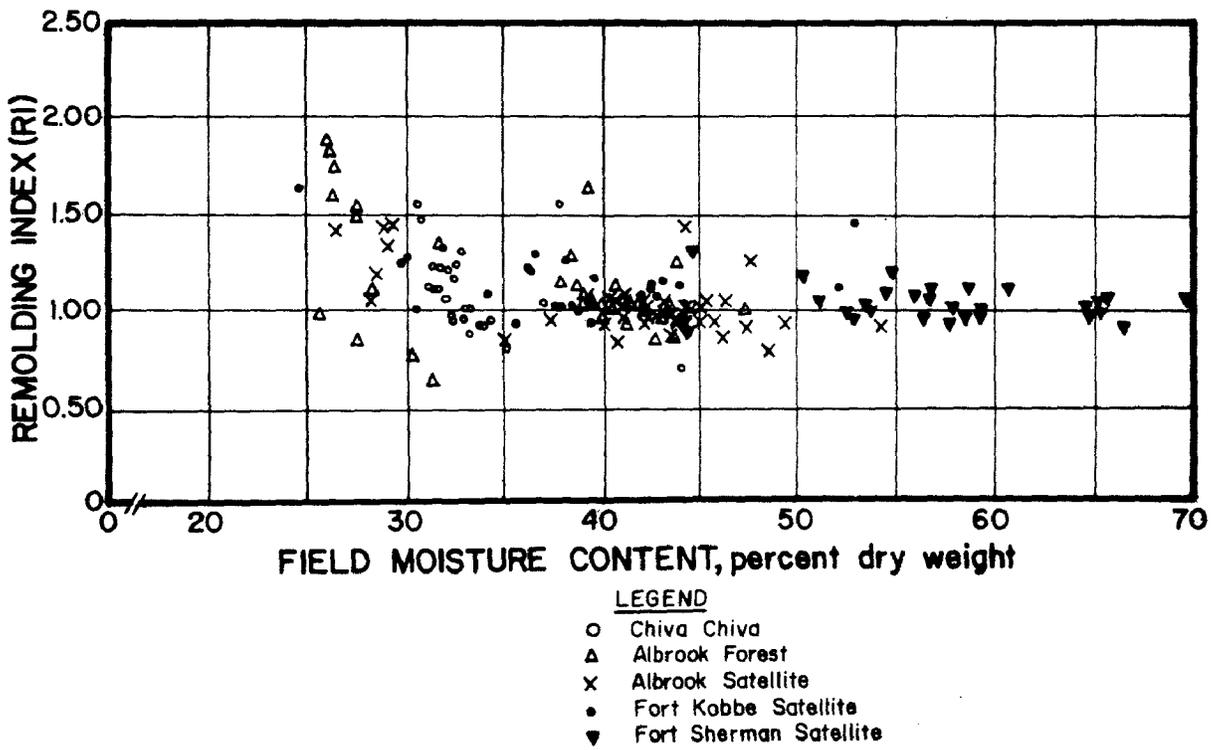


FIGURE V-11. COMBINED REMOLDING INDEX - SOIL MOISTURE RELATIONSHIP FOR ALL SITES, 6 TO 12-INCH LAYER

gained strength after remolding more often than not. The highest gains and losses in strength are exhibited by the soils at the two Albrook sites. In general however, remolding index values are close to unity.

Moisture Content vs. Rating Cone Index. Figure V-12 is a composite of all the rating cone indices computed for the 6- to 12-inch layer for the two main sites and the three satellite sites, using individual remolding index values as determined in the field. Except for the data from the Fort Sherman satellite site which exhibits a reduction in strength after remolding, the remaining data plot along the same general cone index - soil moisture relation established in Figure V-9. The apparent loss of strength of the soils at the Fort Sherman site is on the order of magnitude of 40 percent of the original strength. However when an average remolding index value is used, there appears to be no remolding effects of any of the five sites, the average value for each site having been determined by adding all individual field values and dividing by their total number. Figure V-12 shows the results obtained. If one compares this latter figure with Figure V-10, it is clearly seen that the data contained in both figures are scattered around the same point about the general trend line. This result is to be expected since apparently most of the remolding indices used to compute the rating cone indices did not vary significantly with remolding or with changes in soil moisture at any of the sites.

Moisture Content - Dry Density Relations

Because of the limited data on hand at the time the previous report⁽¹⁾ was prepared, it was stated that the dry density of the soil appeared to be practically unaffected by changes in moisture content within the range studied. Further analysis has revealed the contrary to be true. Relationships between moisture content (percent dry weight) and dry density (pounds per cubic foot) are presented in Figure V-13 for the Chiva Chiva and Albrook Forest main sites, combined in 6-inch incremental layers. Figure V-14 shows the same relationships at the three satellite sites, for the 0- to 6- and 6- to 12-inch layers only. All the data plotted for the five sites tend to produce a hyperbolic curve in which dry density increases from the dry-end portion of the graph to a maximum moisture content, at which point further increments of moisture cause a lowering of the dry density of the soil. This behavior is consistent with that generally obtained from compacted soils in the laboratory in the determination of the maximum density and optimum moisture content. Obviously, dry density is least at the 0- to 6-inch layer where physical conditions are favorable to granulation and soil porosity. Reduction in pore space due to compaction effects exerted by overlying layers is reflected in higher densities at the lower depths. However, densities obtained from soil samples collected at Chiva Chiva showed higher results for the 6- to 12-inch layer than those obtained for the 12- to 18-inch layer. This apparent anomaly may be due in part to slight variations in mineralogical composition and textural differences between the two layers. It was noted, for example, that at the 12- to 18-inch layer ferruginous concretions were present in greater quantity than in the upper layers. At Albrook, on the other hand, dry

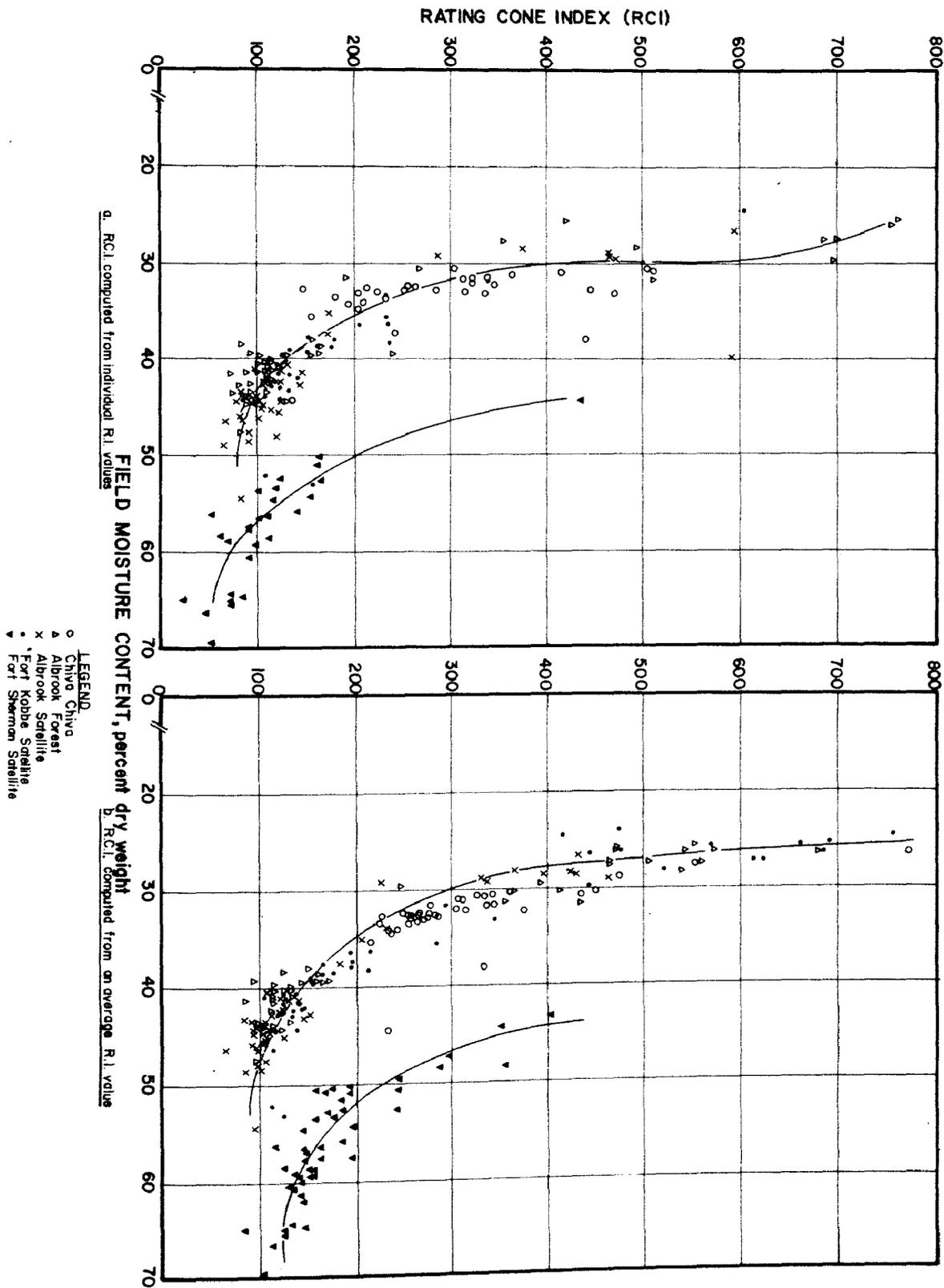


FIGURE V-12. COMBINED RATING CONE INDEX - SOIL MOISTURE RELATIONSHIP FOR ALL SITES, 6 TO 12-INCH LAYER

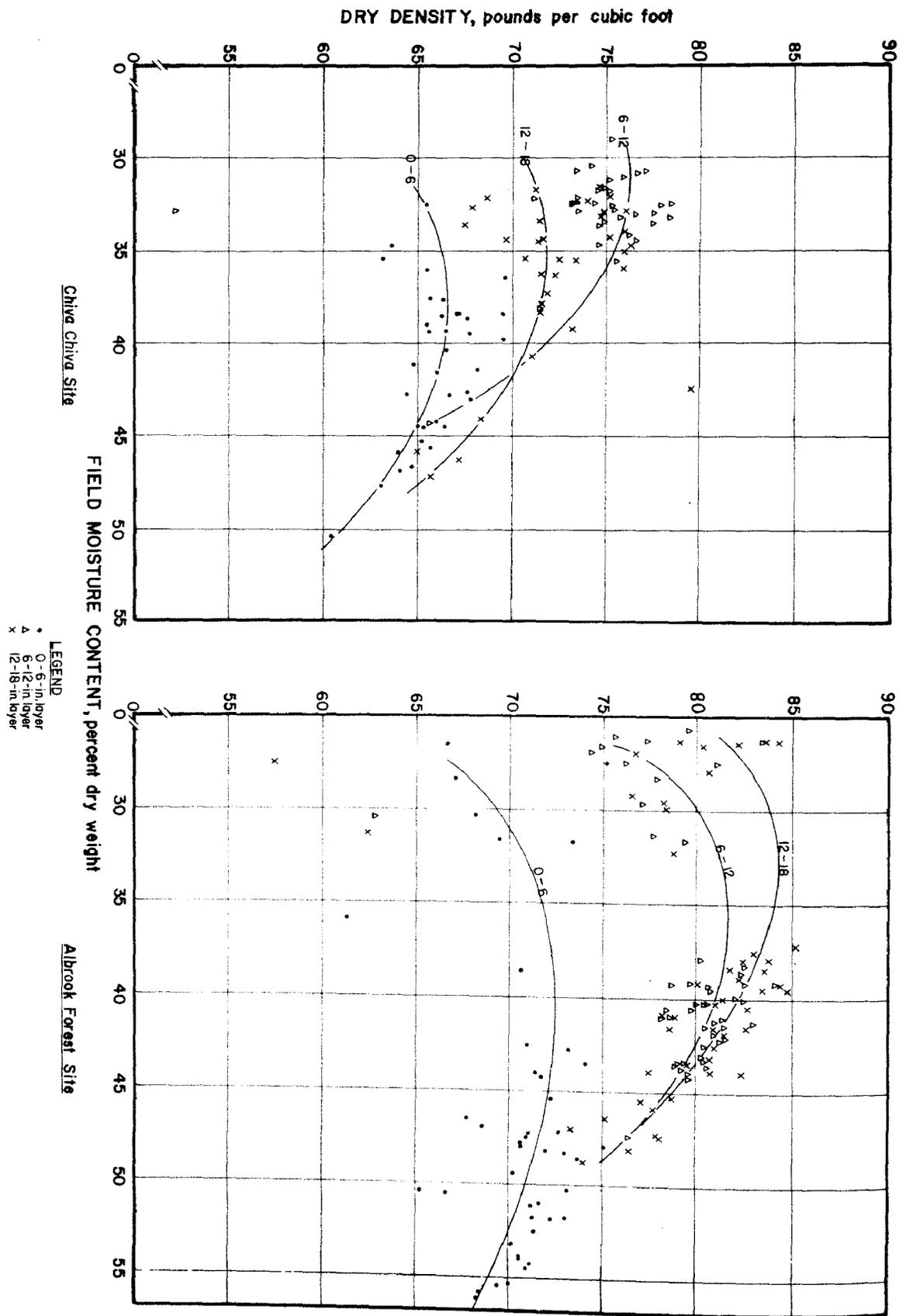


FIGURE V-13. DRY DENSITY - SOIL MOISTURE RELATIONSHIP BY 6-INCH LAYERS, CHIVA CHIVA AND ALBROOK FOREST SITES.

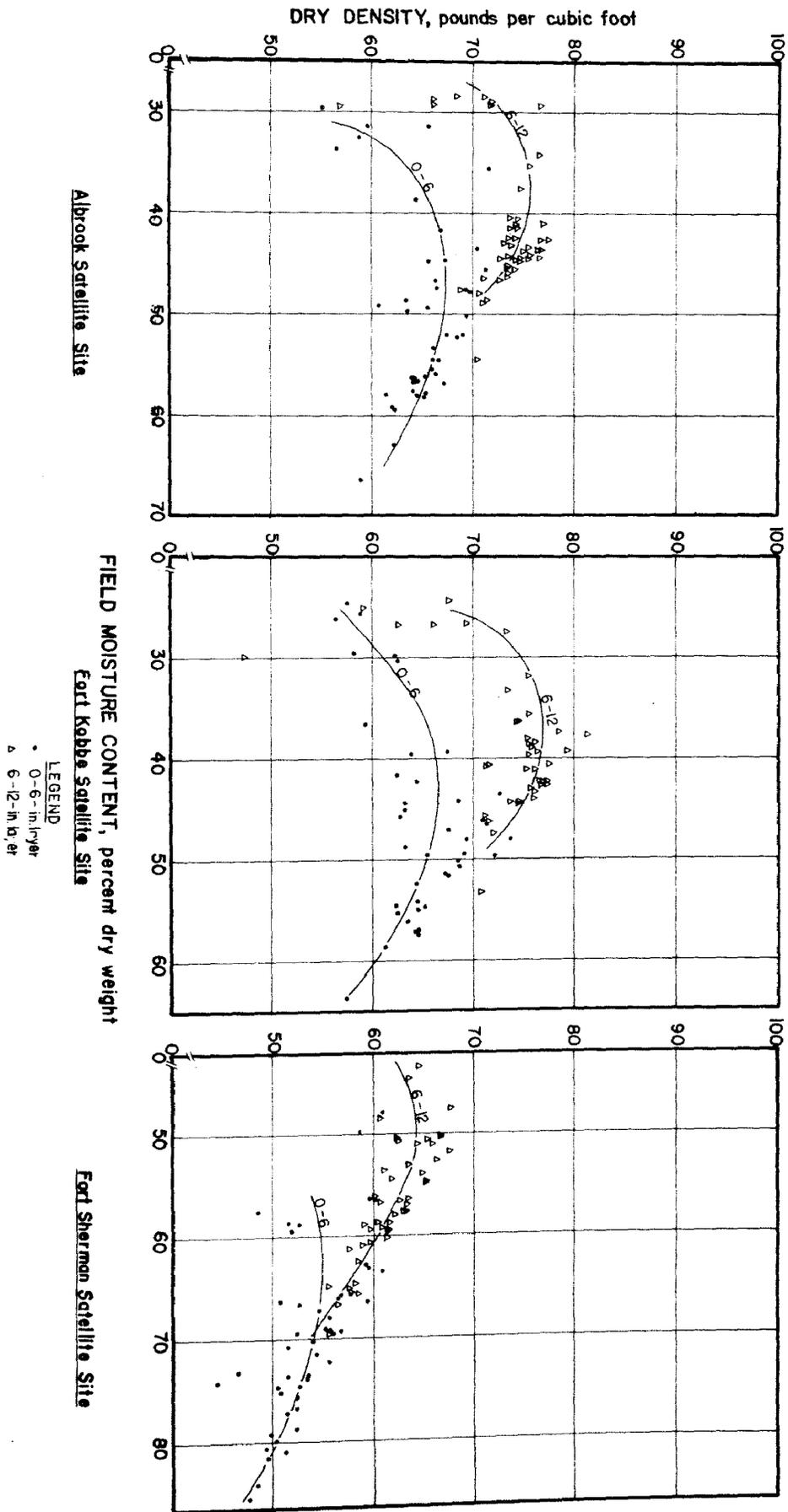


FIGURE V-14. DRY DENSITY - SOIL MOISTURE RELATIONSHIP BY 6-INCH LAYERS, ALBROOK, FORT KOBEE, AND FORT SHERMAN SATELLITE SITES

densities do tend to increase with depth. However, the differences observed between the 6- to 12- and 12- to 18-inch layers, are slight and in most instances, particularly between about 37 percent and 45 percent natural field moisture content, density data obtained for the two lowermost layers tend to converge. Soils at the three satellite sites follow the same general trend and behavior as described for the Albrook Forest site.

PART VI. VEGETATION

Progress was made on the vegetation task of the Data Base project during the current reporting period despite the fact that the Tropic Test Center staff position reserved for a botanist was vacant. This position was filled in May 1967, and research results are expected to be significantly augmented during the next reporting period.

Further analysis has been carried out on the forest litter study which was discussed in the previous project report. Data collected through December 1966 are utilized in the present report.

A brief study on seedlings as well as seed germination and storage was carried out in conjunction with the plant collection activities. Results of this limited study are presented in Appendix B.

The vegetation inventory of the Albrook Forest Site has been updated and revised in format to facilitate machine storage of data. The new inventory is presented in Appendix C.

Forest Litter*

Introduction

The forest litter investigations of the Data Base project provide information concerning the composition and the quantity of litter fall within several humid tropic forests. Forest litter is defined as the recently fallen, non-decomposed ground accumulation under a forest canopy of leaves, seeds, fruits, insect and animal forms, and debris such as animal and bird droppings, sap, and other particulate material. The type, amount, and time of fall of litter in the forest influences ground cover, microbial and insect activity, chemical and particulate matter in the atmosphere, and the conduct of exposure tests in the study of materials deterioration. Observation of contamination, infestation, and damage to fallen leaves and flowers reveals intensity of activity of macro and microfauna. The duration of leaf, flower, and fruit fall can provide a supplementary observation of phenological events usually measured visually and photographically.

Litter samples were collected both in litter pans and directly from the ground. That which fell into the pans provided a basis for measuring rates of litter accumulation; while collections of accumulated litter deposits from the ground provided a measure of the amount of litter on the forest floor throughout the sampling period. Weights of the pan litter samples and their components (leaves, seeds, fruits, insect and animal forms, and various other kinds of debris) were determined. The ground

* This section was prepared by Dr. Robert S. Hutton, Biological Scientist

litter was processed to determine weights, moisture content, and microbial and arthropod content.

The previous Semianual Report⁽¹⁾ contained a preliminary report of observations on forest litter. Data presented here are from an expanded investigation started at the beginning of the report period.

Pan Litter

This report on pan litter contains data collected in two tropical forest types. The forest types examined were at the Albrook Forest site, a semideciduous tropical forest, and a site near Fort Sherman (see map, Figure II-1), a more nearly evergreen tropical forest. Data covered include only three months (Oct-Dec, 66) for the Albrook site and two months (Nov, Dec 66) for the Fort Sherman site. A later report will contain data on litter collected in the remainder of the period as well as information on mineral content of the litter and mineral loss of decaying leaves.

Data Collection Methods

Pan litter collection was greatly expanded in October 1966. Frequency of collection was the same - once each week at each site - but the number of samples was increased. Thirty screen-wire traps or pans, one meter square, were placed at each site in randomized locations under the canopy compared to only five pans at the Albrook forest site in the previous period. After collection, the litter from each pan was weighed, then dried at 100-110 C for 24 hours and re-weighed. Both weights were recorded. The dry litter was sorted and the weight of leaves, fruits and seeds, branches, and debris recorded separately. As species were not known at separation, each species and part was denoted by a number. Later these will be identified and named.

Results

Weights of pan litter before drying are given in Table VI-1. Total dry weights of various components of the litter collected at each site are shown in Table VI-2. Dry weights of the fruits and seeds collected in each pan at the two sites are shown in Table VI-3. Because the data cover such short periods, only the most general sort of conclusions can be drawn from them. Leaf fall, as well as total litter fall, was, as expected, greater in the Albrook forest where trees are deciduous. Both total litter and leaf fall at Fort Sherman were highly variable as compared with Albrook. The coefficient of variation for differences between pans at Sherman is almost double the figure obtained at Albrook. Fruit and seed fall at Fort Sherman is negligible.

Ground Litter

Data Collection Methods

Investigations of litter on the Albrook forest floor continued using

TABLE VI-1. PAN LITTER WEIGHT BEFORE DRYING
(in grams)

ALBROOK FOREST SITE

| | | | | | | |
|--------------|--------|--------|--------|--------|--------|--------|
| PAN No. | 1 | 2 | 3 | 4 | 5 | 6 |
| LEAF WEIGHT | 63.60 | 98.75 | 63.15 | 61.60 | 72.80 | 106.75 |
| TOTAL WEIGHT | 183.05 | 246.80 | 91.75 | 96.40 | 84.70 | 167.15 |
| PAN No. | 7 | 8 | 9 | 10 | 11 | 12 |
| LEAF WEIGHT | 71.20 | 59.85 | 62.75 | 115.73 | 61.61 | 94.05 |
| TOTAL WEIGHT | 190.85 | 68.75 | 70.95 | 131.18 | 104.86 | 136.30 |
| PAN No. | 13 | 14 | 15 | 16 | 17 | 18 |
| LEAF WEIGHT | 35.05 | 82.30 | 78.00 | 55.15 | 40.35 | 60.60 |
| TOTAL WEIGHT | 45.80 | 122.85 | 116.95 | 117.20 | 57.80 | 90.85 |
| PAN No. | 19 | 20 | 21 | 22 | 23 | 24 |
| LEAF WEIGHT | 76.95 | 94.05 | 42.45 | 146.55 | 81.25 | 133.70 |
| TOTAL WEIGHT | 102.25 | 118.15 | 54.60 | 154.95 | 127.20 | 134.90 |
| PAN No. | 25 | 26 | 27 | 28 | 29 | 30 |
| LEAF WEIGHT | 70.20 | 82.63 | 91.50 | 84.55 | 82.65 | 40.80 |
| TOTAL WEIGHT | 83.20 | 292.98 | 133.80 | 118.55 | 121.80 | 64.65 |

ALL PANS

| | GRAND TOTAL | MEAN | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
|--------------|----------------|--------|-----------------------|-----------------------------|
| LEAF WEIGHT | 2310.57 | 77.02 | 26 | .33 |
| TOTAL WEIGHT | 3631.22 | 121.04 | 54 | .45 |

TABLE VI-1. PAN LITTER WEIGHT BEFORE DRYING (Cont'd)
(in grams)

FORT SHERMAN SITE

| | | | | | | |
|--------------|-------|--------|--------|--------|--------|-------|
| PAN No. | 31 | 32 | 33 | 34 | 35 | 36 |
| LEAF WEIGHT | 44.30 | 66.45 | 37.10 | 44.40 | 40.10 | 49.85 |
| TOTAL WEIGHT | 94.65 | 86.80 | 38.90 | 85.60 | 70.05 | 56.35 |
| PAN No. | 37 | 38 | 39 | 40 | 41 | 42 |
| LEAF WEIGHT | 59.15 | 207.25 | 22.40 | 58.30 | 31.00 | 16.45 |
| TOTAL WEIGHT | 63.40 | 215.85 | 29.05 | 113.60 | 35.25 | 17.80 |
| PAN No. | 43 | 44 | 45 | 46 | 47 | 48 |
| LEAF WEIGHT | 45.45 | 25.90 | 28.45 | 15.80 | 9.85 | 26.15 |
| TOTAL WEIGHT | 53.95 | 40.60 | 92.60 | 16.55 | 12.40 | 59.60 |
| PAN No. | 49 | 50 | 51 | 52 | 53 | 54 |
| LEAF WEIGHT | 24.30 | 14.75 | 42.00 | 42.00 | 63.00 | 38.20 |
| TOTAL WEIGHT | 55.85 | 20.95 | 174.75 | 61.60 | 127.50 | 51.65 |
| PAN No. | 55 | 56 | 57 | 58 | 59 | 60 |
| LEAF WEIGHT | 46.30 | 39.50 | 28.00 | 40.55 | 28.65 | 41.40 |
| TOTAL WEIGHT | 86.45 | 85.80 | 49.00 | 53.55 | 105.95 | 54.65 |

ALL PANS

| | | | | |
|--------------|----------------|-------|-----------------------|-----------------------------|
| | GRAND TOTAL | MEAN | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
| LEAF WEIGHT | 1277.00 | 42.57 | 33.6 | .79 |
| TOTAL WEIGHT | 2110.70 | 70.36 | 44 | .63 |

TABLE VI-2. DRY WEIGHT OF PAN LITTER
(in grams)

| ALBROOK FOREST SITE | | | | | |
|---------------------|----------|---------------------|----------|--------|----------|
| MONTH | LEAVES | FRUITS AND SEEDS | BRANCHES | DEBRIS | TOTAL |
| OCT. | 332.59 | 4.50 | 45.55 | 68.80 | 451.44 |
| NOV. | 1,109.63 | 6.95 | 405.60 | 228.00 | 1,750.18 |
| DEC. | 868.35 | 2.20 | 142.25 | 192.90 | 1,205.70 |
| TOTAL | 2,310.57 | 13.65 | 593.40 | 489.70 | 3,407.32 |

| FORT SHERMAN SITE | | | | | |
|-------------------|----------|---------------------|----------|--------|----------|
| MONTH | LEAVES | FRUITS AND SEEDS | BRANCHES | DEBRIS | TOTAL |
| NOV. | 439.50 | 0.35 | 44.95 | 280.20 | 765.00 |
| DEC. | 837.50 | 0 | 46.80 | 236.15 | 1,345.70 |
| TOTAL | 1,277.00 | 0.35 | 91.75 | 516.35 | 2,110.70 |

TABLE VI-3. DRY WEIGHT OF FRUITS AND SEEDS FOUND MONTHLY, BY PAN, 1966

| ALBROOK FOREST SITE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------|------|------|------|------|------|------|------|------|----|------|------|------|----|----|----|-------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| PAN # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | | | | | | | | | | | | | | | |
| OCT. | 0.30 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| NOV. | 1.05 | 0.70 | 0 | 0 | 0 | 0.10 | 0 | 0 | 0 | 0.10 | 0.10 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| DEC. | 0 | 0.25 | 0 | 0.05 | 0.05 | 0 | 0.15 | 0.05 | 0 | 0 | 0.10 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| TOTAL | 1.35 | 1.20 | 0 | 0.05 | 0.05 | 0.10 | 0.15 | 0.05 | 0 | 0.10 | 0.20 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| PAN # | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | TOTAL | | | | | | | | | | | | | | | |
| OCT. | 0 | 0 | 0.10 | 0 | 0 | 0.45 | 0.10 | 0 | 0 | 0 | 3.20 | 0.10 | 0 | 0 | 0 | 4.50 | | | | | | | | | | | | | | | |
| NOV. | 0.15 | 0.40 | 1.90 | 0 | 0 | 1.05 | 0 | 0.05 | 0 | 0 | 1.15 | 0.20 | 0 | 0 | 0 | 6.95 | | | | | | | | | | | | | | | |
| DEC. | 0 | 0 | 0.30 | 0 | 0 | 0.70 | 0 | 0 | 0 | 0 | 0.45 | 0.10 | 0 | 0 | 0 | 2.20 | | | | | | | | | | | | | | | |
| TOTAL | 0.15 | 0.40 | 2.30 | 0 | 0 | 2.20 | 0.10 | 0.05 | 0 | 0 | 4.80 | 0.40 | 0 | 0 | 0 | 13.65 | | | | | | | | | | | | | | | |
| FORT SHERMAN SITE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PAN # | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | | | | | | | | | | | | | | | | |
| NOV. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| DEC. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| PAN # | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | TOTAL | | | | | | | | | | | | | | | |
| NOV. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.35 | 0 | 0 | 0 | 0 | 0 | 0.35 | | | | | | | | | | | | | | | |
| DEC. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | |
| TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.35 | 0 | 0 | 0 | 0 | 0 | 0.35 | | | | | | | | | | | | | | | |

the same methods described in the previous report. Litter was collected every two weeks from ten randomly chosen plots of 200 square cm each. The plots were newly selected each time, independently of the plots previously used. All the litter at each plot was picked up and immediately sealed in a plastic bag to prevent moisture loss and escape of arthropods. A separate collection was made at each plot for microbial analysis, in which a very small amount of litter was aseptically collected to form one composite sample for the entire site area.

Analytical Methods

The wet weight of each individual bulk collection was determined, after which the collected material was placed in a Berlese funnel for 48 hours to remove the arthropods. After the arthropods had been separated, the litter was dried at 50 C for 24 hours and weighed. This weight was recorded as dry weight of the litter. Finally, collections were heated at 450 C for 24 hours and the residual ash weighed and stored for possible radiation analysis. The aseptically collected material for microbial analysis was blended, then plated on nutrient agar and on carrot agar. One-ml aliquots of each dilution of the sample were added to tubes of the melted agars and then transferred to petri plates and incubated for five days at 28 C. Bacterial colonies grow on the nutrient agar, while carrot agar encourages the growth of fungi.

Results

Gravimetric Characteristics of Ground Litter. In order to cover a period of sufficient length to be useful, data from November 1965 through December 1966 are included in this section. Table VI-4 contains data on wet, dry, and ash weights, as well as the moisture and ash percentages for all the samples collected for the period. In this presentation of the data, the collections from the first five and the second five of the ten 200-square-cm plots were combined to form two samples. Standard deviations were calculated for the six samples obtained in each three collecting periods.

Figure VI-1 plots the mean values and standard deviations for each recorded value for dry and ash weights as well as the values for moisture percentage in the collected litter. The litter dry weight remained constant from November through March and increased significantly about mid-April to the middle of June. The time of increase coincides with the start of the rainy season. Ash weight decreased significantly from November through March, and then increased sharply during April and May. Litter moisture decreased to a minimum in the February-March period and then rose to a fairly constant value approaching 65 percent for the remainder of the time of observation.

Differences between samples for all of the observations indicate a distinct lack of homogeneity in the occurrence of ground litter at the Albrook site. Inspection of the area to determine whether this variability

TABLE VI-4. GROUND LITTER SAMPLES: ALBROOK FOREST SITE
WHOLE PLOT SEQUENTIAL SAMPLING.

Weights given in grams per 1000 cm²

| Collection Date | Sub-Sample | Wet Litter | | Dry Litter | | Ash | |
|-----------------|------------|------------|---------|------------|---------|--------|--------------|
| | | Weight | % Water | Weight | % Water | Weight | % Dry Weight |
| 26 Nov 65 | 1 | 236 | 72.8 | 63.6 | 72.8 | 13.7 | 21.9 |
| | 2 | 355 | 69.8 | 108 | 69.8 | 31.0 | 29.0 |
| 10 Dec 65 | 1 | 154 | 69.5 | 47.3 | 69.5 | 12.4 | 25.5 |
| | 2 | 313 | 70.2 | 91.8 | 70.2 | 33.8 | 36.9 |
| 23 Dec 65 | 1 | 218 | 65.5 | 75.7 | 65.5 | 29.6 | 39.2 |
| | 2 | 117 | 64.9 | 40.8 | 64.9 | 17.6 | 43.9 |
| 7 Jan 66 | 1 | 158 | 61.1 | 61.8 | 61.1 | 21.9 | 36.1 |
| | 2 | 150 | 61.3 | 57.7 | 61.3 | 18.8 | 32.7 |
| 20 Jan 66 | 1 | 150 | 46.4 | 78.7 | 46.4 | 15.5 | 20.2 |
| | 2 | 65.4 | 38.4 | 39.5 | 38.4 | 7.13 | 10.8 |
| 4 Feb 66 | 1 | 157 | 24.3 | 119 | 24.3 | 22.5 | 14.4 |
| | 2 | 97.1 | 25.2 | 72.5 | 25.2 | 11.9 | 12.3 |
| 18 Feb 66 | 1 | 91.6 | 52.2 | 43.8 | 52.2 | 9.7 | 10.7 |
| | 2 | 112 | 25.9 | 83.2 | 25.9 | 10.7 | 9.5 |
| 4 Mar 66 | 1 | 123 | 26.9 | 90.1 | 26.9 | 9.9 | 11.0 |
| | 2 | 106 | 28.5 | 76.0 | 28.5 | 13.1 | 12.3 |
| 21 Mar 66 | 1 | 81.0 | 24.3 | 61.2 | 24.3 | 7.6 | 12.4 |
| | 2 | 149 | 17.7 | 122 | 17.7 | 24.4 | 20.0 |

TABLE VI-4. GROUND LITTER SAMPLES: ALBROOK FOREST SITE
WHOLE PLOT SEQUENTIAL SAMPLING (cont'd)

| Collection Date | Sub-Sample | Wet Litter | | Dry Litter | | Ash | |
|-----------------|------------|------------|---------|------------|---------|--------|--------------|
| | | Weight | % Water | Weight | % Water | Weight | % Dry Weight |
| 1 Apr 66 | 1 | 185 | 64.8 | 64.7 | 11.2 | 11.2 | 17.3 |
| | 2 | 115 | 40.8 | 67.2 | 13.4 | 13.4 | 19.9 |
| 15 Apr 66 | 1 | 138 | 23.4 | 106 | 13.8 | 13.8 | 13.1 |
| | 2 | 97.4 | 23.4 | 74.5 | 11.7 | 11.7 | 15.7 |
| 29 Apr 66 | 1 | 167 | 49.0 | 85.1 | 11.9 | 11.9 | 13.9 |
| | 2 | 217 | 49.7 | 109 | 22.1 | 22.1 | 20.2 |
| 13 May 66 | 1 | 356 | 66.6 | 120 | 28.3 | 28.3 | 23.6 |
| | 2 | 455 | 65.9 | 155 | 35.4 | 35.4 | 22.8 |
| 27 May 66 | 1 | 291 | 65.6 | 99.5 | 36.4 | 36.4 | 36.6 |
| | 2 | 321 | 62.0 | 122 | 37.6 | 37.6 | 30.8 |
| 10 Jun 66 | 1 | 315 | 63.5 | 114 | 35.9 | 35.9 | 31.2 |
| | 2 | 412 | 62.9 | 153 | 50.3 | 50.3 | 32.9 |
| 24 Jun 66 | 1 | 202 | 62.6 | 75.5 | 15.9 | 15.9 | 21.1 |
| | 2 | 138 | 54.4 | 62.9 | 17.6 | 17.6 | 28.1 |
| 9 Jul 66 | 1 | 142 | 59.5 | 58.2 | 24.1 | 24.1 | 16.7 |
| | 2 | 308 | 59.7 | 124 | 50.6 | 50.6 | 16.4 |
| 22 Jul 66 | 1 | 282 | 64.2 | 101 | 38.6 | 38.6 | 38.2 |
| | 2 | 174 | 61.5 | 67.1 | 22.1 | 22.1 | 32.9 |
| 5 Aug 66 | 1 | 141 | 59.6 | 56.8 | 14.5 | 14.5 | 25.5 |
| | 2 | 215 | 62.6 | 80.7 | 18.4 | 18.4 | 22.8 |

TABLE VI-4. GROUND LITTER SAMPLES: ALBROOK FOREST SITE
WHOLE PLOT SEQUENTIAL SAMPLING (cont'd)

| Collection Date | Sub-Sample | Wet Litter | | Dry Litter | | Ash | |
|-----------------|------------|------------|---------|------------|---------|--------|--------------|
| | | Weight | % Water | Weight | % Water | Weight | % Dry Weight |
| 19 Aug 66 | 1 | 179 | 70.4 | 53.3 | 70.4 | 14.1 | 26.4 |
| | 2 | 156 | 66.6 | 51.6 | 66.6 | 14.7 | 28.5 |
| 2 Sep 66 | 1 | 116 | 60.5 | 44.8 | 60.5 | 12.0 | 26.8 |
| | 2 | 131 | 68.5 | 40.9 | 68.5 | 13.0 | 31.8 |
| 16 Sep 66 | 1 | 145 | | 53.1 | | 19.6 | |
| | 2 | 140 | | 62.2 | | 14.7 | |
| 30 Sep 66 | 1 | 257 | | 61.1 | | 24.2 | |
| | 2 | 227 | | 68.5 | | 21.8 | |
| 15 Oct 66 | 1 | 141 | | 50.6 | | 8.5 | |
| | 2 | 191 | | 80.9 | | 22.9 | |
| 29 Oct 66 | 1 | 80.8 | | 39.5 | | 8.38 | |
| | 2 | 119 | | 52.9 | | 14.5 | |
| 26 Nov 66 | 1 | 95.4 | | 32.1 | | 10.4 | |
| | 2 | 93.6 | | 25.9 | | 7.75 | |
| 10 Dec 66 | 1 | 77.7 | | 26.4 | | 7.56 | |
| | 2 | 95.5 | | 36.9 | | 6.9 | |

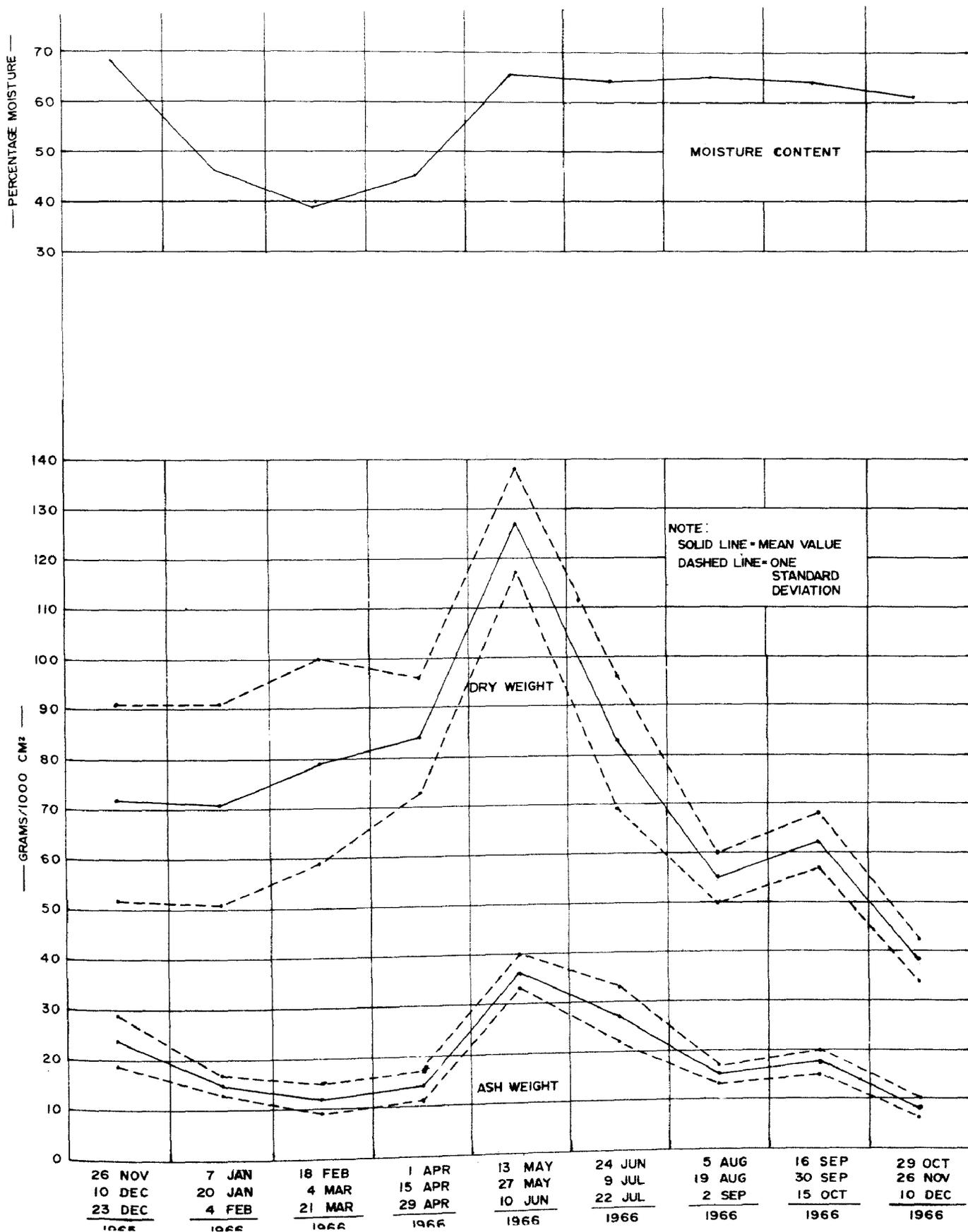


FIGURE VI-1. GROUND LITTER SAMPLES, ALBROOK FOREST SITE: MOISTURE CONTENT, ASH WEIGHT, DRY WEIGHT

was random or whether it might be explained on the basis of some characteristic of the site led to the observation that the site can reasonably be divided into three subordinate zones as shown in Figure VI-2, based on the distribution of the larger trees.

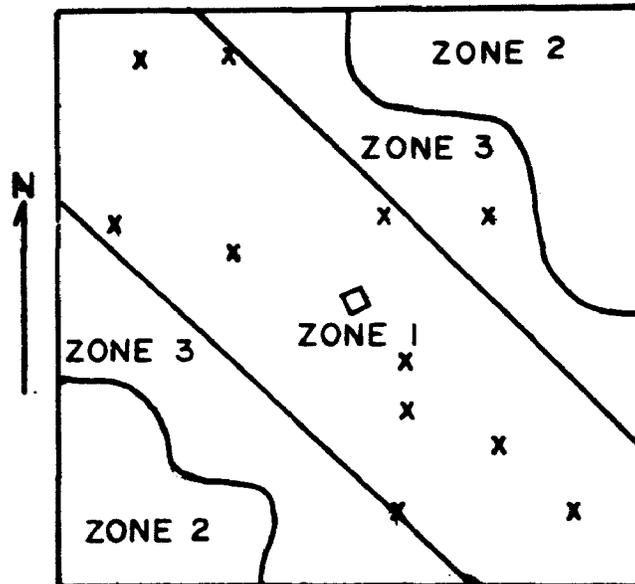


FIGURE VI-2. LOCATION OF TREES WITH TRUNK DIAMETER OF 65 CM OR GREATER, ALBROOK FOREST SITE

With only one exception, all trees of 65-cm trunk diameter and over are located in Zone 1. Zone 2, by contrast, is relatively distant from any large trees, so shading and rooting influences are reduced. Zone 3 lies under the crowns of the large trees and is close enough to be influenced by their shade and the presence of large roots.

Data presented in Table VI-5 and Figure VI-3 compare the litter samples taken from the whole plot against samples from each of the three zones. For comparative purposes, and to minimize the effect of the variations occurring with smaller samples, litter sample collections from three sequential collection dates have been aggregated from weight determinations of the wet and dry litter and ash residue. Except for a short interval early in the rainy season, there is a tendency for dry and ash weights to be higher in Zone 1 than in either Zones 2 or 3.

However, in only a few instances (those marked with an asterisk in Table VI-5) are the differences greater than one standard deviation value obtained for the whole plot values of the samples. The tendency for wet, dry, and ash weight values to be relatively low for Zone 1 during the May-June early rainy season period and relatively high for all the rest of the year may be significant. Increased moisture conducted down large tree

TABLE VI-5. COMPARISON OF WHOLE PLOT WITH ZONED LITTER SAMPLES

Weight given in grams per 1000 cm²; Standard Deviation of Whole Plot in ().

| Sample Collection Dates | Sample Location | Wet Litter | | Dry Litter | | Ash | |
|-------------------------------|--------------------|----------------|-------------|----------------|------------|--------|-----------------|
| | | Weight (SD) | % (SD) | Weight (SD) | % (SD) | Weight | % Dry Weight |
| 1965 | | | | | | | |
| 26 Nov - 10 Dec - 23 Dec | Whole Plot | 232 (82) | 71.1 (23.5) | 68.8 | 23.0 (8.7) | 32.6 | |
| | Zone 1 | 291 | 87.0 | 70.1 | 28.9 | 33.2 | |
| | Zone 2 | 205 | 61.0 | 70.2 | 15.7 | 25.7 | |
| | Zone 3 | 166 | 58.0 | 65.0 | 15.2 | 26.2 | |
| 1966 | | | | | | | |
| 7 Jan - 20 Jan - 11 Feb | Whole Plot | 129 (35) | 71.5 (24.3) | 45.7 | 16.3 (5.6) | 22.8 | |
| | Zone 1 | 141 | 73.0 | 48.2 | 17.5 | 23.9 | |
| | Zone 2 | 121 | 74.5 | 38.4 | 14.1 | 18.9 | |
| | Zone 3 | 119 | 64.5 | 45.8 | 16.8 | 26.0 | |
| 1966 | | | | | | | |
| 18 Feb - 4 Mar - 21 Mar | Whole Plot | 110 (22) | 79.3 (24.5) | 39.3 | 12.5 (5.6) | 15.8 | |
| | Zone 1 | 150* | 117* | 27.7 | 18.7* | 15.9 | |
| | Zone 2 | 103 | 74.5 | 38.9 | 9.30 | 12.4 | |
| | Zone 3 | 70.0* | 48.2* | 45.2 | 9.30 | 19.2 | |
| 1966 | | | | | | | |
| 1 Apr - 15 Apr - 29 Apr | Whole Plot | 153 (41.1) | 84.3 (17.6) | 44.9 | 14.0 (3.8) | 16.6 | |
| | Zone 1 | 164 | 93.5 | 43.0 | 26.4* | 28.2 | |
| | Zone 2 | 134 | 90.0 | 32.9 | 13.7 | 15.2 | |
| | Zone 3 | 122 | 71.0 | 41.8 | 11.3 | 15.9 | |
| 1966 | | | | | | | |
| 13 May - 27 May - 10 Jun | Whole Plot | 358 (57) | 128 (21) | 64.2 | 37.1 (7.3) | 29.0 | |
| | Zone 1 | 323 | 110 | 65.9 | 31.3 | 28.4 | |
| | Zone 2 | 418 | 150* | 64.1 | 44.3 | 29.5 | |
| | Zone 3 | 356 | 132 | 62.9 | 39.5 | 29.9 | |

TABLE VI-5. COMPARISON OF WHOLE PLOT WITH ZONED LITTER SAMPLES (cont'd)

| Sample Collection Dates | Sample Location | Wet Litter Weight (SD) | Dry Litter Weight (SD) | % Water | Weight (SD) | Ash Weight (SD) | % Dry Weight |
|------------------------------------|--------------------|------------------------------|------------------------------|------------|----------------|-----------------------|-----------------|
| 1966 24 Jun - 9 Jul - 22 Jul | Whole Plot | 208 (65) | 81.6 (23.8) | | 28.1 (12.4) | | |
| | Zone 1 | 272 | 100 | 63.2 | 35 | | 35 |
| | Zone 2 | 174 | 70.5 | 59.8 | 20.2 | | 28.7 |
| | Zone 3 | 168 | 79.5 | 52.7 | 29.0 | | 36.5 |
| 1966 5 Aug - 9 Aug - 2 Sept | Whole Plot | 156 (33) | 54.6 (12.8) | 65.3 | 14 (1.5) | | 25.6 |
| | Zone 1 | 181 | 93* | 48.6 | 16.4* | | 17.6 |
| | Zone 2 | 164 | 62.5 | 62.1 | 15.1 | | 24.1 |
| | Zone 3 | 118* | 42.1* | 64.3 | 11.5* | | 27.3 |
| 1966 16 Sept - 30 Sept - 15 Oct | Whole Plot | 184 (55) | 62.7 (10.5) | 65.8 | 18.6 (5.2) | | 29.7 |
| | Zone 1 | 204 | 68.0 | 66.7 | 22.5 | | 30.9 |
| | Zone 2 | 136 | 42.8* | 68.5 | 12.0* | | 28.0 |
| | Zone 3 | 169 | 63.5 | 62.1 | 16.9 | | 26.6 |
| 1966 29 Oct - 26 Nov - 10 Dec | Whole Plot | 96.3 (13) | 37.5 (8.9) | 61.0 | 9.3 (2.3) | | 24.8 |
| | Zone 1 | 80* | 47.0* | 41.2 | 7.75 | | 16.4 |
| | Zone 2 | 111* | 43.0 | 61.4 | 10.6 | | 24.7 |
| | Zone 3 | 92.0 | 35.3 | 61.6 | 9.25 | | 26.2 |

* Indicates those zonal values which differ by more than one Standard Deviation (SD) from the whole plot values.

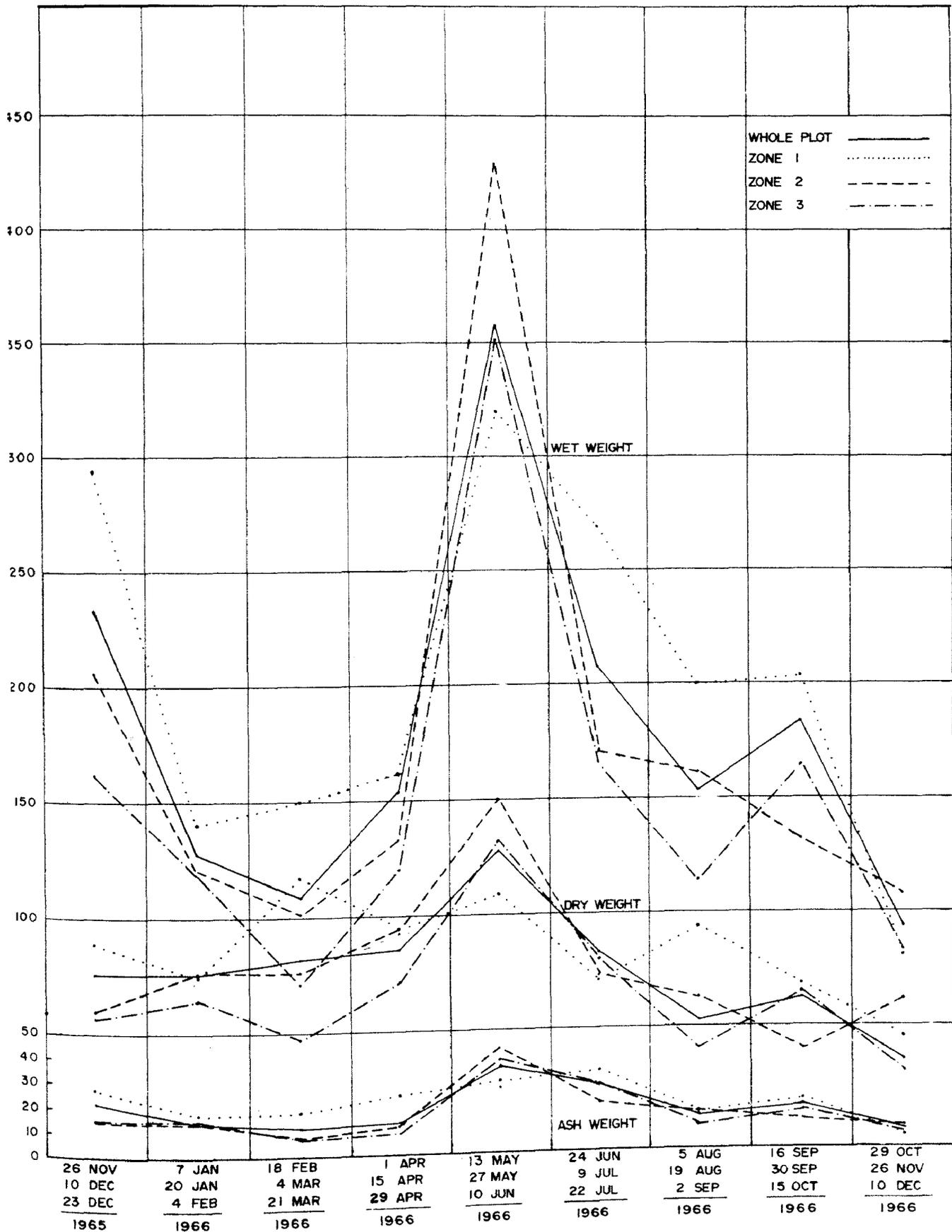


FIGURE VI-3. GROUND LITTER, ALBROOK FOREST SITE: WHOLE PLOT AND ZONAL LITTER ACCUMULATION

trunks and the increased soil-root activity which should characterize Zone 1 could account for an accelerated decomposition of litter in that area.

Arthropods in Ground Litter. The total number of arthropods in each collection of ground litter is recorded. Collections have been retained for future classification by an entomologist. The enumerations of the arthropods collected is less than 25 percent complete; however, at least two of each of the ten collections for each period have been examined. The values given for each collection period in Table VI-6 are the means of 2 to 8 subsamples from 200-square-cm areas. Subsamples selected for preliminary examination were taken randomly from the 30 subsamples collected in each of the periods indicated.

TABLE VI-6. NUMBER OF ARTHROPODS FOUND IN 200-CM² PLOTS OF ALBROOK FOREST GROUND LITTER

| <u>Collection Date - 1966</u> | <u>Sub-Sample Values</u> | <u>Mean</u> |
|-----------------------------------|--------------------------|-------------|
| 7 Jan - 20 Jan - 4 Feb | 81 50 90 87 | 77 |
| 18 Feb - 4 Mar - 21 Mar | 71 77 72 185 | 101 |
| 1 Apr - 15 Apr - 29 Apr | 56 56 | 56 |
| 13 May - 27 May - 10 Jun | 64 78 | 71 |
| 24 Jun - 9 Jul - 22 Jul | 61 89 117 133 262 181 | 140 |
| 5 Aug - 19 Aug - 2 Sep | 352 93 55 66 110 130 | 134 |
| 16 Sep - 30 Sep - 15 Oct | 211 87 55 102 192 210 | 142 |
| 29 Oct - 26 Nov - 10 Dec - 24 Dec | 79 43 65 51 67 35 157 98 | 74 |

Maximum variability between subsamples appears in the periods June through October. This is also the time in which maximum numbers of arthropods are present. As noted above this period is also characterized by maximum dry weight of ground litter and high moisture content.

All of the subsamples collected in the January-February interval were counted. Examination of these data by "zone" (see Figure VI-2) did not indicate any relationship between zone and the number of arthropods present. During these periods of collection the whole-plot mean for arthropods/200 square cm was 77 ± 25 . Arthropods found in the collections for Zones 1, 2, and 3 were 79, 86, and 69 respectively. Even the number 86 is not indicative of a significant zone difference, because one sample which contained 250 very small ants was entirely responsible for the variation from the mean.

Microbiological Observations on Ground Litter. Table VI-7 lists numbers of bacteria and fungi found in the composite samples of ground litter for each of the collecting periods. Numbers vary so greatly that few, if any, seasonal trends can be observed.

TABLE VI-7. VIABLE FUNGI AND BACTERIA RECOVERED
FROM SAMPLES OF ALBROOK FOREST GROUND LITTER

| <u>Collection Date</u> | <u>Bacteria</u> | | <u>Fungi</u> | |
|------------------------|-----------------|-----|----------------|-------|
| | 6 | | 5 | |
| | 121 x 10 /gram | | 500 x 10 /gram | |
| 14 Dec 65 | 121 | " " | 500 | " " |
| 23 Dec | 9 | " " | 34 | " " |
| 7 Jan 66 | 300 | " " | 340 | " " |
| 20 Jan | 800 | " " | - - - | - - - |
| 4 Feb | 105 | " " | - - - | - - - |
| 18 Feb | 173 | " " | 21 | " " |
| 4 Mar | 12 | " " | 3 | " " |
| 21 Mar | 74 | " " | 5 | " " |
| 5 Apr | 58 | " " | 3 | " " |
| 19 Apr | 490 | " " | 74 | " " |
| 29 Apr | 101 | " " | 92 | " " |
| 13 May | 45 | " " | 30 | " " |
| 27 May | 125 | " " | 12 | " " |
| 10 Jun | 158 | " " | 53 | " " |
| 24 Jun | 239 | " " | 68 | " " |
| 14 Jul | 76 | " " | 19 | " " |
| 22 Jul | 5 | " " | 37 | " " |
| 5 Aug | 179 | " " | 18 | " " |
| 19 Aug | 291 | " " | 50 | " " |
| 6 Sep | 1960 | " " | 25 | " " |
| 19 Sep | 670 | " " | 27 | " " |
| 3 Oct | 57 | " " | 43 | " " |
| 20 Oct | 510 | " " | 300 | " " |
| 23 Nov | 40 | " " | 40 | " " |
| 2 Dec | 43 | " " | 5 | " " |
| 27 Dec | 80 | " " | 65 | " " |

The mean values of each three weeks of collection were plotted in an attempt to determine whether there are seasonal trends (Figure IV-4.) Peaks of both microbial and fungal content in samples are indicated. However, in all instances where values result in peaks on the curve, the variation between samples is such that the values and their standard deviations are almost equal.

On the basis of these data it is evident that the investigation has not been very successful. Procedures for future work should involve more samples, or larger samples - or both. Since the interest in microbial content of litter is related to decomposition rate of the litter, future work might well take the form of observing effects of microorganisms present. Perhaps this could be accomplished by determining rates of decomposition or heat evolution in composts of large samples of collected litter maintained under standard conditions.

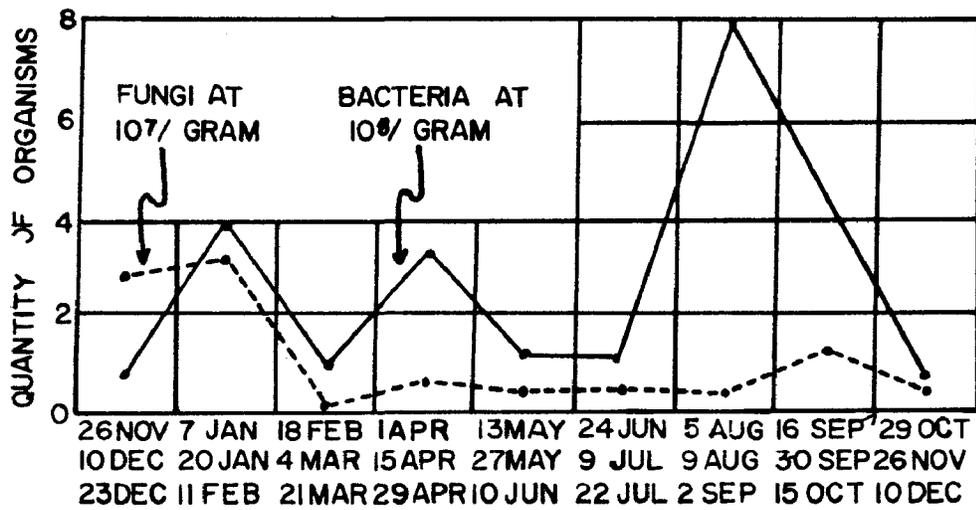


FIGURE VI-4. ANNUAL VARIATION OF FUNGAL AND BACTERIAL CONTENT OF GROUND LITTER

PART VII. MICROBIOLOGY AND CHEMISTRY OF THE ATMOSPHERE

During the reporting period observations were made on the following: deposition of microorganisms on prepared surfaces, distribution of airborne microorganisms, microorganisms in soils, particulate matter in the atmosphere, atmospheric chemistry, and the microbiology of rainwater. Routine observations were made in most of these lines of investigation. Observations of condensation nuclei which were carried out in a limited manner in the preceding period, were discontinued due to equipment troubles.

The reports on airborne and surface microorganisms and on microorganisms in soils which follow were derived from papers given at the 1967 meetings of the Society for Industrial Microbiology by the principal authors. This is the first time that results of the microorganisms in soils work have been given in the semiannual reports. Atmospheric chemistry and the microbiology of rainwater work will be described in later semiannual reports when data for sufficiently long periods are available for meaningful analyses.

Airborne and Surface Deposited Microorganisms*

Introduction

Observations of both the distribution of airborne microorganisms and the deposition of microorganisms on prepared surfaces continued during the reporting period. The study presented here is based on data collected at the Albrook and Chiva Chiva sites during the period of July 1966 through December 1966, and concerns relationships between microorganisms found in air and those which were collected on exposed surfaces. The study attempts to answer the following basic questions: (a) how many and what kind of living microbial forms inhabit the two environments? (b) how do seasonal and diurnal factors, and height above ground affect the numbers and kinds of microbial forms? and (c) is there a direct relationship between the airborne population and the extent of microbial contamination on exposed surfaces?

The environments of the humid tropics are optimum or near optimum for microbial life. Temperature is always warm, never cold, with prevailing levels varying only a few degrees from an average of 80 to 85 F. Moisture is abundant and relative humidity is high. Dying plants continuously provide a supply of organic matter from which microorganisms derive energy. Leaves of living plants provide much of the surface upon which microbial forms grow as well as shade for protection against direct sunlight. In this nearly ideal environment biotic activity is intense; and microbial populations, particularly of degradative and parasitic species, are higher than those found elsewhere in the world.

* This section was prepared by Dr. Robert S. Hutton, Biological Scientist, and Mr. George Gauger, Microbiologist.

Gregory⁽¹¹⁾ wrote that "data from...surface traps have been interpreted on the tacit assumption that the relation between the number of particles suspended in the air flowing over the surface and the number deposited on the surface is known". He found in wind tunnel experiments, however, that spore concentration is only one factor in determining deposition, and that particle size, wind speed, and the dimensions and orientation of the trap surface can exert an overriding effect on deposition. Since exposed surfaces in the tropical environment are subject to infestation and subsequent deterioration by microbial forms, the environmental factors which influence the manner in which contamination takes place could have practical importance. For example, substantial monetary losses have resulted and are continuing to result from biodeterioration of military materiel in humid tropical environments.

Data Collection Methods

Methods used were described in previous reports; briefly, they were as follows. Airborne microorganisms were collected by direct air filtration on type HA, 47 mm., gridded, Millipore membrane filters. After sampling, the filters were placed on plates of sterile carrot agar and incubated at room temperature. Numbers of microorganisms were recorded at the time of appearance of maximum numbers of colonies, usually 72 hours. Fungi to be identified were isolated at the time that numbers of colonies were counted. Colonies exhibiting characteristics of fungi were transferred to other sterile plates containing Czapek's or Saboraud's agar where they were allowed to grow to maturity. The direct air filtration method was selected after comparison of this method with the generally more favored method of liquid scrubbing using the Rosebury-Henderson capillary impinger⁽¹²⁾. Direct filtration yielded consistently higher numbers of microorganisms per unit volume of air sampled. Differences between samples taken at the same time were also less when sampling was accomplished by direct filtration. No attempt was made to determine why this method yielded higher numbers of viable microorganisms.

The per-unit-volume numbers of bacteria and fungi in the atmosphere were determined each six hours of the day for the first five working days (Monday through Friday) of each month. The period of sampling was five minutes. For technical and meteorological reasons, sampling could not be carried out at exactly the same time each day, however, times of sampling varied only slightly from 0300, 0900, 1500, and 2100 and were assumed to be representative of the 0-6, 6-12, 12-18, and 18-24 hour periods each day.

Numbers of bacteria and fungi falling on surfaces were determined by exposing nutrient-free agar plates to the atmosphere for one hour. Plates were exposed each quarter of the day (approximately 0300, 0900, 1500, 2100) each Thursday of every week. Data collection began in July 1966 and extended through December 1966. Gregory⁽¹³⁾ described the gravity Petri dish method of collecting microorganisms. Petri plates containing non-nutrient agar were exposed inside open-ended sterile fiberglass tubes five inches in diameter and sixteen inches long. The tubes served to shield the

plates from insect and plant debris as well as rain. Tube-plate sets were exposed in pairs, one tube being oriented north-south, the other east-west. Over the period of observation, the numbers of both bacteria and fungi collected in the N-S and in the E-W tubes were practically equal. Based on this observation, the overall effect of wind direction was assumed to be negligible and the sets of tubes were regarded as duplicates. After sampling, the plates were brought to the laboratory and overlaid with sterile nutrient-containing pads. Fungi and bacteria growing on plates fortified with Czapek's and nutrient broth respectively were counted and numbers deposited per 100-square cm surface were calculated.

Results

Observations were made in terms of the influence of site, height above ground, time of day, and month. The main effects produced by these factors on the number of fungal spores found in the air are summarized in Table VII-1. Significant differences were determined for airborne spores of fungi associated with site, height, time of day (hours), and month of year. Similar significance was associated with time of day and month of year for fungal spores deposited on surfaces. A quotient was derived by dividing deposited spores by airborne spores. In the overall sampling, the quotient 0.32 indicates a relative rate of fungal spore deposition per unit of time (1 hour). Site and height showed minor effect on this relationship. On the other hand, this quotient varied substantially with time of day and month of year. Relatively more spores were deposited during the afternoon hours and in the months of July and October. Conversely, fewer spores were deposited in the early morning hours and during the months of November and December.

Similar effects were observed with bacterial cells in the air and those deposited on surfaces (see Table VII-2). Substantial differences were found for bacterial cells associated with height over ground, time of day (hours), and month of year. The numbers of bacterial cells deposited on surfaces as well as those found in the air also varied with height, time of day, and month of day. Site appeared to have little effect on the airborne and deposited bacterial cells. The relative rate of deposition for bacterial cells is 0.76, more than twice that derived for fungal spores. Relatively greater numbers of bacterial cells were deposited from noon to midnight and during the months of August and October, while fewer numbers were deposited from midnight to sunrise and in the months of November and December.

These effects were re-examined to determine their influence on the occurrence and distribution of fungi. Fungi were most numerous during the month of July, decreased abruptly in August, increased, somewhat irregularly, during the following months (Table VII-3). Representatives of each genus differed individually throughout the six-month period. Representatives of the genera Fusarium, Gliocladium, Penicillium, Hormodendrum, Cephalosporium, and Oidium comprised nearly 80 percent of the isolates found in the air.

TABLE VII-1. QUANTITATIVE EFFECTS ON AIRBORNE AND SURFACE-DEPOSITED FUNGAL SPORES RELATED TO SITE, HEIGHT OVER GROUND, TIME OF DAY, AND MONTH.

| <u>Type of Sample</u> | <u>Mean Numbers in 100 L of Air</u> | <u>Mean Numbers Falling on 100 CM² in 1 Hr.</u> | <u>Ratio: Deposited/ Airborne</u> |
|-----------------------|---|--|---|
| ALL SAMPLES | 84 | 27 | .32 |
| SITE | ** | | |
| Forested | 79 | 27 | .34 |
| Clear | 90 | 27 | .30 |
| HEIGHT OVER GROUND | ** | | |
| Surface | 92 | 27 | .29 |
| 37 m | 76 | 27 | .36 |
| TIME, HOURS | ** | ** | |
| 0-6 | 140 | 31 | .22 |
| 6-12 | 80 | 25 | .31 |
| 12-18 | 42 | 23 | .55 |
| 18-24 | 76 | 26 | .34 |
| MONTH (1966) | ** | ** | |
| July | 73 | 31 | .42 |
| August | 83 | 29 | .35 |
| September | 94 | 32 | .34 |
| October | 73 | 45 | .61 |
| November | 73 | 11 | .15 |
| December | 110 | 11 | .10 |

NOTE: Values below asterisks differ from mean of all samples at the 1% level (*), or the 5% level (**).

TABLE VII-2. QUANTITATIVE EFFECTS ON AIRBORNE AND SURFACE-DEPOSITED BACTERIA RELATED TO SITE, HEIGHT OVER GROUND, TIME OF DAY, AND MONTH.

| <u>Type of Sample</u> | <u>Mean Numbers in 100 L of Air</u> | <u>Mean Numbers Deposited on a 100 CM² in 1 Hr.</u> | <u>Ratio: Deposited/ Airborne</u> |
|-----------------------|---|--|---|
| ALL SAMPLES | 25 | 19 | .76 |
| SITE | | | |
| Forested | 25 | 19 | .76 |
| Clear | 25 | 19 | .76 |
| HEIGHT OVER GROUND | | | |
| Surface | ** | * | |
| 37 m | 28 | 20 | .71 |
| | 21 | 18 | .85 |
| TIME, HOURS | | | |
| 0-6 | ** | ** | |
| 6-12 | 46 | 23 | .50 |
| 12-18 | 21 | 16 | .76 |
| 18-24 | 16 | 21 | 1.31 |
| | 16 | 15 | .93 |
| MONTH (1966) | | | |
| July | * | ** | |
| August | 23 | 20 | .86 |
| September | 22 | 39 | 1.77 |
| October | 22 | 17 | .77 |
| November | 26 | 24 | .92 |
| December | 24 | 8 | .33 |
| | 30 | 7 | .23 |

NOTE: Values below asterisks differ from mean of all samples at the 1% level (*), or the 5% level (**).

TABLE VII-3. RELATIVE FREQUENCY OF 15 GENERA
OF AIRBORNE FUNGI DURING A SIX-MONTH
EXAMINATION PERIOD.

| <u>ORGANISM</u> | <u>JULY</u> | <u>AUG</u> | <u>SEPT</u> | <u>OCT</u> | <u>NOV</u> | <u>DEC</u> | <u>TOTAL</u> |
|-----------------|-------------|------------|-------------|------------|------------|------------|--------------|
| Fusarium | 32 | 39 | 82 | 41 | 100 | 97 | 391 |
| Gliocladium | 17 | 11 | 22 | 19 | 59 | 68 | 196 |
| Penicillium | 60 | 16 | 38 | 33 | 25 | 23 | 195 |
| Hormodendrum | 76 | 2 | 21 | 7 | 3 | 58 | 167 |
| Cephalosporium | 44 | 22 | 23 | 15 | 6 | 45 | 155 |
| Oidium | 45 | 21 | 23 | 36 | 5 | 19 | 149 |
| Streptomyces | 0 | 1 | 30 | 31 | 34 | 0 | 96 |
| Aspergillus | 37 | 16 | 2 | 12 | 4 | 4 | 75 |
| Spicaria | 27 | 13 | 8 | 4 | 5 | 0 | 57 |
| Curvularia | 5 | 10 | 14 | 12 | 10 | 2 | 53 |
| Trichoderma | 11 | 2 | 0 | 8 | 4 | 18 | 43 |
| Rhizotrichum | 1 | 2 | 2 | 12 | 6 | 8 | 31 |
| Nigrospora | 0 | 0 | 4 | 1 | 3 | 1 | 9 |
| Monilia | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| Verticillium | 1 | 2 | 1 | 0 | 1 | 0 | 5 |
| TOTAL | 358 | 157 | 270 | 231 | 265 | 343 | |

More fungi were found in the dark environment than in daylight (Table VII-4). Representatives of the genera Fusarium, Gliocladium, and Trichoderma, in particular, were more numerous during the hours of darkness. The dark-spored forms representing the genera Curvularia and Nigrospora appeared more abundantly in daylight hours.

Fungi isolated from the cleared and from the forested (shaded) sites paralleled the pattern observed for the daylight and dark conditions, in many instances. Isolates of Fusarium, Gliocladium, and Trichoderma were more abundant in the forested site than the cleared site (Table VII-5). Again, Curvularia spp. and Nigrospora sp. were encountered more frequently in the cleared site, which is more comparable to daylight, than in the forested site, which compares favorably to darkness.

Unexpectedly there was little effect in the numbers of fungal isolates associated with height above ground level (Table VII-6). The abundance of Fusarium spp. at the surface more than accounted for the total difference observed between the surface and 37 meters. Another unusual observation was that Nigrospora sp. was found only at the 37-meter level and was never detected at the surface. Additional differences were expected to account for the significance associated with heights in the first analysis (Table VII-1). In all other cases sufficient differences were expressed to add to the validity of the significance attributed to sites, time of day, and month.

Summary

The important finding is that the different conditions of time and position existing at the two locations produced significant variations in the microbial populations. Tables VII-1 and -2 show that the numbers of both fungi and bacteria within the air and deposited on surfaces varied substantially from place to place, hour to hour, month to month and, even with difference in height above ground. These results become even more interesting if it is recognized that those relationships were significant in spite of substantial variation between parallel samples. Continued inspection of the data projects the supposition that the basic variables which influence the presence of microbial forms in the environment are not adequately defined in simple terms of site, time, height over ground, and season. Instead, the data tend to confirm Gregory's contention that specific elements of the micrometeorological environment such as temperature, wind speed, relative and absolute humidity, as well as light, may, in combination exert overriding influences. Furthermore there is some evidence, in the form of the variation between calculated relative rates of deposition of airborne forms on surfaces, that rates of deposition also are related to these environmental factors. Data on most of the environmental factors were collected in parallel with the sampling of microorganisms and an attempt will be made to determine their influences.

Taken collectively, the results of observations on representatives of genera of fungi encountered in air (Tables VII-3 through -6) confirm the

TABLE VII-4. RELATIVE FREQUENCY OF 15 GENERA OF
 AIRBORNE FUNGI DURING DAYLIGHT AND DARK HOURS
 OVER A SIX-MONTH PERIOD (1966)

| ORGANISM | DAYLIGHT | DARK | TOTAL |
|----------------|----------|------|-------|
| Fusarium | 123 | 268 | 391 |
| Gliocladium | 55 | 141 | 196 |
| Penicillium | 103 | 92 | 195 |
| Hormodendrum | 84 | 83 | 167 |
| Cephalosporium | 82 | 73 | 155 |
| Oidium | 77 | 72 | 149 |
| Streptomyces | 37 | 59 | 96 |
| Aspergillus | 39 | 36 | 75 |
| Spicaria | 22 | 35 | 57 |
| Curvularia | 47 | 6 | 53 |
| Trichoderma | 6 | 37 | 43 |
| Rhinotrichum | 19 | 12 | 31 |
| Nigrospora | 9 | 0 | 9 |
| Verticillium | 3 | 2 | 5 |
| Monilia | 1 | 1 | 1 |
| TOTAL | 707 | 917 | |

TABLE VII-5. RELATIVE FREQUENCY OF 15 GENERA OF
 AIRBORNE FUNGI AT CLEARED AND FORESTED SITES
 DURING A SIX-MONTH PERIOD (1966)

| ORGANISM | CLEARED | FORESTED | TOTAL |
|----------------|---------|----------|-------|
| Fusarium | 184 | 207 | 391 |
| Gliocladium | 74 | 122 | 196 |
| Penicillium | 85 | 110 | 195 |
| Hormodendrum | 91 | 76 | 167 |
| Cephalosporium | 68 | 87 | 155 |
| Oidium | 66 | 83 | 149 |
| Streptomyces | 62 | 34 | 96 |
| Aspergillus | 28 | 47 | 75 |
| Spicaria | 34 | 23 | 57 |
| Curvularia | 37 | 16 | 53 |
| Trichoderma | 9 | 34 | 43 |
| Rhinotrichum | 25 | 6 | 31 |
| Nigrospora | 9 | 0 | 9 |
| Verticillium | 3 | 2 | 5 |
| Monilia | 2 | 0 | 2 |
| TOTAL | 777 | 847 | |

TABLE VII-6. RELATIVE FREQUENCY OF 15 GENERA OF AIRBORNE FUNGI FOUND AT SURFACE AND 37 M ABOVE GROUND DURING A SIX-MONTH PERIOD (1966)

| ORGANISM | SURFACE | 37 METERS | TOTAL |
|----------------|---------|-----------|-------|
| Fusarium | 236 | 155 | 391 |
| Gliocladium | 97 | 99 | 196 |
| Penicillium | 98 | 97 | 195 |
| Hormodendrum | 80 | 87 | 167 |
| Cephalosporium | 77 | 78 | 155 |
| Oidium | 71 | 78 | 149 |
| Streptomyces | 50 | 46 | 96 |
| Aspergillus | 37 | 38 | 75 |
| Spicaria | 21 | 36 | 57 |
| Curvularia | 25 | 28 | 53 |
| Trichoderma | 28 | 15 | 43 |
| Rhinotrichum | 10 | 21 | 31 |
| Nigrospora | 0 | 9 | 9 |
| Verticillium | 4 | 1 | 5 |
| Monilia | 2 | 0 | 2 |
| TOTAL | 836 | 788 | |

observations on the effects just described. Examination of the effects of time, light, location, and height on each of the genera of fungi revealed that not all individuals react to these variables in the same way. For example, some fungi appear more abundantly in the light, while others were more prevalent in the dark. The ultimate desire to define the tropical microbial environment will require studies of interactions between elements of the environment and each microbial form within the milieu of the dynamic state of the microbial community.

Even at the present time, patterns of occurrence of microorganisms are beginning to emerge. The two most common forms in the soil, namely Fusarium spp. and Penicillium spp. are listed first and third respectively, in order of frequency of appearance in air.* On the other hand, Gliocladium spp., which rated second in order of frequency of appearance in air, was relatively infrequent in samples of soil, while Trichoderma spp., the third most numerous soil form, appeared in the group seen least frequently in the air. The maximum rate of fungus deposition for October (Table VII-1) coincides with the highest incidence of soil fungi observed.

* See section "Microbial Inhabitants of a Tropical Semideciduous Forest Soil in the Canal Zone", which follows.

Microbial Inhabitants of Soil in a Tropical Semideciduous Forest*

Introduction

Soil is an ever-changing site of biological activity which influences the plant and animal populations that it supports as well as providing a primary reservoir for microorganisms. Determinations of numbers per gram of soil, as well as the isolation and description of microorganisms that are associated with soil, are quite common. An understanding of the actual activities of these organisms in the soil environment requires further experimentation and evaluation.

An organism becomes ecologically important when it is metabolically active, capable of colonizing the available substrates, and present in sufficient numbers to materially alter the environment. Soil fungi have been, in recent years, studied more extensively than other types of microbes. Within microbial populations, fungi are generally accompanied by other organisms which also contribute to the overall aspect of the microhabitat. The existence of a specific organism in a given locality, e.g., a warm, humid environment, usually develops through the ability of that organism to grow and multiply on the available substrates or to be transmitted to the locality from elsewhere. Information included herein is primarily involved with the microorganisms that grow and multiply on the organic substrates of the soil in the Canal Zone.

Previous Investigations

A few investigations of the soil fungi of Panama and the Canal Zone have been conducted. Farrow⁽¹⁴⁾ isolated 135 species representing 73 genera from soil samples obtained from six major areas in the Canal Zone and Costa Rica. Goos⁽¹⁵⁾ isolated and identified 47 species of fungi representing 33 genera from soils and banana root samples obtained from Costa Rica and Panama. In most instances direct plating of soils onto agar surfaces, or dilution plate techniques were employed. These techniques do not allow for accuracy in determination of population changes.

Numerous investigators (Sadasivan⁽¹⁶⁾; Walker⁽¹⁷⁾; Sorgel⁽¹⁸⁾; Staffeldt⁽¹⁹⁾; and Calderon and Staffeldt⁽²⁰⁾) have employed the trap burial technique to determine the general succession of different types of fungi that will colonize the buried traps. Garrett⁽²¹⁾ stated that once an organic segment is added to the soil it is invaded by those species that are both "eligible" and in the immediate vicinity at the moment the

* This section was prepared by Dr. Eugene E. Staffeldt, professor of Biology, New Mexico State University, who serves as a consultant for the Environmental Data Base project. Work reported was carried out at New Mexico State University by Dr. Staffeldt and student assistants and was based on a period of sampling (1965-1966) prior to the period covered by this semiannual report.

substrate becomes available for colonization. He also reported that the successful saprophytic organisms possess (a) rapid growth rate of hyphae and germination of spores, (b) broad enzyme-producing systems, (c) ability to produce toxins and/or (d) tolerance of toxins produced by other microorganisms. The composition of a micro-community at a given time would be dependent upon the many physical, chemical and biological aspects of the soil habitat.

Data Collection and Analysis

Soil samples were obtained on a monthly basis, from May 1965 through April 1966, from Tropic Test Center personnel. These samples were collected during the third week of each month from a 25 X 45-foot plot at the Albroom Forest site, that had previously been sectioned for sampling on a randomized basis. A cylinder of soil, 2½ inches in diameter and 1 inch thick was removed and represented the 0- to 3-, 3- to 6-, 6- to 12-, 12- to 15-, 15- to 18-inch layers. Three complete cores were removed each month. Following removal each cylinder was individually wrapped in aluminum foil and sealed in paraffin before shipping. Upon arrival in the United States, the soil samples were placed in a refrigerator until the experimentation commenced.

The 0- to 3- and 3- to 6-inch samples of each soil core were opened, and the central areas of each were aseptically moved to a sterile, covered dish and thoroughly mixed. This soil was then placed as a layer over the bottom of a sterile petri dish. Sterile, unbroken alfalfa straws were placed on the soil surface, and additional soil was added to completely bury the stems. Three straws were removed from each sample after 2, 4, 8, 16, and 32 days of burial. Following removal, each stem was washed in tap water, rinsed five times in sterile distilled water and placed between sterile paper towels that absorbed the excess water. The ends of each stem were aseptically removed, and the remainder was cut into three equal segments. These pieces were then placed on the surface of carrot agar contained in petri dishes. Fungal growth from the plant stems and reproduction occurring on the stems were observed and recorded over a three-week period. Transfers were made to agar slants for identifications of some organisms and verifications of others.

In addition to the above, individual samples of soil were employed in dilution studies. Standard bacteriological dilution techniques were utilized. Nutrient agar was used for the enumeration of aerobic bacteria while Brewer's anaerobic agar, Czapek's agar and Sabouraud's agar were employed to determine quantities of anaerobic bacteria, fungi, and yeasts and similar forms, respectively. Adequate controls were maintained. All plates were maintained at ambient temperature, approximately 30 C. The plates containing Brewer's agar were placed in vacuum chambers, evacuated and a nitrogen atmosphere was introduced. Colony counts were obtained from the plates at 24-hour intervals for three days. A plate was considered valid when it contained more than 30 and less than 300 colonies. Likewise the counts on the valid plates had to be substantiated by the other dilutions

employed. Three replications of each soil sample were included in these studies.

Results

Soil dilution studies were conducted to obtain a comparison of the relative abundance of the various types of organisms that could be encountered. The relative density of bacteria per gram of soil exceeded that of the fungi throughout the 12-month examination period (Figure VII-1). Major peaks were observed for bacteria during the months of August and October while a third, and lower, peak was expressed in the month of April. Fungi were generally fewer in number than bacteria, and the only predominant peak occurred during the month of October. Low fungal counts were made during May, November, December, January, and April. A more critical examination of the bacterial densities revealed that the high numbers of bacteria in August and April were primarily anaerobic forms while those in October were aerobic forms (Figure VII-2). Both aerobic and anaerobic bacteria were apparent throughout the wet season (approximately 80 inches of rainfall during the months of May through December) and the dry season (almost no measurable rainfall during the months of January through April).

The activities of fungi were more closely examined as they colonized buried, sterile, plant stems and grew out of these after 2, 4, 8, 16, and 32 days burial. Monthly totals of three of the most prevalent genera of fungi invading and growing from straws are summarized in Figure VII-3. Fusarium spp. appeared most frequently and were found on 80 percent or more of the stems during every month but February. Representatives of this genus were observed more consistently than any of the other fungi recorded. On the other hand Fusarium spp. were not observed regularly or abundantly in soil dilution studies. Similarly, Penicillium spp. were observed less frequently than Trichoderma spp.. During nine months of the year these organisms (Penicillium) were found on 50 percent or more of the stems and were most abundant in February. The pattern of appearance suggested a bimonthly increase of these organisms. Penicillium spp. were not as abundant as either Fusarium spp. or Trichoderma spp. in the stem burial study but accounted for almost 100 percent of the organisms observed during October in the soil dilution experiment. Trichoderma spp. produced the most erratic expression of the three genera of organisms observed. Representatives of this genus were found on 50 percent or more of the stems during six months of the examination period. During two months of the year these organisms were not observed on any of the stems.

Appearances of each of the above organisms were re-examined on the basis of the five stem removals during each month. There were no consistent colonization patterns expressed that would indicate that these organisms occur early and slowly disappear or that they colonize the stem after the establishment of another organism. The occurrence of Fusarium spp. usually varied between 80 and 100 percent with the exception found in February. During this month 83 percent of the stems possessed colonies of

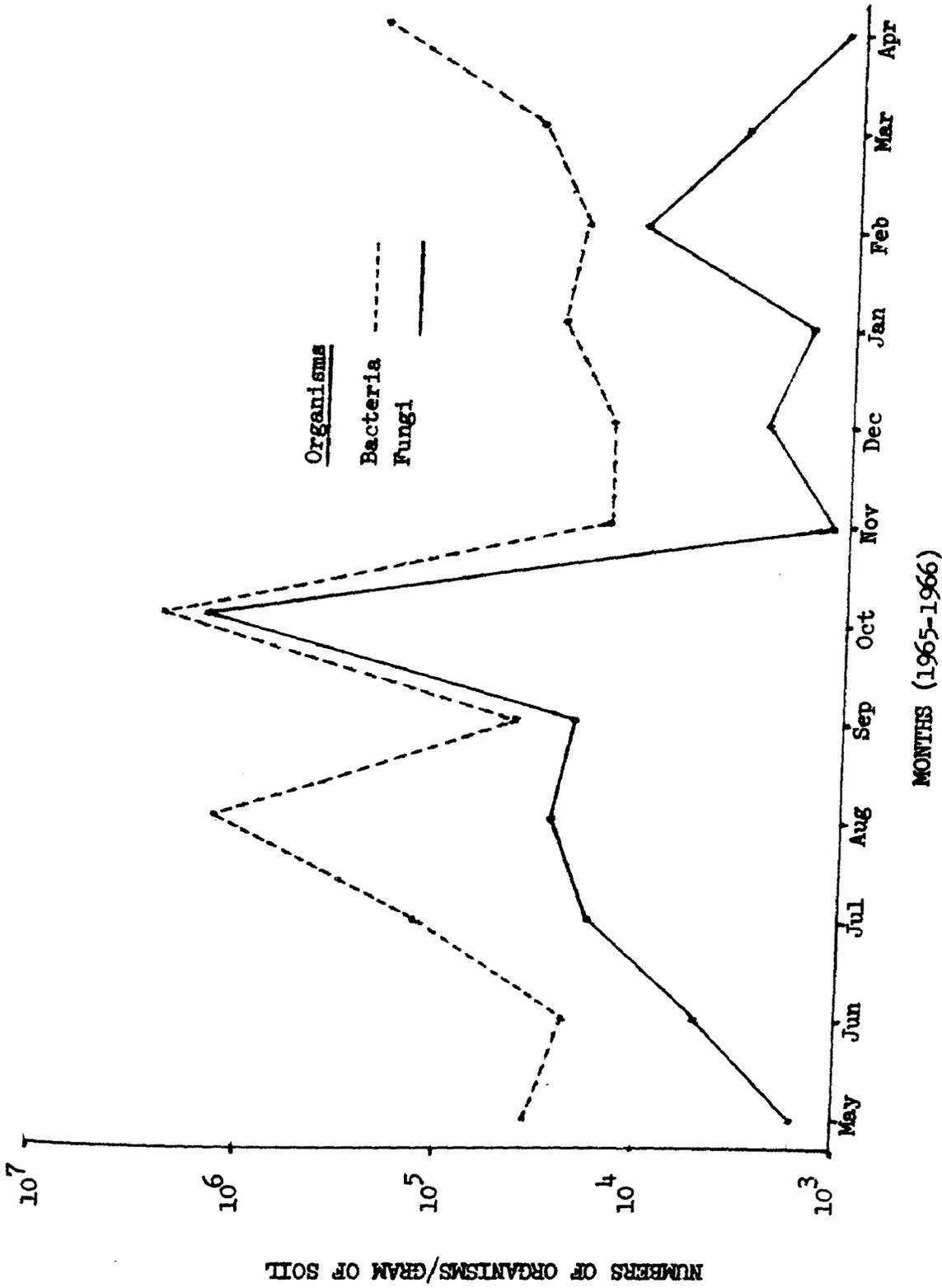
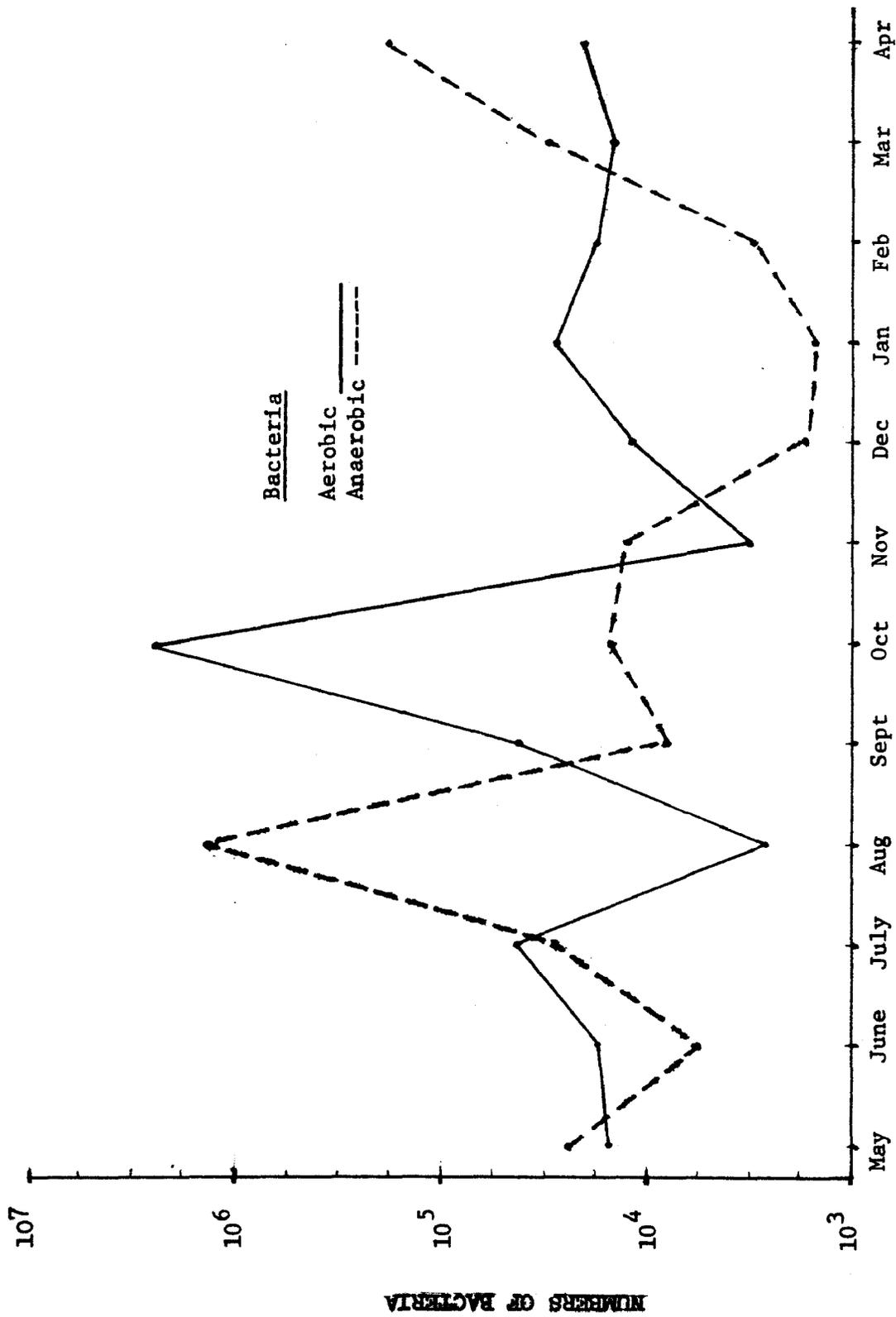
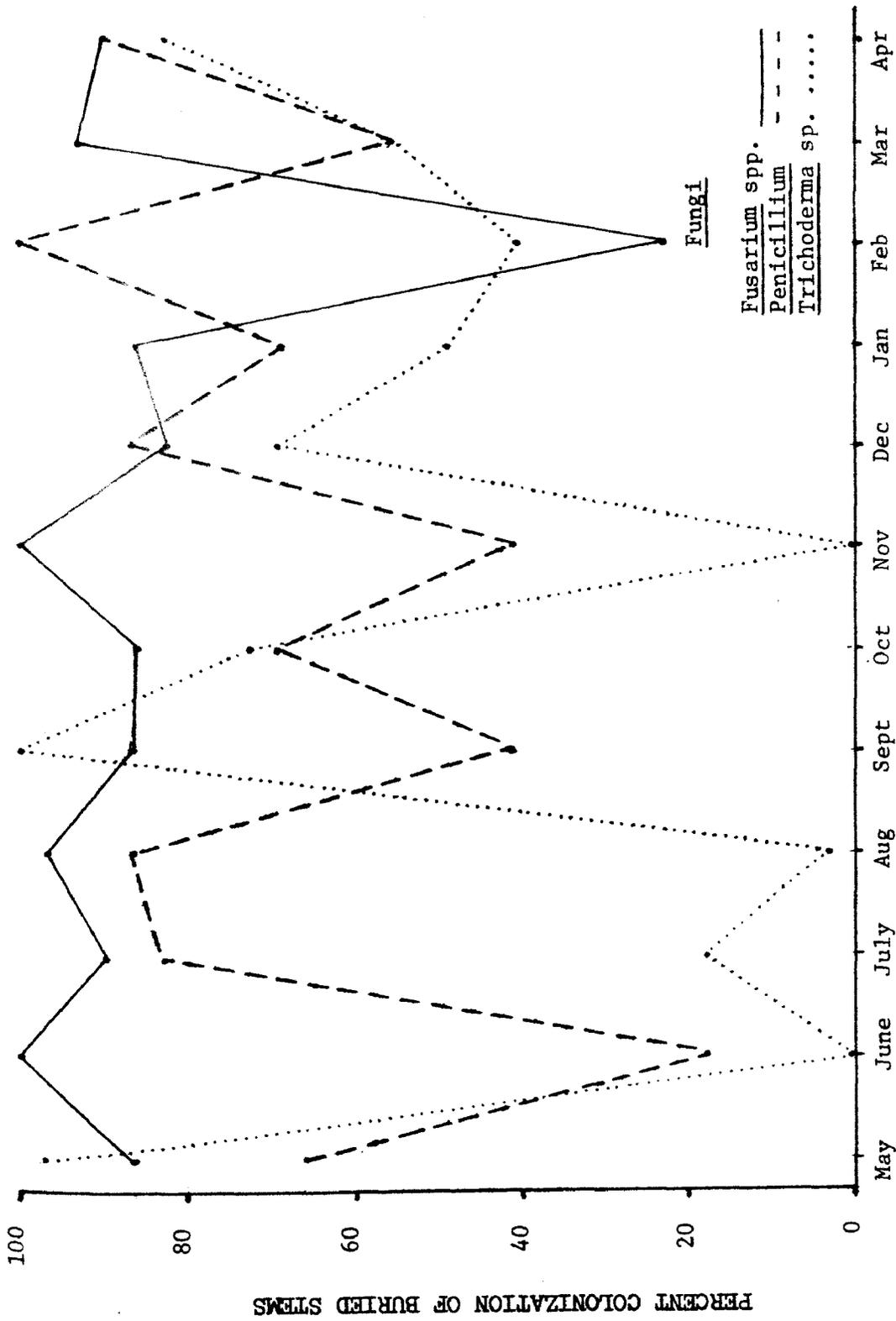


FIGURE VII-1. RELATIVE FREQUENCY OF BACTERIA AND FUNGI PER GRAM OF SOIL OVER A ONE-YEAR PERIOD.



MONTHS (1965-1966)

FIGURE VII-2. RELATIVE FREQUENCY OF AEROBIC AND ANAEROBIC BACTERIA PER GRAM OF SOIL OVER A ONE-YEAR PERIOD.



MONTHS (1965-1966)

FIGURE VII-3. PERCENT COLONIZATION OF BURIED STEMS BY THREE GENERA OF FUNGI OVER A ONE-YEAR PERIOD.

these organisms after two days, and no Fusarium colonies were found after 4, 8, 16, and 32 days. Variations between the end of one month and the beginning of the next month were usually never greater than the variations that occurred between examination days within the month. Greater variations were found in the colonization and expression patterns of Penicillium spp. and Trichoderma spp. Total suppression of Penicillium spp. occurred during the month of June. During ten months of the year these organisms were found on 100 percent of the stems on one of the examination dates of that month. This expression of high numbers was usually followed by a fairly rapid decline. In this respect, Trichoderma spp. were more consistent. These organisms were found either relatively abundantly or few in numbers throughout the month. These three genera of organisms did not appear to be drastically affected by readily apparent seasonal trends.

Other fungi colonized the buried stems but their colonization and appearance patterns have not been evaluated to date. The most common, to least common, fungi include representatives of the genera Phoma, Hyalopus, Streptomyces, Aspergillus, Masoniella, Myrothecium, Stachybotrys, Alternaria, Pythium, Xylaria, Cunninghamella, Hormodendrum, Gliocladium, Saksenaesa, Monilia, Curvularia, Mucor, Pyrenochaeta, Nigrospora, Volutella, Chaetomium, Helminthosporium, Sphaeronema, and Ophiostoma.

Bacteria were found growing in small colonies from the straws, but did not influence the growth and reproduction of the fungi. Nematodes were not observed on any of the plated stems.

Many interesting facts developed during the course of this investigation. The density of bacteria per gram of soil was relatively low throughout the 12-month examination period. This was emphasized by the occurrence of 10^4 to 10^6 total bacterial cells per gram of soil compared to the 10^9 cells per gram of agricultural soil as reported by Burges⁽²²⁾. Brock⁽²³⁾ reported that a single species becomes ecologically important only when the population density reaches 10^6 cells per ml. Assuming this statement to be correct, the bacteria could have influenced this tropical soil microenvironment only during August and October, 1965, if the majority of the bacteria represented a single species. Additional dilution plates have been examined for the period August 1966 - May 1967, and all but two months yield bacterial densities of less than 10^6 cells per gram of soil. Presently the handling and shipping techniques are being investigated to insure that population densities are not being reduced during these procedures. If data reported herein continue to be collected and reveal similar bacterial soil concentrations it might be assumed that bacteria are less important than previously suspected in tropical soil environments.

Another aspect that requires additional investigation is the relatively high number of aerobic bacteria that appeared in October, within the prolonged rainy season. Also, the increase in number of anaerobic bacteria during March and April, the end of the dry season, requires further examination.

In this semideciduous forest the most extensive amount of litter fall occurs during the dry season (January through April). This increased addition of organic substrate did not change the soil microbial densities as had been expected in the dilution plate techniques. During the straw burial study, however, the soil samples collected in April produced the greatest variety and number of organisms.

The high fungal population expressed on dilution plates during the month of October were identified as Penicillium spp.. This organism grew equally well under aerobic and anaerobic conditions. In addition to growing in a nitrogen atmosphere which was passed through three bottles of pyrogallic acid, this organism grew well when the anaerobic containers were evacuated and maintained at -24 psi.

Three genera of fungi were most prevalent during the stem burial studies. Fusarium spp. were observed on 85 percent of the stems while Penicillium spp. and Trichoderma spp. were found on 67 and 49 percent of the traps, respectively. These soil inhabitants could be referred to as dominant organisms (Brock⁽²³⁾) more easily than they could be referred to as primary invaders (Garrett⁽²¹⁾). The colonization patterns established within individual monthly examinations were not sufficiently consistent to enable one to predict the relative numbers of a specific organism. There was indication that possibly the metabolic wastes inhibited the further activity of certain organisms. Representatives of the other 24 genera of fungi were less prevalent and were considered as associated or incidental fungi. Within these organisms it was easier to detect primary and secondary types as well as late colonizers. Brock⁽²³⁾ stated that an analysis of a large system is difficult and often baffling, and this investigation was no exception. Many small, simple experiments defining one variable will have to be conducted before an understanding of the gross changes can be reached.

Particulate Matter*

Introduction

Air contamination has long been recognized as a significant cause of damage to material in urban areas. Stern (24) emphasizes the effect of airborne particulate matter in deterioration caused by exposure to polluted atmospheres. He points out that deposited particulate matter markedly accelerates the corrosion of metals, and he estimates that corrosion and deterioration attributable to air pollution involve yearly costs of more than a billion dollars. The majority of reports citing deterioration of materials caused by air pollutants deal with observations made in and around cities. Deterioration of material in tropical regions, on the other hand, is seldom associated with contaminated atmosphere. Instead, reports on tropical deterioration cite effects of moisture, high temperature, and microbial action as the main factors responsible for deterioration and corrosion. There is a paucity of reports on the particulate content of tropical atmospheres, but air in such regions is usually assumed to be relatively free from pollutants because of general lack of major urban influence and the fact that it is washed frequently by torrential rains.

The previous Semiannual Report⁽¹⁾ contains results of air sampling for detection of particulates too small to reflect white light. This work was done because we too assumed that the major source of atmospheric pollution in the tropics would be from the gradual condensation of large molecules of plant volatiles to form freezing nuclei, with the subsequent agglomeration of these to form larger particles. Results reported in the above cited report (Condensation Nuclei and Particulate Matter) confirmed the existence of a high concentration of particulate matter in the submicron region, and also revealed the presence of a high concentration of large particulates.

No new work on sampling for sub-micron size particulate matter is to be reported here. Instead this report is limited to a presentation of data from extended and continuous observations of larger atmospheric particles. Investigation of particles large enough to be seen should include microscopic examination to determine structure and composition. For example, particulates may be fibrous; and they may consist of minerals, industrial wastes, or biological substances. Particulates should also be subjected to chemical analysis, if appropriate. Neither manpower nor equipment was available for microscopic examination or chemical analysis during this period. Instead air was sampled approximately every two hours to determine the amount of contaminant present and the samples collected were retained for eventual future chemical analysis.

Data Collection and Analytical Methods

A modified Gelman paper tape sampler, shown in Figure VII-4 was

* This section has been prepared by Mr. George W. Gauger, Microbiologist, and Dr. Robert S. Hutton, Biological Scientist.

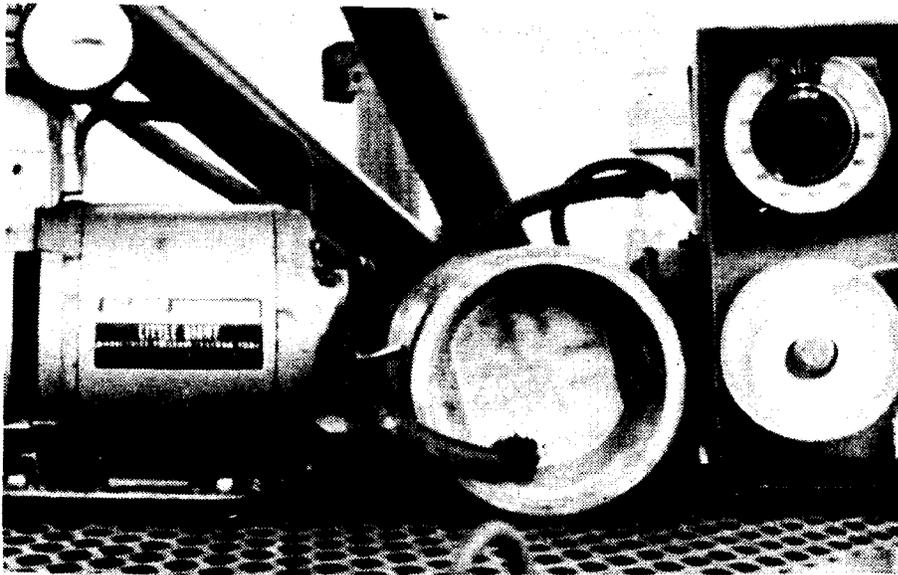


FIGURE VII-4. PAPER TAPE SAMPLER, SILICAGEL CARTRIDGE, AND VACUUM PUMP

located 46 meters above ground on the tower at the Chiva Chiva open site. Air was sampled continuously. Each sample of air collected over a two hour period was drawn by reduced pressure through a Whatman # 41 filter paper. The removal of particulates was not complete, but about 90 percent of the particles one micron or larger were deposited on the paper. The filter paper strip is fed automatically from the tape dispenser through the sampling head and along the tape guide and wound on a take-up spool for analysis and storage. At the end of each 24-hour period the filter paper strip is dated and returned to the laboratory for optical density measurements. The measurements are made with the Gelman Paper Densitometer shown in Figure VII-5. Its function is to measure the difference in light transmittal through the paper tape between a clean and sampled spot. This is done by placing a light source on one side of the paper tape and measuring the current generated by a photoelectric cell mounted on the other side of the tape. The amount of light transmitted through the paper strip is proportional to the concentration of particulate deposits and correspondingly affects the output of the photoelectric cell. The sampled paper tape is inserted into the densitometer and the optical density readings are recorded. Optical density readings are read arbitrarily as COH units (Coefficient of Haze).

Results and Conclusions

The data obtained beginning 1 April 1966 are graphically represented in Figure VII-6 which demonstrates that the highest number of COH units are recorded for the latter part of the dry season months, while a decreased number of COH units is recorded for samples taken during the wet season and early dry season months. The mean, maximum, and minimum COH units, with date and hour of occurrence, are recorded in Appendix D.

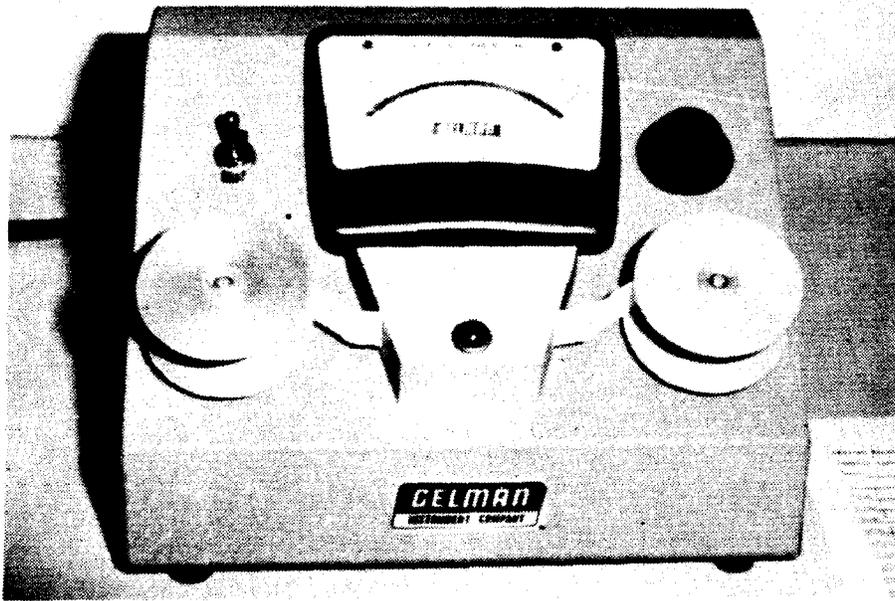


FIGURE VII-5. GELMAN PAPER DENSITOMETER

The values in the graph (Figure VII-6) below as well as those shown in the appendix are given as COH units per 1000 linear feet. This is an accepted standard; "linear feet" refers to a cylindrical column of air corresponding to the size of spot resulting from passage of the air through the paper tape.

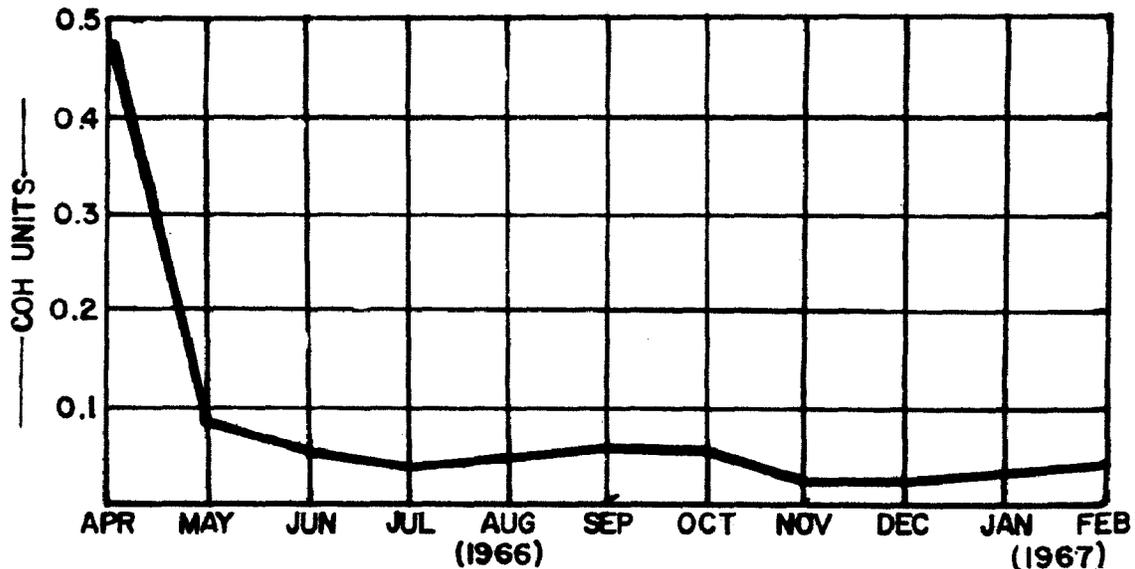


FIGURE VII-6. COH UNITS/1000 LINEAR FEET OF AIR SAMPLED AT CHIVA CHIVA SITE

Data obtained to date indicate that the highest COH values were recorded between 1400 and 1800 hours near the end of the dry season. Undoubtedly much of the increase in airborne particulate matter found at this time is from the extensive burning which goes on during this season, and unfortunately these data do little more than provide an index to the time of burning of grass and shrubs. This information may be useful in determining meteorological conditions which might favor or prevent the incidence of forest fires. The overloading of samples with smoke particles, however, completely precludes examination of the tapes for the presence of particulates originating from other sources. During times when particulate samplings are not influenced by smoke, the times for maximum and minimum values vary widely. Interpretation of the data will require both chemical analysis of the samples and correlation of maximum and minimum values in sampling with prevailing meteorological conditions.

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- APPENDIX A -

SOIL PROFILE DESCRIPTIONS AND SUMMARY TABLES
OF PHYSICAL CHARACTERISTICS

SOIL PROFILE DESCRIPTION
(Albrook Forest Site)

1. Location: Albrook Air Force Base, Dump road, approximate grid coordinates 17P-PV 602 964.

2. Profile Description:

- A₀₀ Loose dry leaves, 3 to 5 centimeters thick.
- A₀ Partly decomposed forest litter from deciduous trees. 1 to 2 centimeters thick.
- A₁₁ 0 to 4 centimeters, very dark brown (10YR 2/2, moist) light clay with a fine to medium strong granular or fine weak subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; roots plentiful; moderate to fairly high organic matter content; moderately permeable when undisturbed. 2 to 8 centimeters thick; gradual smooth lower boundary;
- A₁₂ 4 to 30 centimeters, very dark gray (10YR 3/1, moist) to very dark brown (10YR 2/2, moist) clay with a medium strong subangular blocky structure; hard when dry; slightly friable to firm when moist, sticky and plastic when wet; roots numerous to abundant; 20 to 30 centimeters thick; abrupt wavy lower boundary;
- A₃ 30 to 35 centimeters, very dark grayish brown (10YR 3/2, moist) to very dark brown (10YR 2/2, moist) clay with common, fine, and distinct yellowish brown and yellowish red (10YR 5/6 and 5YR 4/6) mottles with a structure, consistency, and root content similar to the A₁₂ horizon above. 5 to 8 centimeters thick; abrupt smooth to wavy lower boundary;
- B₂₁ 35 to 47 centimeters, very dark grayish brown (10YR 3/2, moist) clay with a coarse strong subangular blocky structure, with many concretions of limonite and hematite and with mottles similar to the A₃ horizon above; slightly hard when dry, friable to slightly firm when moist, sticky and plastic when wet; roots numerous; 10 to 25 centimeters thick; gradual wavy lower boundary;
- B₂₂ 47 to 57 centimeters, very dark grayish brown (10YR 3/2, moist) clay similar in all respect to horizon B₂₁ above, except for the more prominent mottling and concretions. 8 to 20 centimeters thick; gradual wavy lower boundary;

Albrook Forest Profile (Cont'd)

BC

57+ centimeters, very dark grayish brown matrix (10YR 3/2, moist) clay prominently mottled with many medium to coarse reddish and yellowish brown mottles, black, purple, yellowish brown and reddish brown ferrogionous concretions 5 to 10 millimeters in diameter; massive structure; hard when dry, friable when moist, very sticky and plastic when wet; roots few; At 3 meters soil is heavily gleyed, olive-bluish-gray colors.

SOIL PROFILE DESCRIPTION
(Chiva Chiva Site)

1. Location: Fort Clayton Army Reservation, Chiva Chiva antenna field, approximate grid coordinates 17P-PV- 562 979.

2. Profile Description:

- Ao Loose and partly decomposed organic matter. 0.5 centimeters thick.
- A₁ 0 to 3.5 centimeters, dark brown (10YR 3/3, moist) silty clay loam to silty clay with many fine ferrogenuous concretions and with a fine to medium strong subangular blocky structure; very hard when dry, firm when moist, sticky and slightly plastic when wet; roots plentiful. Thin, generally not more than 5 centimeters thick; abrupt smooth lower boundary;
- AB
or
B₁ 3.5 to 11.5 centimeters, brown to dark brown (7.5YR 4/4, moist) silty clay with numerous reddish and yellowish ferrogenuous concretions and with a medium to coarse strong subangular blocky or fine moderate prismatic structure; very hard when dry, firm to slightly friable when moist, sticky and plastic when wet; roots plentiful; 5 to 12 centimeters thick; abrupt wavy lower boundary;
- B₂ 11.5 to 40.0 centimeters, dark brown (10YR 3/3, moist) to dark yellowish brown (10YR 3/4, moist) clay with numerous fine and coarse iron concretions (red, yellow, black) some peds 3 or 4 millimeters in diameter, and with a coarse to very coarse strong blocky or medium moderate to strong prismatic structure; slightly hard when dry, friable to slightly firm when moist, sticky and plastic when wet; roots/abundant; 15 to 30 centimeters thick; abrupt wavy lower boundary;
- B₃ 40.0 to 46.0 centimeters, dark yellowish brown (10YR 4/4, moist) clay with concretions similar to horizon above and with a medium strong subangular blocky structure; slightly hard when dry, friable to slightly firm when moist, sticky and plastic when wet; roots few. 3 to 10 centimeters thick; gradual wavy lower boundary;
- BC 46.0 to 53.0 centimeters, same as the B₃ horizon except numerous, fine, clear yellowish (10YR 5/6) mottles and increasing amount of fine to medium reddish hematitic concretions. Gradual wavy lower boundary;

Chiva Chiva Profile (Cont'd)

- C₁ 53.0 to 64.0 centimeters, dark grayish brown (10YR 4/2, moist) clay with common fine distinct yellowish brown mottles and numerous medium to coarse ferromagnesian concretions; medium moderate subangular blocky structure slightly hard when dry, slightly friable when moist, sticky and plastic when wet; roots few to absent;
- C₂ 64.0 to 100.0+ centimeters, grayish brown matrix (10YR 5/2, moist) clay with many medium distinct yellowish brown mottles and numerous concretions coarser than those contained in the C₁ horizon above, massive structure; slightly hard when dry, friable when moist, sticky and plastic when wet; roots practically absent;

SOIL PROFILE DESCRIPTION
(Albrook Satellite Site)

1. Location: Albrook Air Force Base, Dump road, approximate grid coordinates 17P-FV- 600 960.

2. Profile Description:

- A_{oo} Loose leaves, 3 to 5 centimeters thick.
- A_o Partly decomposed forest litter from deciduous trees.
1 to 2 centimeters thick.
- A₁₁ 0 to 2.5 centimeters, dark brown (7.5YR 3/2, moist) silty clay to clay with a medium strong subangular blocky structure; slightly hard when dry, friable to slightly firm when moist, slightly sticky and slightly plastic when wet; roots plentiful; moderate to fairly high organic matter content; moderately permeable when undisturbed. 1 to 6 centimeters thick; abrupt wavy lower boundary;
- A₁₂ 2.5 to 7.5 centimeters, dark brown (7.5YR 3/2, moist) clay with a medium strong subangular blocky structure; hard when dry, slightly friable to firm when moist, sticky and slightly plastic when wet; roots numerous; 5 to 10 centimeters thick; abrupt wavy lower boundary;
- A₃ 7.5 to 12.0 centimeters, dark reddish brown (5YR 3/3, moist) clay with a medium strong subangular blocky structure; hard to very hard when dry, slightly friable to firm when moist, sticky and plastic when wet; roots numerous; 3 to 12 centimeters thick; clear wavy lower boundary;
- B₁ 12.0 to 19.0 centimeters, dark reddish brown (5YR 3/4, moist) clay with a medium strong subangular blocky structure; hard to very hard when dry, firm when moist, sticky and plastic when wet; roots numerous; 7 to 15 centimeters thick; gradual smooth lower boundary;
- B₂₁ 19.0 to 27.0 centimeters, dark reddish brown (5YR 3/4, moist) clay with a medium to coarse strong subangular blocky structure; hard when dry, friable to slightly firm when moist, sticky and plastic when wet; roots numerous; 9 to 25 centimeters thick; gradual smooth lower boundary;

Albrook Satellite Profile (Cont'd)

- B22 27.0 to 52.0 centimeters, dark reddish brown (5YR 3/4, moist) clay with few fine faint reddish and yellowish red mottles and with a medium moderate subangular blocky structure; hard when dry, friable when moist, very sticky and plastic when wet; roots numerous; 10 to 20 centimeters thick; gradual wavy lower boundary;
- BC 52.0 to 133.0, dark grayish brown (10YR 4/2, moist) clay with common fine distinct reddish brown mottles and with a massive structure; hard when dry, very friable when moist, very sticky and plastic when wet; roots few;
- C 133.0 to 200.0+ centimeters, same as above except slightly redder and with many medium and coarse prominent mottles of red, reddish brown, yellowish brown, and grayish brown.

SOIL PROFILE DESCRIPTION
(Fort Kobbe Satellite Site)

1. Location: Fort Kobbe Military Reservation, Kl road, approximate grid coordinates 17P-PV- 569 848.

2. Profile Description:

- A₀₀ Loose leaves, 2.5 to 3.0 centimeters thick.
- A₀ Partly decomposed forest litter. Very thin, 3 to 5 millimeters thick.
- A₁₁ 0 to 12 centimeters, very dark brown (10YR 2/2, moist, to black (10YR 2/1, moist) clay with a coarse to very coarse strong subangular blocky or medium moderate prismatic structure; very hard when dry; very firm when moist, very sticky and very plastic when wet; roots plentiful; 10 to 16 centimeters thick; abrupt wavy lower boundary;
- A₁₂ 12 to 24 centimeters, black (10YR 2/1, moist) clay with a coarse to very coarse strong subangular blocky or medium moderate prismatic structure; very hard when dry; firm when moist, very sticky and very plastic when wet; roots abundant; 15 to 25 centimeters thick; clear wavy to irregular lower boundary;
- B₂₁ 24 to 40 centimeters, very dark gray (10YR 3.1, moist) clay with common fine distinct reddish brown and yellowish brown mottles together with many iron concretions 3 to 5 millimeters in diameter; very coarse strong blocky or medium strong prismatic structure; hard to very hard when dry, firm to slightly friable when moist, sticky and plastic when wet; roots numerous; 15 to 30 centimeters thick; gradual wavy to irregular lower boundary;
- B₂₂ 40 to 56 centimeters, similar to the B horizon above except common fine faint reddish and yellowish brown mottles and few small concretions; roots few; 7 to 30 centimeters thick; clear wavy to irregular lower boundary;
- C 56 to 60+ centimeters, dark yellowish brown (10YR 3/4, moist) clay with few fine faint yellowish and grayish brown mottles and concretions; massive structure; hard when dry, firm to very slightly friable when moist, sticky and plastic when wet; roots few;

SOIL PROFILE DESCRIPTION
(Fort Sherman Satellite Site)

1. Location: Fort Sherman Military Reservation, S1 Road, approximate grid coordinates 17P-PA- 117 261.

2. Profile Description:

- A₀₀ Loose leaves, 3 to 4 centimeters thick.
- A₀ Partly decomposed forest litter. 1 to 1.5 centimeters thick.
- A₁₁ 0 to 4.5 centimeters, dark reddish brown (5YR 3/4, moist) silty clay to clay with a medium moderate granular to fine weak subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; roots plentiful; very permeable when undisturbed; 2 to 10 centimeters thick; abrupt wavy lower boundary;
- A₁₂ 4.5 to 8.0 centimeters, similar to horizon A₁₁ above except yellowish red (5YR 4/6, moist). 2 to 6 centimeters thick; clear wavy lower boundary;
- A₁₃ 8.0 to 14.0 centimeters, yellowish red (5YR 4/8, moist) silty clay with a medium moderate granular to fine weak subangular blocky structure; slightly hard when dry; friable when moist, sticky and plastic when wet; roots abundant; 5 to 12 centimeters thick; clear wavy lower boundary;
- A₃ 14.0 to 21.0 centimeters, yellowish red (5YR 4/6, moist) light clay with a medium strong subangular blocky structure; hard when dry, friable to slightly firm when moist, slightly plastic and sticky when wet; roots numerous; 4 to 10 centimeters thick; clear wavy lower boundary;
- B₂₁ 21.0 to 26.0 centimeters, red (2.5YR 4/8, moist) silty clay with a medium strong subangular blocky structure; hard when dry, friable to slightly firm when moist, sticky and slightly plastic when wet; roots numerous; 5 to 12 centimeters thick; clear wavy lower boundary;
- B₂₂ 26.0 to 44.0 centimeters, same as horizon B₂₁ above except red (2.5YR 4/6, moist) roots few; gradual wavy lower boundary;
- B₂₃ 44.0 to 100.0+ centimeters, same as horizon B₂₂ above except red (2.5YR 5/8, moist);

Soils Properties Summary
(Trafficability Layers)

| Site | Soil Layer in. | U.S. Department of Agriculture Textural Classification | Mechanical Analysis Percent | | | Unified Soil Classification System | | | Soil Moisture Content, | | Specific Gravity | | | | | |
|-------------------|----------------|--|-----------------------------|------|------|------------------------------------|----------------|---------------|---------------------------|-----------------|------------------|----------------------------|------|------|------|------|
| | | | Gravel | Sand | Silt | Clay | Classification | Fines Percent | Atterberg Limits LL PL PI | Dry Density pcf | | Percent Atmosphere Tension | | | | |
| Albrook Forest | 0-3 | Clay | 0 | 13 | 29 | 58 | MH | 87 | 85 | 49 | 36 | 55.7 | 81.2 | 70.4 | 33.0 | 2.62 |
| | 3-6 | Clay | 0 | 6 | 29 | 65 | MH | 96 | 70 | 44 | 26 | 62.6 | 69.1 | 59.1 | 28.0 | 2.67 |
| | (0-6) | Clay | 0 | 9 | 29 | 62 | MH | 92 | 78 | 36 | 32 | 59.2 | 75.2 | 64.8 | 30.0 | 2.64 |
| | 6-9 | Clay | 0 | 3 | 29 | 68 | MH | 97 | 65 | 36 | 29 | 64.0 | 68.0 | 58.4 | 27.7 | 2.69 |
| | 9-12 | Clay | 0 | 6 | 18 | 76 | MH | 94 | 71 | 36 | 35 | 65.2 | 63.3 | 54.8 | 27.2 | 2.70 |
| | (6-12) | Clay | 0 | 4 | 24 | 72 | MH | 96 | 68 | 36 | 32 | 64.6 | 65.6 | 54.6 | 27.4 | 2.70 |
| | 12-15 | Clay | 0 | 19 | 24 | 57 | CH | 86 | 65 | 30 | 35 | 67.6 | 61.0 | 54.2 | 28.0 | 2.64 |
| | 15-18 | Clay | 0 | 7 | 19 | 74 | CH | 93 | 70 | 32 | 38 | 69.6 | 57.2 | 52.1 | 28.4 | 2.55 |
| | (12-18) | Clay | 0 | 12 | 22 | 66 | CH | 90 | 68 | 31 | 37 | 68.6 | 59.1 | 53.2 | 28.2 | 2.60 |
| | Chiva Chiva | 0-3 | Clay | 0 | 21 | 33 | 46 | MH | 79 | 68 | 48 | 20 | 54.5 | 81.6 | 79.7 | 26.1 |
| 3-6 | | Clay | 0 | 21 | 26 | 53 | MH | 73 | 60 | 44 | 16 | 61.8 | 65.8 | 23.7 | 23.7 | 2.54 |
| (0-6) | | Clay | 0 | 21 | 30 | 49 | MH | 76 | 64 | 46 | 18 | 58.2 | 73.7 | 71.6 | 24.9 | 2.52 |
| 6-9 | | Clay | 0 | 30 | 21 | 49 | MH | 66 | 60 | 40 | 20 | 63.4 | 62.5 | 60.9 | 22.0 | 2.54 |
| 9-12 | | Clay | 0 | 30 | 19 | 51 | MH | 65 | 56 | 37 | 19 | 69.5 | 54.9 | 53.3 | 20.4 | 2.56 |
| (6-12) | | Clay | 0 | 30 | 20 | 50 | MH | 66 | 58 | 38 | 20 | 66.4 | 58.7 | 57.1 | 21.2 | 2.55 |
| 12-15 | | Clay | 0 | 32 | 18 | 50 | MH | 64 | 55 | 37 | 18 | 68.5 | 57.4 | 55.6 | 20.0 | 2.60 |
| 15-18 | | Clay | 0 | 30 | 22 | 48 | MH | 65 | 59 | 39 | 20 | 66.9 | 57.6 | 56.2 | 20.0 | 2.60 |
| (12-18) | | Clay | 0 | 31 | 20 | 49 | MH | 64 | 57 | 38 | 19 | 67.7 | 57.5 | 55.9 | 20.0 | 2.60 |
| Albrook Satellite | | 0-3 | Clay | 0 | 11 | 31 | 58 | MH | 89 | 89 | 49 | 40 | 57.2 | 77.0 | 69.8 | 31.8 |
| | 3-6 | Clay | 0 | 5 | 36 | 59 | MH | 96 | 77 | 39 | 38 | 60.3 | 69.8 | 60.2 | 29.5 | 2.64 |
| | (0-6) | Clay | 0 | 8 | 34 | 58 | MH | 92 | 83 | 44 | 39 | 58.8 | 73.4 | 65.0 | 30.6 | 2.62 |
| | 6-9 | Clay | 0 | 7 | 35 | 58 | MH | 94 | 70 | 41 | 29 | 64.9 | 62.6 | 56.3 | 27.6 | 2.70 |
| | 9-12 | Clay | 0 | 7 | 36 | 57 | MH | 94 | 72 | 39 | 33 | 67.9 | 59.8 | 55.6 | 27.0 | 2.70 |
| | (6-12) | Clay | 0 | 6 | 36 | 58 | MH | 94 | 71 | 40 | 31 | 66.4 | 61.2 | 56.0 | 27.3 | 2.70 |
| | 12-15 | Clay | 0 | 6 | 36 | 58 | MH | 95 | 74 | 38 | 36 | 68.6 | 57.8 | 54.9 | 28.4 | 2.81 |
| | 15-18 | Clay | 0 | 13 | 37 | 50 | MH | 87 | 70 | 43 | 27 | 71.8 | 53.7 | 51.2 | 29.0 | 2.74 |
| | (12-18) | Clay | 0 | 10 | 36 | 54 | MH | 91 | 72 | 41 | 31 | 70.2 | 55.8 | 53.0 | 28.7 | 2.78 |

Soils Properties Summary
(Trafficability Layers)

| Site | Soil Layer in. | U.S. Department of Agriculture Textural Classification | Mechanical Analysis Percent | | | Unified Soil Classification | Atterberg Limits | | | Dry Density pcf | Soil Moisture Content, Percent Dry Weight | | Specific Gravity | | | |
|-----------------------|----------------|--|-----------------------------|------|------|-----------------------------|------------------|----|-----|-----------------|---|------------|------------------|---------|------|------|
| | | | Gravel | Sand | Silt | | Clay | LL | PL | | PI | Atmosphere | | Tension | | |
| Ft. Kobbe Satellite | 0-3 | Clay | 0 | 6 | 34 | 60 | MH | 94 | 82 | 47 | 35 | 58.4 | 81.3 | 72.4 | 30.9 | 2.56 |
| | 3-6 | Clay | 0 | 1 | 21 | 78 | MH | 99 | 70 | 40 | 30 | 59.4 | 75.9 | 60.9 | 28.9 | 2.59 |
| | (0-6) | Clay | 0 | 3 | 28 | 69 | MH | 96 | 76 | 44 | 32 | 58.9 | 78.6 | 66.6 | 29.9 | 2.58 |
| | 6-9 | Clay | 0 | 4 | 19 | 77 | MH | 96 | 66 | 37 | 29 | 61.2 | 72.7 | 55.0 | 27.0 | 2.60 |
| | 9-12 | Clay | 0 | 7 | 11 | 82 | MH | 96 | 63 | 33 | 30 | 61.1 | 70.0 | 58.3 | 26.2 | 2.61 |
| | (6-12) | Clay | 0 | 5 | 15 | 80 | MH | 96 | 64 | 35 | 29 | 61.2 | 71.4 | 56.6 | 26.6 | 2.60 |
| | 12-15 | Clay | 0 | 5 | 12 | 83 | CH | 97 | 63 | 30 | 33 | 62.1 | 68.1 | 56.8 | 26.9 | 2.64 |
| | (12-15) | Clay | 0 | 8 | 10 | 82 | CH | 95 | 68 | 33 | 35 | 64.8 | 63.1 | 53.8 | 27.4 | 2.67 |
| (12-18) | Clay | 0 | 7 | 11 | 82 | CH | 96 | 66 | 32 | 34 | 63.5 | 65.6 | 55.3 | 27.2 | 2.66 | |
| Ft. Sherman Satellite | 0-3 | Clay | 0 | 8 | 19 | 73 | MH | 93 | 100 | 74 | 26 | 38.7 | 127.1 | 118.2 | 42.7 | 2.48 |
| | 3-6 | Clay | 0 | 4 | 15 | 81 | MH | 96 | 100 | 66 | 34 | 44.6 | 100.3 | 88.4 | 42.1 | 2.55 |
| | (0-6) | Clay | 0 | 6 | 17 | 77 | MH | 94 | 100 | 70 | 30 | 41.6 | 113.7 | 103.3 | 42.4 | 2.52 |
| | 6-9 | Clay | 0 | 4 | 6 | 90 | MH | 96 | 100 | 64 | 36 | 47.7 | 93.3 | 76.2 | 40.4 | 2.57 |
| | 9-12 | Clay | 0 | 4 | 11 | 85 | MH | 96 | 97 | 63 | 34 | 52.3 | 80.0 | 68.8 | 40.4 | 2.61 |
| | (6-12) | Clay | 0 | 4 | 8 | 88 | MH | 96 | 98 | 64 | 35 | 50.0 | 86.6 | 72.5 | 40.4 | 2.59 |
| | 12-15 | Clay | 0 | 5 | 23 | 72 | MH | 96 | 95 | 63 | 32 | 53.8 | 76.3 | 70.1 | 39.7 | 2.63 |
| | (12-15) | Clay | 0 | 7 | 26 | 65 | MH | 93 | 98 | 66 | 32 | 50.9 | 76.2 | 69.8 | 39.8 | 2.66 |
| (12-18) | Clay | 0 | 6 | 26 | 68 | MH | 94 | 96 | 64 | 32 | 52.4 | 76.2 | 70.0 | 39.8 | 2.64 | |

Soil Properties Summary
(Genetic Layers)

| Site | Horizon | U.S. Department of Agriculture Textural Classification | Mechanical Analysis Percent | | | |
|--------------------------|----------|---|--------------------------------|------|------|------|
| | | | Gravel | Sand | Silt | Clay |
| Albrook Forest | A11 | Clay | 0 | 13 | 29 | 58 |
| | A12 | Clay | 0 | 18 | 20 | 62 |
| | A3 | Clay | 0 | 4 | 25 | 71 |
| | B21 | Clay | 0 | 6 | 18 | 76 |
| | B22 | Clay | 0 | 3 | 16 | 81 |
| | BC | Clay | 0 | 2 | 19 | 79 |
| Chiva Chiva | A1 | Silty Clay Loam to Silty Clay | 0 | 10 | 50 | 40 |
| | AB or B1 | Silty Clay | 0 | 14 | 41 | 45 |
| | B2 | Clay | 0 | 17 | 31 | 52 |
| | B3 | Clay | 0 | 13 | 21 | 66 |
| | BC | Clay | 0 | 12 | 21 | 67 |
| | C | Clay | 0 | 26 | 16 | 58 |
| Albrook Satellite | A11 | Silty Clay to Clay | 0 | 4 | 40 | 56 |
| | A12 | Clay | 0 | 7 | 33 | 60 |
| | A3 | Clay | 0 | 4 | 32 | 64 |
| | B1 | Clay | 0 | 4 | 30 | 66 |
| | B21 | Clay | 0 | 5 | 25 | 70 |
| | B22 | Clay | 0 | 5 | 28 | 67 |
| | BC | Clay | 0 | 4 | 26 | 70 |
| | C | Clay | 0 | 3 | 23 | 74 |
| Ft. Kobbe Satellite | A11 | Clay | 0 | 4 | 36 | 60 |
| | A12 | Clay | 0 | 6 | 30 | 64 |
| | B21 | Clay | 0 | 13 | 30 | 57 |
| | B22 | Clay | 0 | 2 | 13 | 85 |
| | C | Clay | 0 | 6 | 20 | 74 |
| Ft. Sherman Satellite | A11 | Silty Clay to Clay | 0 | 14 | 40 | 46 |
| | A12 | Clay | 0 | 13 | 34 | 53 |
| | A13 | Silty Clay | 0 | 5 | 42 | 53 |
| | A3 | Clay | 0 | 2 | 32 | 66 |
| | B21 | Silty Clay | 0 | 3 | 41 | 56 |
| | B22 | Silty Clay | 0 | 3 | 42 | 55 |
| | B23 | Silty Clay | 0 | 3 | 46 | 51 |

Moisture-Strength-Density Summary

Albrook Forest Site, Soil Plot No. 1

| Date | Cone Index | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | | Soil Moisture | | Dry Density | |
|-----------|-----------------|------|---|---|--------|--------------------|------|-----------------|------|
| | per 6-in. Layer | | | Ind. RI | Avg RI | Percent Dry Weight | | per 6-in. Layer | |
| | 0-6 | 6-12 | | | | 0-6 | 6-12 | 0-6 | 6-12 |
| 2 Feb 65 | 199 | 311 | 0.62 | 191 | 354 | 35.9 | 31.4 | 58.1 | 74.8 |
| 9 Feb 65 | 195 | 361 | 0.78 | 269 | 412 | 31.7 | 30.4 | 70.4 | 59.8 |
| 16 Feb 65 | 228 | 408 | 0.84 | 358 | 465 | 30.0 | 27.7 | - | - |
| 23 Feb 65 | 153 | 344 | 2.66 | 890 | 392 | 31.6 | 29.7 | 66.3 | 74.0 |
| 2 Mar 65 | 236 | 474 | 1.09 | 497 | 540 | 30.2 | 28.4 | 65.1 | 74.9 |
| 9 Mar 65 | 279 | 492 | 1.55 | 700 | 561 | 28.4 | 27.5 | 64.0 | 73.1 |
| 16 Mar 65 | 373 | 599 | - | - | 683 | 27.5 | 26.6 | 72.1 | 71.9 |
| 23 Mar 65 | 245 | 401 | 1.50 | 690 | 457 | 29.1 | 27.5 | - | 78.0 |
| 30 Mar 65 | 198 | 445 | - | - | 507 | 27.8 | 27.4 | - | - |
| 6 Apr 65 | 241 | 415 | 1.89 | 761 | 473 | 26.3 | 25.9 | - | 71.4 |
| 13 Apr 65 | 200 | 415 | 1.82 | 753 | 473 | 26.5 | 26.1 | 63.7 | 72.8 |
| 20 Apr 65 | 232 | 478 | 1.59 | 818 | 545 | 26.1 | 26.2 | - | 74.2 |
| 27 Apr 65 | 236 | 486 | 0.98 | 424 | 554 | 24.7 | 25.8 | - | 76.6 |
| 4 May 65 | 201 | 507 | 1.72 | 876 | 578 | 26.5 | 26.3 | - | 80.5 |
| 11 May 65 | 159 | 381 | 1.36 | 511 | 434 | 38.7 | 31.6 | 67.5 | 76.4 |
| 18 May 65 | 80 | 140 | 1.62 | 240 | 160 | 43.7 | 39.2 | 71.0 | 81.0 |
| 25 May 65 | 79 | 111 | 0.79 | 88 | 126 | 42.7 | 38.4 | 67.9 | 79.6 |
| 1 Jun 65 | 61 | 86 | 1.10 | 94 | 98 | 44.1 | 39.2 | 68.2 | 76.8 |
| 8 Jun 65 | 68 | 104 | 1.01 | 102 | 118 | 47.8 | 40.4 | 67.9 | 77.2 |
| 15 Jun 65 | 96 | 132 | 1.26 | 159 | 150 | 45.5 | 38.0 | 69.1 | 77.1 |
| 22 Jun 65 | 67 | 104 | 1.06 | 111 | 118 | 47.0 | 40.4 | 65.5 | 76.9 |
| 29 Jun 65 | 57 | 101 | 1.04 | 105 | 115 | 46.7 | 39.6 | 64.8 | 77.8 |
| 6 Jul 65 | 77 | 115 | 1.01 | 117 | 131 | 47.4 | 40.0 | 68.0 | 79.0 |
| 13 Jul 65 | 88 | 141 | 1.13 | 165 | 161 | 44.3 | 38.8 | 68.8 | 79.2 |
| 20 Jul 65 | 68 | 112 | 0.99 | 113 | 128 | 48.2 | 40.3 | 68.9 | 77.4 |
| 27 Jul 65 | 66 | 99 | 1.02 | 102 | 113 | 50.7 | 41.1 | 63.7 | 75.0 |
| 3 Aug 65 | 73 | 116 | 1.03 | 119 | 132 | 47.9 | 41.0 | 67.7 | 75.7 |
| 10 Aug 65 | 73 | 99 | 1.15 | 114 | 113 | 48.1 | 40.8 | 67.7 | 75.2 |
| 17 Aug 65 | 81 | 116 | 1.02 | 118 | 132 | 47.2 | 40.1 | 69.8 | 79.6 |
| 24 Aug 65 | 66 | 103 | 1.08 | 111 | 117 | 48.1 | 41.6 | 72.0 | 78.3 |
| 31 Aug 65 | 57 | 98 | 0.99 | 96 | 112 | 52.6 | 42.4 | 68.2 | 78.1 |
| 7 Sep 65 | 71 | 115 | 0.96 | 111 | 131 | 48.8 | 43.3 | 70.6 | 77.2 |
| 14 Sep 65 | 63 | 100 | 0.95 | 95 | 114 | 51.9 | 43.9 | 68.2 | 76.1 |
| 21 Sep 65 | 61 | 109 | 1.06 | 116 | 124 | 51.9 | 42.1 | 69.2 | 78.5 |
| 28 Sep 65 | 54 | 94 | 0.99 | 92 | 107 | 54.1 | 44.1 | 67.5 | 76.7 |

| | | | | | | | | | | | | |
|-----------|-----|-----|-----|------|-----|-----|------|------|------|------|------|------|
| 5 Oct 65 | 76 | 108 | 105 | 1.09 | 117 | 123 | 48.5 | 42.0 | 44.0 | 70.0 | 77.9 | 77.8 |
| 12 Oct 65 | 69 | 106 | 125 | 1.26 | 133 | 121 | 54.0 | 44.4 | 47.4 | 67.5 | 76.5 | 74.9 |
| 19 Oct 65 | 55 | 86 | 86 | 1.00 | 87 | 98 | 54.7 | 47.5 | 47.1 | 67.9 | 73.3 | 70.3 |
| 26 Oct 65 | 57 | 113 | 117 | 0.97 | 110 | 129 | 55.1 | 41.1 | 44.1 | 67.1 | 78.2 | 74.7 |
| 2 Nov 65 | 55 | 77 | 81 | 0.97 | 74 | 88 | 51.9 | 41.3 | 39.7 | 70.0 | 80.0 | 81.8 |
| 9 Nov 65 | 48 | 94 | 104 | 1.04 | 98 | 107 | 54.4 | 43.5 | 48.9 | 68.1 | 76.3 | 70.9 |
| 16 Nov 65 | 59 | 96 | 107 | 1.02 | 98 | 109 | 50.4 | 43.4 | 42.7 | 70.1 | 77.1 | 77.9 |
| 23 Nov 65 | 57 | 91 | 90 | 1.07 | 98 | 104 | 53.2 | 43.7 | 45.9 | 67.1 | 75.9 | 74.6 |
| 29 Nov 65 | 62 | 110 | 117 | 1.01 | 111 | 125 | 56.6 | 41.7 | 46.5 | 65.2 | 77.4 | 72.1 |
| 7 Dec 65 | 51 | 86 | 104 | 0.88 | 75 | 98 | 55.6 | 43.5 | 45.7 | 66.6 | 76.0 | 74.0 |
| 14 Dec 65 | 60 | 91 | 96 | 0.98 | 89 | 104 | 55.6 | 43.8 | 48.2 | 67.0 | 77.6 | 73.4 |
| 22 Dec 65 | 63 | 98 | 110 | 0.85 | 83 | 112 | 55.9 | 42.8 | 43.6 | 65.4 | 77.3 | 76.7 |
| 27 Dec 65 | 82 | 118 | 126 | 1.03 | 122 | 134 | 49.5 | 40.8 | 41.4 | 67.2 | 76.8 | 78.1 |
| 1966 | | | | | | | | | | | | |
| 4 Jan 66 | 77 | 127 | 133 | 1.03 | 131 | 145 | 51.1 | 39.4 | 38.6 | 68.7 | 79.7 | 80.6 |
| 11 Jan 66 | 71 | 98 | 93 | 0.92 | 90 | 112 | 51.2 | 41.3 | 41.8 | 68.0 | 77.9 | 79.7 |
| 18 Jan 66 | 89 | 147 | 156 | 1.07 | 158 | 168 | 50.5 | 39.5 | 39.7 | 62.1 | 77.7 | 80.4 |
| 25 Jan 66 | 108 | 150 | 156 | 1.06 | 163 | 171 | 42.9 | 39.4 | 38.1 | 70.1 | 75.7 | 79.5 |
| 8 Feb 66 | 190 | 322 | 380 | - | - | 367 | 39.6 | 30.2 | 31.1 | - | - | - |
| 21 Feb 66 | 126 | 216 | 240 | - | - | 246 | 35.8 | 29.6 | 30.4 | - | - | - |

Chiva Chiva Site, Soil Plot No. 1

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | | Soil Moisture per 6-in. Layer | | Dry Density per 6-inch. Layer | | |
|-----------|-------------------------------|-------|---|---|---------|----------------------------------|------|----------------------------------|------|------|
| | 0-6 | 6-12 | | Ind. RI | Avg. RI | 0-6 | 6-12 | 0-6 | 6-12 | |
| | 12-18 | 12-18 | | | | pcf | pcf | | | |
| 3 Feb 65 | 750 | 750 | - | - | 832 | 18.3 | 18.9 | 21.3 | - | - |
| 9 Feb 65 | 750 | 750 | - | - | 832 | 19.2 | 19.5 | 21.1 | - | - |
| 17 Feb 65 | 750 | 750 | - | - | 832 | 17.8 | 18.4 | 21.6 | - | - |
| 24 Feb 65 | 750 | 750 | - | - | 832 | 18.5 | 18.8 | 22.1 | - | - |
| 3 Mar 65 | 750 | 750 | - | - | 832 | 18.0 | 19.4 | 22.5 | - | - |
| 10 Mar 65 | 750 | 750 | - | - | 832 | 17.6 | 19.1 | 22.5 | - | - |
| 17 Mar 65 | 750 | 750 | - | - | 832 | 17.2 | 17.4 | 19.0 | - | - |
| 24 Mar 65 | 750 | 750 | - | - | 832 | 17.7 | 18.8 | 21.8 | - | - |
| 31 Mar 65 | 750 | 750 | - | - | 832 | 15.8 | 16.8 | 18.1 | - | - |
| 7 Apr 65 | 750 | 750 | - | - | 832 | 16.0 | 18.2 | 18.5 | - | - |
| 19 Apr 65 | 750 | 750 | - | - | 832 | 16.2 | 17.8 | 19.5 | - | - |
| 21 Apr 65 | 750 | 750 | - | - | 832 | 15.2 | 17.6 | 21.4 | - | - |
| 28 Apr 65 | 750 | 750 | - | - | 832 | 15.9 | 18.1 | 19.8 | - | - |
| 5 May 65 | 750 | 750 | - | - | 832 | 18.6 | 19.7 | 21.5 | - | - |
| 12 May 65 | 186 | 307 | - | - | 341 | 36.4 | 30.8 | 30.2 | 77.6 | 84.7 |
| 19 May 65 | 210 | 324 | - | 441 | 360 | 32.2 | 30.2 | 31.4 | 81.4 | - |
| 26 May 65 | 194 | 299 | 0.98 | 149 | 332 | 36.0 | 38.1 | 32.1 | 73.4 | 79.5 |
| 2 Jun 65 | 153 | 232 | 1.25 | 313 | 258 | 37.6 | 32.8 | 34.4 | 73.7 | 81.3 |
| 9 Jun 65 | 158 | 251 | 1.03 | 306 | 279 | 38.5 | 31.7 | 34.5 | 74.1 | 83.1 |
| 16 Jun 65 | 169 | 301 | 1.49 | 417 | 334 | 37.6 | 30.7 | 32.9 | 74.2 | 85.0 |
| 23 Jun 65 | 173 | 276 | 1.24 | 347 | 306 | 39.0 | 31.0 | 33.4 | 73.2 | 83.9 |
| 30 Jun 65 | 182 | 279 | 1.13 | 364 | 310 | 38.7 | 32.1 | 35.4 | 75.0 | 79.0 |
| 7 Jul 65 | 276 | 391 | 1.29 | 507 | 434 | 32.4 | 30.4 | 31.6 | 75.7 | 83.1 |
| 14 Jul 65 | 171 | 302 | 1.12 | 340 | 335 | 39.2 | 31.7 | 32.0 | 73.3 | 82.1 |
| 21 Jul 65 | 132 | 247 | 1.07 | 264 | 274 | 41.1 | 32.4 | 34.4 | 74.3 | 82.9 |
| 28 Jul 65 | 162 | 292 | 1.55 | 510 | 324 | 39.4 | 30.8 | 32.7 | 72.8 | 81.0 |
| 4 Aug 65 | 131 | 227 | 1.03 | 234 | 252 | 42.8 | 33.6 | 36.3 | 73.5 | 81.3 |
| 11 Aug 65 | 156 | 309 | 1.12 | 324 | 343 | 39.5 | 31.8 | 32.8 | 72.3 | 82.5 |
| 18 Aug 65 | 121 | 236 | 1.01 | 233 | 262 | 42.6 | 33.4 | 33.9 | 75.7 | 82.5 |
| 25 Aug 65 | 129 | 231 | 1.07 | 258 | 265 | 41.3 | 32.4 | 37.4 | 75.6 | 82.9 |
| 1 Sep 65 | 136 | 231 | 0.98 | 226 | 256 | 41.5 | 33.1 | 35.4 | 76.1 | 86.4 |
| 8 Sep 65 | 132 | 229 | 0.95 | 215 | 254 | 42.8 | 32.6 | 40.7 | 73.9 | 83.8 |
| 15 Sep 65 | 129 | 224 | 1.07 | 242 | 249 | 45.6 | 37.4 | 47.2 | 74.8 | 85.9 |
| 22 Sep 65 | 129 | 243 | 0.95 | 205 | 270 | 44.5 | 33.1 | 47.2 | 73.7 | 81.2 |
| 29 Sep 65 | 129 | 243 | 0.95 | 205 | 270 | 44.5 | 33.1 | 34.7 | 74.3 | 86.4 |

| | | | | | | | | | | | | |
|-----------|-----|-----|-----|------|-----|-----|------|------|------|------|------|------|
| 6 Oct 65 | 157 | 277 | 321 | 1.32 | 333 | 307 | 38.3 | 32.1 | 32.2 | 75.1 | 81.4 | 82.0 |
| 13 Oct 65 | 121 | 201 | 317 | 0.90 | 180 | 223 | 46.9 | 33.5 | 39.2 | 72.0 | 85.4 | 81.1 |
| 20 Oct 65 | 110 | 236 | 331 | 1.19 | 287 | 262 | 44.2 | 32.8 | 35.4 | 73.9 | 83.3 | 80.4 |
| 27 Oct 65 | 141 | 259 | 342 | 1.25 | 317 | 287 | 39.8 | 32.9 | 34.3 | 77.5 | 85.5 | 83.1 |
| 4 Nov 65 | 108 | 204 | 319 | 1.22 | 252 | 226 | 43.0 | 32.7 | 37.9 | 75.8 | 60.1 | 79.7 |
| 10 Nov 65 | 116 | 193 | 286 | 0.83 | 157 | 214 | 47.8 | 35.5 | 46.3 | 70.9 | 83.4 | 75.1 |
| 17 Nov 65 | 128 | 209 | 302 | 0.94 | 196 | 232 | 44.6 | 34.4 | 36.0 | 73.2 | 84.6 | 83.9 |
| 24 Nov 65 | 115 | 208 | 304 | 0.72 | 138 | 231 | 50.4 | 44.4 | 45.9 | 68.3 | 73.6 | 72.9 |
| 1 Dec 65 | 117 | 213 | 284 | 0.97 | 208 | 236 | 45.9 | 34.7 | 44.1 | 71.9 | 82.6 | 76.2 |
| 8 Dec 65 | 121 | 216 | 284 | 0.97 | 210 | 240 | 46.6 | 34.1 | 34.9 | 72.7 | 84.1 | 83.9 |
| 15 Dec 65 | 132 | 245 | 371 | 1.31 | 338 | 272 | 44.5 | 33.0 | 36.2 | 73.0 | 84.5 | 80.2 |
| 22 Dec 65 | 139 | 253 | 315 | 0.99 | 251 | 281 | 45.3 | 32.6 | 38.4 | 73.1 | 83.4 | 79.6 |
| 28 Dec 65 | 293 | 430 | 474 | - | - | 477 | 35.3 | 28.9 | 31.7 | 71.0 | 83.2 | 79.1 |
| 1966 | | | | | | | | | | | | |
| 5 Jan 66 | 173 | 341 | 459 | - | - | 378 | 37.4 | 32.3 | 33.1 | 77.4 | 82.2 | 82.8 |
| 12 Jan 66 | 191 | 405 | 500 | - | - | 450 | 40.4 | 40.2 | 31.1 | 74.4 | - | - |
| 19 Jan 66 | 341 | 499 | 530 | - | - | 554 | 34.7 | 27.5 | 31.5 | 71.7 | - | - |
| 26 Jan 66 | 449 | 698 | 733 | - | - | 775 | 32.4 | 26.5 | 28.9 | - | - | - |
| 9 Feb 66 | 526 | 741 | 750 | - | - | 832 | 21.9 | 23.5 | 22.5 | - | - | - |
| 23 Feb 66 | 557 | 750 | 750 | - | - | 832 | 21.4 | 20.1 | 22.4 | - | - | - |
| 9 Mar 66 | 559 | 750 | 750 | - | - | 832 | 20.1 | 20.1 | 23.5 | - | - | - |

Moisture-Strength-Density Summary

Albrook Satellite Site

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | | Soil Moisture per 6-in. Layer Percent Dry Weight | | Dry Density per 6-in. Layer pcf | |
|-----------|-------------------------------|------|---|---|---------|--|------|---------------------------------------|------|
| | 0-6 | 6-12 | | Ind. RI | Avg. RI | 0-6 | 6-12 | 0-6 | 6-12 |
| 14 Mar 65 | 191 | 360 | 1.05 | 378 | 31.1 | 28.2 | 65.5 | 71.2 | |
| 15 Mar 65 | 192 | 388 | 1.20 | 466 | 31.8 | 28.7 | - | 72.0 | |
| 29 Mar 65 | 187 | 327 | 1.44 | 471 | 29.6 | 29.3 | 55.0 | 57.0 | |
| 12 Apr 65 | 170 | 324 | 1.44 | 466 | 30.7 | 29.0 | - | 71.9 | |
| 26 Apr 65 | 232 | 423 | 1.41 | 596 | 28.9 | 26.7 | - | - | |
| 10 May 65 | 125 | 219 | 1.32 | 289 | 35.3 | 29.1 | 71.7 | 76.8 | |
| 24 May 65 | 91 | 119 | 0.83 | 99 | 44.7 | 41.0 | 67.2 | 76.0 | |
| 7 Jun 65 | 67 | 107 | 0.94 | 101 | 44.8 | 40.4 | 65.8 | 73.9 | |
| 22 Jun 65 | 46 | 90 | 0.90 | 81 | 47.4 | 44.4 | 66.3 | 74.8 | |
| 6 Jul 65 | 90 | 119 | 1.04 | 124 | 46.6 | 41.0 | 66.4 | 74.4 | |
| 22 Jul 65 | 70 | 122 | 1.02 | 124 | 45.3 | 42.3 | 71.1 | 74.2 | |
| 2 Aug 65 | 89 | 137 | 1.08 | 148 | 49.0 | 41.3 | 61.8 | 73.7 | |
| 16 Aug 65 | 77 | 119 | 0.90 | 107 | 49.2 | 42.3 | 65.6 | 73.7 | |
| 30 Aug 65 | 61 | 114 | 1.00 | 114 | 52.3 | 42.6 | 68.6 | 76.9 | |
| 13 Sep 65 | 54 | 67 | 1.03 | 69 | 53.0 | 46.5 | 66.1 | 72.8 | |
| 30 Sep 65 | 49 | 104 | 0.93 | 97 | 63.0 | 44.6 | 62.2 | 74.8 | |
| 14 Oct 65 | 49 | 97 | 1.01 | 101 | 59.4 | 46.1 | 62.2 | 73.7 | |
| 28 Oct 65 | 54 | 86 | 0.98 | 84 | 56.6 | 43.4 | 64.5 | 75.7 | |
| 12 Nov 65 | 56 | 90 | 1.43 | 129 | 56.4 | 44.3 | 64.4 | 75.7 | |
| 26 Nov 65 | 51 | 102 | 1.00 | 102 | 56.9 | 44.4 | 64.1 | 72.9 | |
| 9 Dec 65 | 48 | 99 | 0.92 | 91 | 54.7 | 48.6 | 66.7 | 71.6 | |
| 21 Dec 65 | 52 | 92 | 0.98 | 90 | 58.0 | 44.2 | 65.6 | 76.7 | |
| 6 Jan 66 | 67 | 119 | 1.03 | 122 | 58.4 | 45.5 | 65.2 | 74.2 | |
| 20 Jan 66 | 104 | 148 | 0.98 | 145 | 49.8 | 42.9 | 63.6 | 73.1 | |
| 3 Feb 66 | 101 | 179 | 0.96 | 172 | 48.6 | 37.5 | 63.6 | 74.8 | |
| 17 Feb 66 | 127 | 204 | 0.86 | 175 | 43.5 | 35.1 | 70.4 | 75.7 | |
| 3 Mar 66 | 147 | 226 | - | - | 38.6 | 34.0 | 64.4 | 76.7 | |

Moisture-Strength-Density Summary

Albrook Satellite Site (cont'd)

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | | Soil Moisture per 6-in. Layer Percent Dry Weight | | Dry Density per 6-in. Layer pcf | |
|-----------|-------------------------------|------|---|---|---------|--|------|---------------------------------------|------|
| | 0-6 | 6-12 | | Ind. RI | Avg. RI | 0-6 | 6-12 | 0-6 | 6-12 |
| 17 Mar 66 | 184 | 421 | - | - | 429 | 33.5 | 28.6 | 56.5 | 66.4 |
| 31 Mar 66 | 231 | 453 | - | - | 462 | 32.3 | 29.0 | 58.9 | 66.3 |
| 14 Apr 66 | 198 | 415 | - | - | 423 | 31.3 | 28.4 | 59.8 | 68.6 |
| 28 Apr 66 | 85 | 128 | 0.96 | 123 | 130 | 41.6 | 41.2 | 66.9 | 74.6 |
| 12 May 66 | 63 | 110 | 0.98 | 108 | 112 | 47.5 | 42.6 | 69.3 | 77.6 |
| 26 May 66 | 58 | 96 | 0.94 | 90 | 98 | 52.0 | 44.0 | 69.0 | 75.7 |
| 9 Jun 66 | 51 | 104 | 0.96 | 100 | 106 | 50.1 | 43.8 | 69.5 | 75.0 |
| 23 Jun 66 | 50 | 94 | 0.90 | 85 | 96 | 47.8 | 54.6 | 69.9 | 70.8 |
| 5 Jul 66 | 51 | 105 | 1.00 | 105 | 107 | 55.6 | 45.1 | 66.0 | 73.8 |
| 21 Jul 66 | 56 | 109 | 0.92 | 100 | 111 | 56.7 | 44.2 | 64.5 | 73.8 |
| 4 Aug 66 | 58 | 105 | 1.05 | 111 | 107 | 52.1 | 43.5 | 67.5 | 76.7 |
| 18 Aug 66 | 55 | 97 | 1.26 | 122 | 99 | 54.7 | 47.9 | 66.0 | 70.9 |
| 1 Sep 66 | 65 | 115 | 1.14 | 131 | 117 | 56.2 | 40.6 | 65.4 | 74.6 |
| 15 Sep 66 | 56 | 97 | 0.88 | 85 | 99 | 57.0 | 46.4 | 67.4 | 71.2 |
| 29 Sep 66 | 54 | 108 | 0.99 | 107 | 110 | 57.8 | 44.6 | 64.2 | 74.3 |
| 13 Oct 66 | 67 | 103 | 0.90 | 93 | 105 | 58.1 | 47.6 | 61.6 | 69.0 |
| 27 Oct 66 | 58 | 123 | 0.92 | 113 | 125 | 58.3 | 45.1 | 64.8 | 73.3 |
| 9 Nov 66 | 46 | 91 | 0.92 | 84 | 93 | 56.0 | 45.9 | 66.5 | 73.7 |
| 21 Nov 66 | 45 | 90 | 0.85 | 76 | 92 | 56.2 | 43.5 | 64.0 | 76.8 |
| 9 Dec 66 | 39 | 84 | 0.78 | 66 | 86 | 66.6 | 48.8 | 59.0 | 71.2 |
| 21 Dec 66 | 81 | 139 | - | - | 142 | 59.7 | 43.1 | 62.3 | 73.9 |
| 5 Jan 67 | 98 | 138 | - | - | 141 | 49.2 | 42.8 | 63.8 | 71.7 |
| 20 Jan 67 | 176 | 282 | - | - | 288 | 39.1 | 33.6 | 66.8 | 71.5 |
| 30 Jan 67 | 106 | 176 | - | - | 180 | 41.8 | 37.0 | 66.0 | 70.1 |

Moisture-Strength-Density Summary

Fort Kobbe Satellite Site

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCL), 6 to 12 in. From | | Soil Moisture per 6-in. Layer | | Dry Density per 6-in. Layer | |
|-----------|-------------------------------|------|---|---|---------|----------------------------------|------|--------------------------------|------|
| | 0-6 | 6-12 | | Ind. RI | Avg. RI | 0-6 | 6-12 | 0-6 | 6-12 |
| | Percent Dry Weight | | | pcf | | pcf | | pcf | |
| 4 Mar 65 | 273 | 561 | - | - | 617 | 29.9 | 27.2 | 62.0 | 73.2 |
| 15 Mar 65 | 293 | 601 | - | - | 661 | 26.6 | 25.8 | - | - |
| 29 Mar 65 | 197 | 433 | - | - | 476 | 26.7 | 26.3 | - | 69.3 |
| 12 Apr 65 | 215 | 377 | 1.61 | 607 | 415 | 23.6 | 24.8 | - | - |
| 26 Apr 65 | 274 | 518 | - | - | 570 | 23.9 | 25.9 | - | - |
| 10 May 65 | 173 | 404 | 1.24 | 501 | 444 | 31.3 | 29.9 | 75.2 | 47.7 |
| 24 May 65 | 79 | 141 | 1.07 | 151 | 155 | 44.0 | 39.3 | 68.7 | 76.5 |
| 7 Jun 65 | 76 | 141 | 0.90 | 127 | 155 | 48.0 | 39.6 | 73.8 | 75.6 |
| 21 Jun 65 | 118 | 195 | 1.20 | 234 | 214 | 41.7 | 36.3 | 62.4 | 74.8 |
| 6 Jul 65 | 142 | 192 | 1.24 | 238 | 211 | 42.2 | 38.4 | 64.2 | 76.1 |
| 22 Jul 65 | 178 | 266 | 1.28 | 340 | 293 | 34.4 | 31.8 | 63.2 | 75.6 |
| 2 Aug 65 | 94 | 174 | 1.19 | 207 | 191 | 39.2 | 36.4 | 67.5 | 74.5 |
| 16 Aug 65 | 100 | 148 | 1.14 | 169 | 163 | 45.0 | 38.9 | 63.1 | 75.9 |
| 30 Aug 65 | 65 | 99 | 1.10 | 109 | 109 | 49.7 | 44.0 | 72.1 | 76.0 |
| 16 Sep 65 | 102 | 180 | 1.00 | 180 | 198 | 48.9 | 38.0 | 63.2 | 75.4 |
| 30 Sep 65 | 69 | 134 | 1.05 | 141 | 147 | 56.1 | 42.1 | 63.8 | 76.6 |
| 14 Oct 65 | 63 | 118 | 1.13 | 133 | 130 | 50.8 | 43.2 | 68.7 | 76.1 |
| 28 Oct 65 | 53 | 116 | 1.04 | 121 | 128 | 57.5 | 40.7 | 64.6 | 77.6 |
| 12 Nov 65 | 64 | 128 | 1.04 | 133 | 141 | 57.0 | 41.8 | 64.8 | 76.8 |
| 26 Nov 65 | 43 | 101 | 1.09 | 110 | 111 | 63.9 | 52.4 | 57.6 | 72.0 |
| 9 Dec 65 | 59 | 112 | 1.12 | 125 | 123 | 57.1 | 42.7 | 64.2 | 77.3 |
| 23 Dec 65 | 108 | 161 | 1.00 | 161 | 177 | 47.2 | 38.7 | 67.4 | 75.8 |
| 6 Jan 66 | 128 | 257 | 0.91 | 234 | 283 | 39.7 | 35.8 | 63.9 | 75.8 |
| 20 Jan 66 | 181 | 312 | - | - | 343 | 36.6 | 33.2 | 59.2 | 73.5 |
| 3 Feb 66 | 277 | 473 | - | - | 520 | 30.3 | 28.2 | 62.4 | - |
| 17 Feb 66 | 357 | 633 | - | - | 696 | 24.1 | 25.6 | - | - |
| 3 Mar 66 | 200 | 432 | - | - | 475 | 26.1 | 24.1 | 56.6 | 67.9 |

Moisture-Strength-Density Summary

Fort Kobbe Satellite Site (Cont'd)

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCL), 6 to 12 in. From | Soil Moisture per 6-in. Layer | | Dry Density per 6-in. Layer pcf | | |
|-----------|-------------------------------|------|---|---|----------------------------------|---------|---------------------------------------|------|------|
| | 0-6 | 6-12 | | | Ind. RI | Avg. RI | | 0-6 | 6-12 |
| 17 Mar 66 | 330 | 690 | - | - | 759 | 24.5 | 24.9 | 57.5 | 59.2 |
| 31 Mar 66 | 238 | 566 | - | - | 623 | 25.6 | 27.3 | 58.9 | - |
| 14 Apr 66 | 351 | 626 | - | - | 689 | 24.2 | 26.6 | - | 62.8 |
| 28 Apr 66 | 156 | 404 | - | - | 444 | 29.5 | 26.5 | 58.1 | 66.1 |
| 12 May 66 | 99 | 151 | 1.01 | 152 | 166 | 43.5 | 37.8 | 72.5 | 81.5 |
| 26 May 66 | 44 | 98 | - | - | 108 | 50.3 | 41.0 | 68.5 | 76.0 |
| 9 Jun 66 | 52 | 113 | 1.42 | 160 | 124 | 58.8 | 53.2 | 61.4 | 71.0 |
| 23 Jun 66 | 95 | 180 | - | - | 198 | 45.8 | 37.4 | 62.9 | 78.4 |
| 7 Jul 66 | 68 | 126 | 1.01 | 127 | 139 | 52.4 | 44.3 | 64.3 | 74.8 |
| 21 Jul 66 | 59 | 92 | 0.92 | 85 | 101 | 51.4 | 44.3 | 67.1 | 74.5 |
| 4 Aug 66 | 95 | 121 | 1.03 | 125 | 133 | 46.1 | 43.0 | 71.0 | 75.9 |
| 18 Aug 66 | 69 | 109 | 1.08 | 118 | 120 | 54.2 | 42.7 | 64.8 | 76.6 |
| 1 Sep 66 | 92 | 139 | 0.97 | 135 | 153 | 48.0 | 39.1 | 69.4 | 79.7 |
| 15 Sep 66 | 56 | 107 | 0.95 | 102 | 118 | 51.8 | 44.2 | 67.2 | 73.9 |
| 29 Sep 66 | 79 | 126 | - | - | 139 | 49.7 | 40.8 | 65.4 | 71.2 |
| 14 Oct 66 | 63 | 103 | - | - | 113 | 54.8 | 46.2 | 65.1 | 71.8 |
| 27 Oct 66 | 68 | 120 | 1.00 | 120 | 132 | 49.6 | 42.3 | 69.0 | 76.8 |
| 10 Nov 66 | 70 | 99 | - | - | 109 | 55.2 | 45.7 | 62.7 | 71.1 |
| 21 Nov 66 | 70 | 116 | 1.05 | 122 | 128 | 55.0 | 41.6 | 64.7 | 71.4 |
| 8 Dec 66 | 80 | 129 | - | - | 142 | 54.6 | 42.2 | 67.2 | 77.3 |
| 22 Dec 66 | 77 | 115 | - | - | 126 | 46.5 | 41.0 | 71.2 | 75.1 |
| 5 Jan 67 | 134 | 167 | - | - | 184 | 39.2 | 36.2 | 65.3 | 79.6 |
| 20 Jan 67 | 246 | 468 | - | - | 515 | 30.6 | 29.8 | 58.7 | 63.9 |
| 30 Jan 67 | 180 | 380 | - | - | 418 | 33.1 | 30.6 | 59.2 | 65.4 |

Moisture-Strength-Density Summary

Fort Sherman Satellite Site

| Date | Cone Index | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | Soil Moisture | | Dry Density per 6-in. Layer pcf | |
|-----------|-----------------|-----------------|---|---|--------------------|-----------------|---------------------------------------|------|
| | per 6-in. Layer | per 6-in. Layer | | | Percent Dry Weight | per 6-in. Layer | | |
| | 0-6 | 6-12 | | | 0-6 | 6-12 | | |
| 11 Mar 65 | 145 | 235 | 0.93 | 219 | 242 | 58.8 | 52.7 | 40.2 |
| 25 Mar 65 | 170 | 280 | - | - | 288 | 56.2 | 59.4 | - |
| 8 Apr 65 | 196 | 340 | 1.29 | 439 | 350 | 49.8 | 58.5 | 63.4 |
| 22 Apr 65 | 112 | 153 | - | - | 158 | 67.3 | 54.5 | 62.7 |
| 6 May 65 | 133 | 287 | - | - | 296 | 56.3 | 60.0 | 67.8 |
| 20 May 65 | 102 | 143 | 1.08 | 154 | 147 | 66.7 | 52.7 | 60.6 |
| 3 Jun 65 | 85 | 149 | 1.10 | 164 | 153 | 74.3 | 44.6 | 59.0 |
| 17 Jun 65 | 87 | 157 | 0.92 | 144 | 162 | 66.0 | 56.4 | 63.4 |
| 1 Jul 65 | 93 | 115 | 0.92 | 106 | 118 | 65.7 | 57.8 | 63.7 |
| 15 Jul 65 | 117 | 191 | 1.08 | 206 | 197 | 73.1 | 46.6 | 61.9 |
| 29 Jul 65 | 108 | 170 | 1.00 | 170 | 175 | 65.7 | 56.8 | 61.0 |
| 13 Aug 65 | 72 | 145 | 0.96 | 139 | 149 | 74.8 | 52.7 | 55.5 |
| 26 Aug 65 | 65 | 81 | 0.98 | 79 | 83 | 71.5 | 54.2 | 57.6 |
| 9 Sep 65 | 78 | 130 | 1.10 | 143 | 134 | 80.8 | 49.4 | 58.9 |
| 23 Sep 65 | 75 | 128 | 1.00 | 128 | 132 | 84.4 | 48.6 | 58.1 |
| 7 Oct 65 | 80 | 142 | 1.19 | 169 | 146 | 81.8 | 49.5 | 65.2 |
| 21 Oct 65 | 89 | 186 | 1.16 | 216 | 192 | 66.3 | 59.2 | 66.8 |
| 5 Nov 65 | 62 | 104 | 1.04 | 108 | 107 | 79.3 | 49.9 | 55.5 |
| 18 Nov 65 | 71 | 124 | 1.03 | 128 | 128 | 81.0 | 51.2 | 58.6 |
| 2 Dec 65 | 74 | 111 | 0.90 | 100 | 114 | 80.0 | 50.3 | 56.4 |
| 16 Dec 65 | 90 | 156 | 1.04 | 162 | 161 | 76.8 | 52.2 | 62.7 |
| 29 Dec 65 | 69 | 123 | 1.02 | 125 | 127 | 85.6 | 47.8 | 57.8 |
| 13 Jan 66 | 82 | 152 | 0.99 | 150 | 156 | 75.8 | 52.4 | 59.6 |
| 27 Jan 66 | 114 | 188 | 1.14 | 214 | 194 | 69.5 | 52.2 | 65.9 |
| 10 Feb 66 | 119 | 181 | 1.06 | 192 | 186 | 66.2 | 50.7 | 60.0 |
| 24 Feb 66 | 169 | 341 | - | - | 351 | 57.4 | 48.4 | 60.7 |
| 10 Mar 66 | 126 | 234 | - | - | 241 | 59.4 | 51.9 | - |

Moisture-Strength-Density Summary

Fort Sherman Satellite Site (Cont'd)

| Date | Cone Index per 6-in. Layer | | Remolding Index (RI), 6 to 12 in. Layer | Rating Cone Index (RCI), 6 to 12 in. From | Soil Moisture per 6-in. Layer | | Dry Density per 6-in. Layer pcf | |
|-----------|-------------------------------|------|---|---|----------------------------------|------|---------------------------------------|------|
| | 0-6 | 6-12 | | | 0-6 | 6-12 | | 0-6 |
| 24 Mar 66 | 247 | 389 | - | - | 47.8 | 43.2 | 60.8 | 64.5 |
| 7 Apr 66 | 153 | 235 | - | - | 58.5 | 50.6 | 51.3 | 62.2 |
| 21 Apr 66 | 79 | 130 | 0.94 | 122 | 70.9 | 59.1 | 51.4 | 60.9 |
| 5 May 66 | 67 | 126 | - | - | 74.7 | 60.7 | 50.4 | 59.6 |
| 19 May 66 | 75 | 137 | - | - | 73.8 | 60.0 | 51.4 | 61.2 |
| 2 Jun 66 | 98 | 179 | 0.98 | 175 | 63.4 | 52.6 | 60.8 | 66.2 |
| 16 Jun 66 | 76 | 141 | - | - | 73.9 | 62.2 | 53.1 | 58.3 |
| 30 Jun 66 | 90 | 154 | 0.99 | 152 | 73.7 | 53.8 | 53.4 | 64.8 |
| 14 Jul 66 | 78 | 136 | - | - | 77.1 | 59.5 | 51.1 | 61.5 |
| 28 Jul 66 | 88 | 149 | - | - | 69.1 | 58.8 | 55.6 | 61.6 |
| 11 Aug 66 | 89 | 177 | - | - | 69.4 | 51.7 | 56.7 | 67.5 |
| 25 Aug 66 | 76 | 142 | - | - | 72.3 | 57.0 | 55.3 | 63.4 |
| 22 Sep 66 | 73 | 142 | 1.00 | 142 | 78.8 | 57.9 | 52.2 | 62.0 |
| 6 Oct 66 | 104 | 189 | - | - | 68.0 | 57.6 | 55.5 | 63.0 |
| 20 Oct 66 | 96 | 169 | - | - | 62.8 | 50.5 | 59.0 | 65.3 |
| 10 Nov 66 | 86 | 164 | - | - | 63.1 | 51.0 | 59.4 | 64.2 |
| 17 Nov 66 | 64 | 121 | 0.96 | 116 | 70.2 | 58.6 | 53.9 | 60.4 |
| 5 Dec 66 | 88 | 147 | - | - | 69.4 | 59.4 | 55.8 | 61.2 |
| 15 Dec 66 | 77 | 165 | - | - | 69.0 | 53.0 | 55.0 | 63.7 |
| 29 Dec 66 | 60 | 137 | - | - | 75.4 | 61.2 | 50.8 | 57.5 |
| 12 Jan 67 | 89 | 162 | - | - | 76.8 | 59.6 | 51.4 | 57.4 |
| 26 Jan 67 | 173 | 303 | - | - | 53.5 | 47.5 | 56.3 | 59.4 |

Soil Moisture Summary
(per three-inch layer)

Albrook Forest Site, Soil Plot No. 1

| Date | Layer | | | | | |
|-----------|-------|------|------|------|-------|-------|
| | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 |
| 2 Feb 65 | 38.1 | 33.7 | 31.4 | 31.4 | 32.0 | 32.3 |
| 9 Feb 65 | 33.3 | 30.1 | 29.7 | 31.0 | 31.1 | 31.5 |
| 16 Feb 65 | 30.9 | 29.2 | 27.7 | 27.7 | 28.1 | 26.0 |
| 23 Feb 65 | 32.4 | 30.7 | 29.8 | 29.6 | 29.9 | 29.9 |
| 2 Mar 65 | 31.1 | 29.3 | 28.4 | 28.3 | 29.2 | 29.2 |
| 9 Mar 65 | 28.9 | 27.9 | 27.3 | 27.7 | 28.1 | 27.9 |
| 16 Mar 65 | 27.8 | 27.2 | 26.3 | 26.8 | 27.1 | 26.8 |
| 23 Mar 65 | 29.7 | 28.4 | 27.2 | 27.8 | 27.7 | 27.4 |
| 30 Mar 65 | 27.4 | 28.2 | 27.4 | 27.5 | 28.6 | 27.8 |
| 6 Apr 65 | 26.5 | 26.0 | 25.9 | 26.0 | 26.3 | 26.6 |
| 13 Apr 65 | 26.9 | 26.2 | 25.8 | 26.4 | 26.6 | 26.7 |
| 20 Apr 65 | 26.2 | 25.9 | 26.0 | 26.4 | 26.4 | 26.3 |
| 27 Apr 65 | 23.9 | 25.5 | 25.6 | 26.1 | 26.3 | 26.8 |
| 4 May 65 | 27.0 | 25.9 | 26.0 | 26.6 | 26.5 | 26.4 |
| 11 May 65 | 41.4 | 36.0 | 32.5 | 30.8 | 29.2 | 30.0 |
| 18 May 65 | 47.2 | 40.3 | 39.0 | 39.4 | 38.2 | 36.5 |
| 25 May 65 | 44.3 | 41.1 | 37.8 | 39.0 | 39.1 | 39.0 |
| 1 Jun 65 | 47.1 | 41.1 | 39.4 | 38.9 | 39.3 | 39.1 |
| 8 Jun 65 | 52.4 | 43.2 | 40.5 | 40.3 | 40.8 | 41.1 |
| 15 Jun 65 | 50.3 | 40.6 | 37.4 | 38.6 | 37.4 | 37.8 |
| 22 Jun 65 | 50.1 | 43.9 | 40.4 | 40.4 | 39.0 | 37.9 |
| 29 Jun 65 | 49.1 | 44.3 | 39.5 | 39.7 | 40.3 | 40.1 |
| 6 Jul 65 | 53.0 | 41.8 | 39.8 | 40.3 | 40.2 | 39.9 |
| 13 Jul 65 | 47.9 | 40.7 | 39.0 | 38.6 | 39.1 | 36.7 |
| 20 Jul 65 | 53.1 | 43.3 | 40.6 | 40.1 | 39.6 | 38.7 |
| 27 Jul 65 | 56.5 | 44.9 | 41.6 | 40.7 | 42.0 | 41.7 |
| 3 Aug 65 | 52.2 | 43.6 | 41.0 | 41.0 | 41.7 | 41.6 |
| 10 Aug 65 | 53.1 | 43.2 | 41.0 | 40.7 | 40.8 | 41.3 |
| 17 Aug 65 | 52.3 | 42.1 | 39.2 | 41.0 | 43.3 | 40.6 |
| 24 Aug 65 | 53.1 | 42.9 | 41.2 | 42.0 | 42.8 | 42.9 |
| 31 Aug 65 | 60.8 | 44.5 | 42.3 | 42.6 | 45.0 | 45.8 |
| 7 Sep 65 | 55.4 | 42.3 | 41.2 | 45.5 | 41.1 | 40.3 |
| 14 Sep 65 | 58.1 | 45.7 | 42.9 | 44.9 | 46.0 | 48.9 |
| 21 Sep 65 | 58.9 | 44.8 | 41.9 | 42.3 | 43.1 | 43.5 |
| 28 Sep 65 | 61.8 | 46.3 | 43.8 | 44.4 | 45.3 | 43.1 |
| 5 Oct 65 | 55.8 | 43.6 | 41.3 | 42.6 | 43.9 | 44.2 |
| 12 Oct 65 | 61.3 | 46.9 | 45.2 | 43.6 | 47.7 | 47.4 |
| 19 Oct 65 | 62.0 | 47.3 | 45.2 | 49.9 | 47.1 | 47.2 |
| 26 Oct 65 | 64.1 | 46.2 | 41.2 | 40.9 | 43.6 | 44.6 |
| 2 Nov 65 | 59.7 | 44.2 | 41.2 | 41.3 | 41.1 | 38.3 |

Soil Moisture Summary
(per three-inch layer)

Albrook Forest Site, Soil Plot No. 1 (Cont'd)

| Date | Layer | | | | | |
|-----------|-------|------|------|------|-------|-------|
| | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 |
| 9 Nov 65 | 61.9 | 46.9 | 43.2 | 43.8 | 47.3 | 50.6 |
| 16 Nov 65 | 57.0 | 43.8 | 42.9 | 44.0 | 43.3 | 42.1 |
| 23 Nov 65 | 59.5 | 46.8 | 43.7 | 43.7 | 45.6 | 46.3 |
| 29 Nov 65 | 67.3 | 45.8 | 41.5 | 41.9 | 46.1 | 46.8 |
| 7 Dec 65 | 64.6 | 46.5 | 43.5 | 43.5 | 45.0 | 46.3 |
| 14 Dec 65 | 64.7 | 46.5 | 43.6 | 43.8 | 46.8 | 49.5 |
| 22 Dec 65 | 66.3 | 45.5 | 42.6 | 42.9 | 41.7 | 45.5 |
| 27 Dec 65 | 55.5 | 43.6 | 40.4 | 41.2 | 41.7 | 41.1 |
| 4 Jan 66 | 59.6 | 42.6 | 39.7 | 39.1 | 38.9 | 38.3 |
| 11 Jan 66 | 57.7 | 44.7 | 41.6 | 41.1 | 41.7 | 41.9 |
| 18 Jan 66 | 55.8 | 45.2 | 40.0 | 38.9 | 39.8 | 39.5 |
| 25 Jan 66 | 46.3 | 39.6 | 37.4 | 41.4 | 38.4 | 37.9 |
| 8 Feb 66 | 47.5 | 31.8 | 30.1 | 30.5 | 31.6 | 30.5 |
| 21 Feb 66 | 31.6 | 39.9 | 30.6 | 28.7 | 30.8 | 29.8 |

Soil Moisture Summary
(per three-inch layer)

Chiva Chiva Site, Soil Plot No. 1

| Date | Layer | | | | | |
|-----------|-------|------|------|------|-------|-------|
| | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 |
| 3 Feb 65 | 17.8 | 18.7 | 18.8 | 18.9 | 21.0 | 21.9 |
| 9 Feb 65 | 19.1 | 19.4 | 19.1 | 19.9 | 20.6 | 21.6 |
| 17 Feb 65 | 18.0 | 17.7 | 17.7 | 19.1 | 20.7 | 22.6 |
| 24 Feb 65 | 18.3 | 18.7 | 18.4 | 19.1 | 21.8 | 22.4 |
| 3 Mar 65 | 17.3 | 18.9 | 18.8 | 20.1 | 21.9 | 23.2 |
| 10 Mar 65 | 17.1 | 18.2 | 18.5 | 19.8 | 22.1 | 23.0 |
| 17 Mar 65 | 16.2 | 18.2 | 17.4 | 17.5 | 18.7 | 19.3 |
| 24 Mar 65 | 16.9 | 18.6 | 18.3 | 19.4 | 21.1 | 22.6 |
| 31 Mar 65 | 14.8 | 16.7 | 16.4 | 17.2 | 18.3 | 17.9 |
| 7 Apr 65 | 15.2 | 16.9 | 17.6 | 18.8 | 18.2 | 18.8 |
| 14 Apr 65 | 15.2 | 17.1 | 17.3 | 18.3 | 19.1 | 19.8 |
| 21 Apr 65 | 14.1 | 16.4 | 16.7 | 18.4 | 22.6 | 20.3 |
| 28 Apr 65 | 14.8 | 16.9 | 17.0 | 19.2 | 20.0 | 19.6 |
| 5 May 65 | 18.5 | 18.7 | 18.1 | 19.4 | 21.1 | 21.9 |
| 12 May 65 | 38.3 | 34.5 | 31.1 | 30.6 | 30.7 | 29.7 |
| 19 May 65 | 36.3 | 30.7 | 30.1 | 30.3 | 30.7 | 32.2 |
| 26 May 65 | 38.3 | 33.7 | 31.8 | 32.9 | 32.4 | 31.8 |
| 2 Jun 65 | 39.6 | 35.7 | 33.1 | 32.7 | 33.8 | 35.1 |
| 9 Jun 65 | 41.9 | 35.1 | 31.7 | 31.7 | 34.5 | 34.5 |
| 16 Jun 65 | 37.5 | 35.6 | 30.6 | 30.7 | 32.4 | 33.5 |
| 23 Jun 65 | 42.9 | 35.3 | 31.0 | 31.1 | 32.6 | 34.2 |
| 30 Jun 65 | 42.4 | 34.6 | 31.4 | 32.8 | 35.6 | 35.1 |
| 7 Jul 65 | 44.0 | 33.4 | 30.9 | 31.4 | 33.6 | 33.6 |
| 14 Jul 65 | 34.0 | 30.8 | 30.2 | 30.7 | 31.1 | 32.2 |
| 21 Jul 65 | 43.5 | 34.9 | 31.6 | 31.8 | 31.4 | 32.6 |
| 28 Jul 65 | 45.7 | 36.5 | 32.7 | 32.2 | 34.2 | 34.6 |
| 4 Aug 65 | 45.3 | 33.6 | 30.5 | 31.1 | 32.5 | 32.9 |
| 11 Aug 65 | 48.4 | 37.2 | 33.2 | 33.9 | 35.9 | 36.7 |
| 18 Aug 65 | 45.4 | 33.6 | 31.9 | 31.6 | 31.9 | 33.8 |
| 25 Aug 65 | 47.9 | 37.2 | 34.3 | 32.6 | 33.2 | 34.5 |
| 1 Sep 65 | 46.9 | 35.8 | 32.3 | 32.5 | 35.2 | 39.6 |
| 8 Sep 65 | 45.8 | 37.2 | 33.0 | 33.1 | 34.4 | 36.4 |
| 15 Sep 65 | 50.3 | 35.6 | 31.2 | 34.0 | 39.3 | 42.1 |
| 22 Sep 65 | 51.8 | 39.4 | 34.0 | 40.6 | 44.7 | 49.6 |
| 29 Sep 65 | 51.4 | 37.7 | 33.5 | 32.7 | 34.1 | 35.4 |
| 6 Oct 65 | 42.4 | 34.1 | 31.6 | 32.4 | 33.7 | 30.6 |
| 13 Oct 65 | 54.7 | 39.1 | 33.1 | 34.0 | 38.0 | 39.5 |
| 20 Oct 65 | 51.3 | 37.1 | 32.0 | 33.6 | 35.2 | 35.7 |
| 27 Oct 65 | 45.1 | 34.5 | 31.6 | 34.3 | 32.9 | 35.7 |
| 4 Nov 65 | 51.6 | 34.4 | 33.0 | 32.4 | 36.9 | 39.5 |

Soil Moisture Summary
(per three-inch layer)

Chiva Chiva Site, Soil Plot No. 1 (Cont'd)

| Date | Layer | | | | | |
|-----------|-------|------|------|------|-------|-------|
| | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 |
| 10 Nov 65 | 55.1 | 40.6 | 34.7 | 36.3 | 41.0 | 51.8 |
| 17 Nov 65 | 51.0 | 38.2 | 35.0 | 33.7 | 35.4 | 36.6 |
| 24 Nov 65 | 55.6 | 45.3 | 43.9 | 45.0 | 46.4 | 45.5 |
| 1 Dec 65 | 53.4 | 38.3 | 35.3 | 34.1 | 36.9 | 51.3 |
| 8 Dec 65 | 53.9 | 39.2 | 34.6 | 33.6 | 33.8 | 35.9 |
| 15 Dec 65 | 51.7 | 37.3 | 33.1 | 32.9 | 35.7 | 36.7 |
| 22 Dec 65 | 52.2 | 38.3 | 32.6 | 32.6 | 34.1 | 42.6 |
| 28 Dec 65 | 39.9 | 30.8 | 28.7 | 29.0 | 31.8 | 31.7 |
| 5 Jan 66 | 40.0 | 34.7 | 31.6 | 33.0 | 33.2 | 33.1 |
| 12 Jan 66 | 45.9 | 34.8 | 30.3 | 30.1 | 30.9 | 31.4 |
| 19 Jan 66 | 39.0 | 30.4 | 27.3 | 27.8 | 28.8 | 34.2 |
| 26 Jan 66 | 35.7 | 29.1 | 26.3 | 26.6 | 28.8 | 28.9 |
| 9 Feb 66 | 24.8 | 19.1 | 21.1 | 25.8 | 22.5 | 22.5 |
| 23 Feb 66 | 21.7 | 21.2 | 20.2 | 19.9 | 22.0 | 22.9 |
| 9 Mar 66 | 20.4 | 19.8 | 19.7 | 20.4 | 23.3 | 23.8 |

- APPENDIX B -

SEED STABILITY AND GERMINATION, AND CHARACTERISTICS OF SOME
SEEDLINGS OF TROPICAL FOREST TREES

Seed Stability and Germination, and Characteristics of Some Seedlings of Tropical Forest Trees*

Introduction

A limited study of seeds and seedlings was made to establish facts about seed stability and seedling characteristics for some of the most frequently encountered tree species in the Canal Zone. The ripe seeds of some tropical forest trees fall on moist earth or into forest litter and germinate almost immediately. Other seeds appear to remain dormant indefinitely, even in moist soil or wet forest litter. Salisbury⁽²⁵⁾ reported a highly variable tendency for seeds to germinate immediately after falling.

Methods of Study

The collectors of vegetation specimens for the Tropic Test Center Data Base herbarium made collections of ripe seeds or fruits, as they were found. The seeds and fruits were placed in paper bags numbered to correspond with the parent plant. Some specimens of each specie of seed were planted in paper cups filled with vermiculite. Developing seedlings were allowed to grow until growth ceased, at which time the seedlings were pressed, dried, and mounted for retention in the herbarium. Other specimens were placed in storage for subsequent examination.

Results

Ripe seeds from 221 species of trees and shrubs were collected. Ninety, or 41 percent, of the collected seeds germinated and produced seedlings of some size. Seeds which failed to germinate usually rotted after standing for eight to ten weeks in the moist vermiculite. Planted seeds which remained hard and bright for ten weeks were scored and further tested for ability to germinate. Scoring always resulted in swelling and rapid decay of the seed. In no instance did scoring produce germination.

In addition to germination tests the collected seeds were stored for six months and observed for stability of the seed during a storage period. Of the 90 seed species which germinated, 38, (42 percent) remained hard and bright after storage. On the other hand only 36 of 131 seeds (27 percent), of the species which failed to germinate remained hard and bright after storage. The remainder of the seeds had completely decayed after six months.

Table B is a listing, by family, of the species included in the seed germination test. The number of specimens whose seeds were successfully

* This section has been prepared by Dr. Robert Hutton, Biologist, and Dr. Edwin Tyson. The assistance of Elinor V. Hutton is acknowledged.

germinated and/or stored for six months without deterioration, as well as the number of individuals of each species observed is indicated.

TABLE B. GERMINATION AND STORAGE OF TROPICAL FOREST SEEDS
Successful storage based on retention of form for six months

| Family | Genus-Species | Collector's No. | Successful Germination | Storage | Number of Separate Collections Observed |
|-------------------|---------------------------|-----------------|------------------------|---------|---|
| ANACARDIACEAE | Anacardium occidentale | 3573 | 1 | 1 | 1 |
| ANNONACEAE | Unonopsis | 3486 | | 1 | 1 |
| | Annona | 4548 | | 1 | 1 |
| APOCYNACEAE | | 3910 | 1 | | 1 |
| ARACEAE | | 3954 | 1 | | 1 |
| | | 3983 | 1 | | 1 |
| | | 4486 | 1 | | 1 |
| | | 4494 | | | 1 |
| | 4498 | | | 1 | |
| ARISTOLOCHINACEAE | Aristolochia maxima | 4179 | 1 | 1 | 1 |
| BIGNONIACEAE | Crescentia cujete L | 3797 | 1 | 1 | 2 |
| | Tecoma Stans L./Juss | 3569 | | | 1 |
| | Tabebuia | 4456 | 1 | 1 | 1 |
| BIXACEAE | Bixa orellana | 4223 | 1 | 1 | 2 |
| BOMBACACEAE | | B2239 | 1 | 1 | 1 |
| | Ochroma limonensis Rowlee | 3676 | | 1 | 1 |
| BORAGINACEAE | Cordia alba | 4289 | | | 1 |
| BURSERACEAE | Bursera semiruba Sarg. | 3542 | 1 | | 1 |
| CANNACEAE | Canna | 4677 | | 1 | 1 |

| Family | Genus-Species | Collector's No. | Successful Germination | Storage | Number of Separate Collections Observed |
|------------------|--|-----------------|------------------------|---------|---|
| CAPRIFOLIACEAE | | B2630 | | | 1 |
| COCHLOSPERMACEAE | Cochlospermum vitifolium (Willd) Spreng. | 3557 | | 1 | 1 |
| CAESALPINIACEAE | Cassia fistulosa L | 3469 | 1 | 1 | 1 |
| | Rauhinis | 4006 | 1 | | 1 |
| | Hymenaea | 4268 | | | 1 |
| COMPOSITAE | Veronia canescens HBK | 3477 | | | 1 |
| | | 3903 | | | 1 |
| | | 3923 | | | 1 |
| | | 3974 | | 1 | 1 |
| | Eupatorium odoratum L. | 3793 | 1 | | 1 |
| CONNARACEAE | Cnestidium rufescens Planch | 3571 | | 1 | 1 |
| | Connarus williamsii Britton | 3829 | 1 | | 1 |
| CLUSIACEAE | Rheedia | 3721 | 1 | 1 | 1 |
| | Clusia | 3964 | 1 | 2 | 2 |
| | Clusia | 4357 | | | |
| CUCURBITACEAE | Luffa cylindrica L. | 3606 | | 1 | 1 |
| CYCLANTHACEAE | | 4359 | | | 1 |
| DILLENIACEAE | Curatella americana | B2237 | 1 | | 1 |
| | Davilla aspera | 3616 | 1 | | 1 |
| | | 3790 | | 1 | 1 |
| | Tertacera volubilis | 3480 | | 1 | 1 |
| EUPHORBIACEAE | Latropha | 3955 | | | 1 |
| | Ricinus communis | 4129 | | 1 | 1 |

| Family | Genus-Species | Collector's No. | Successful Germination | Storage | Number of Separate Collections Observed | |
|----------------|------------------------------------|-----------------------------------|------------------------|---------|---|---|
| FABACEAE | <i>Erythrina rubrinervia</i> | B2238 | 1 | | | |
| | <i>Erythrina costaricensis</i> | B2440-A 3724 | 1 | 1 | 2 | |
| | <i>Ormosia coccinea</i> | 3472 | 1 | 1 | 1 | |
| | <i>Indigofera panamensis</i> | 3474 | | | 1 | |
| | <i>Cajanus bicolor</i> | 3551 | 1 | | 1 | |
| | <i>Gliricidium sepium</i> | 3626 3723 3781 | 2 | 1 | 3 | |
| | <i>Flemingia strobilifera</i> | 3752 | 1 | 1 | 1 | |
| | <i>Securidaca diversifolia</i> | 3757 | 1 | 1 | 1 | |
| | <i>Dioclea</i> | 3926 | 1 | 1 | 1 | |
| | FLACOURTIACEAE | <i>Casearia arguta</i> | 3730 | | | 1 |
| | | <i>Xilosma panamensis</i> | 3771 | | | 1 |
| | LOGANIACEAE | <i>Strychnos panamensis</i> Seem. | 3570 | | 1 | 1 |
| | LYTHRACEAE | <i>Adendria floribunda</i> | 3751 | | | 1 |
| MALPHIGHIACEAE | <i>Serjania mexicana</i> (L.) | 3479 | | | 1 | |
| | <i>Heteropteris</i> | 3654 | 1 | 1 | 1 | |
| | <i>Bunchosia cornifolia</i> H.B.K. | 3795 | | | 1 | |
| MALVACEAE | <i>Hibiscus tiliaceus</i> L. | 3539 | 1 | 1 | 1 | |
| | | 3778 | | 1 | 1 | |
| MELASTOMACEAE | <i>Miconia</i> | B2296 3782 | | | | |
| | | 4728 4770 | | 1 | 4 | |
| | <i>Miconia cf. prasina</i> | 3534 4043 | | | 2 | |
| | <i>Miconia argentia</i> (Sw.) | 3709 | | | 1 | |
| | <i>Clidemia rubra</i> | 3763 4322 | | | 2 | |
| | | 3806 | | 1 | 1 | |
| | | 3862 | | | 1 | |
| | 3968 | | | 1 | | |
| | 4064 | | | 1 | | |

| Family | Genus-Species | Collector's No. | Successful Germination | Storage | Number of Separate Collections Observed |
|------------------------|-------------------------------------|-----------------|------------------------|---------|---|
| MELASTOMACEAE (Cont'd) | <i>Miconia impetiolaris</i> | 4117 | 1 | | 1 |
| | | 4516 | | | 1 |
| | <i>Miconia lacera</i> Humb. & Bond. | 4550 | 1 | | 1 |
| MIMOSACEAE | <i>Enterolobium Cyclocarpum</i> | 3663 | | | 1 |
| | <i>Inga</i> | 3665 | 1 | 1 | 1 |
| | <i>Cassia undulata</i> | 3762 | 1 | 1 | 1 |
| | | 3464 3575 | | | 2 |
| MORACEAE | <i>Ficus</i> | 3485 | | | 1 |
| | <i>Ficus benjamina</i> L. | 4018 | 1 | | 1 |
| | <i>Ficus obtusifolia</i> H.B.K. | 4124 4142 | | | 2 |
| | <i>Ficus insipida</i> Willd. | | | | 2 |
| MYRSINACEAE | <i>Ardisia</i> | 3605 3735 | 2 | 1 | 2 |
| MYRTACEAE | <i>Psidium guajaval</i> | 3630 | 1 | 1 | 1 |
| | <i>Eugenia</i> | 4333 | 1 | | 1 |
| | <i>Eugenia malaccensis</i> | 4514 | | | 1 |
| | <i>Neea laetevirens</i> | 4141 | | | 1 |
| ONAGRACEAE | <i>Fuchsia</i> | B2429 | | | 1 |
| PHOENICACEAE | | 4491 | 1 | | 1 |
| PINGUICULACEAE | <i>Utricularia pusilla</i> Vahl. | 2471 | | 1 | 1 |
| PIPERACEAE | <i>Piper aduncum</i> | B2442 | | | 1 |
| | <i>Piper tuberculatum</i> Jacq. | 3562 | 1 | | 1 |
| | | 3765 3766 3890 | | | |
| | | 3933 3949 3953 | | | |
| | | 4067 4087 4714 | 2 | | 9 |

| Family | Genus-Species | Collector's No. | Successful Germination | Storage | Number of Separate Collections Observed |
|--------------------|---|-----------------|------------------------|---------|---|
| RHAMNACEAE | <i>Cotenva</i> | 3558 | 1 | 1 | 1 |
| ROSACEAE | <i>Hirtella racemosa</i> Sw. | 3713 | 1 | | 1 |
| RUBIACEAE | <i>Alibertia edulis</i> | 3734 | 1 | 1 | 1 |
| | <i>Psychotria undata</i> | 3787 | 1 | | 1 |
| | <i>Genipa americana</i> L. | 4009 | 1 | 1 | 1 |
| | <i>Amiouna corymbosa</i> | 3951 | | | 1 |
| | <i>Palicourea guineensis</i> | 4061 | 1 | 1 | 1 |
| | | 4368 | | 1 | 1 |
| SAPINDACEAE | | B2345 | 1 | | 1 |
| | <i>Sapindus saponaria</i> L. | 3481 | | 1 | 1 |
| | <i>Serjania</i> | 3568 | 2 | 2 | 3 |
| | <i>Allophylus occidentalis</i> (Sw.) | 4283 | 1 | 1 | 1 |
| | <i>Talisia</i> | 4336 | | | 1 |
| | | 4540 | 1 | | 1 |
| SAPOTACEAE | | 4671 | 1 | 1 | 1 |
| SOLANACEAE | | B2292 | | | 1 |
| | <i>Solanum diversifolia</i> | 4479 | 1 | | 3 |
| | <i>Schlecht</i> | 3584 | | | 1 |
| | | 3942 | | | 1 |
| | | 4079 | 1 | | 1 |
| TILIACEAE | <i>Apeiba tibourbou</i> Aubl. | 3555 | 1 | 1 | 1 |
| | <i>Belotia panamensis</i> Pittier | 3705 | | | 1 |
| | <i>Luehea seemannii</i> Triana & Planck | 3887 | 1 | | 1 |
| VERBENACEAE | <i>Tectona grandis</i> L. | 2791 | | | 1 |
| | <i>Citharexylum caudatum</i> | 3780 | | 1 | 1 |

| Family | Genus-Species | Collector's No. | Successful Germination | Storage Collections Observed | Number of Separate Collections Observed |
|--------------------------|----------------|-----------------|------------------------|------------------------------|---|
| VERBENACEAE (Cont'd) | | | | | |
| | Lantana camara | 4105 | 1 | | 1 |
| VITACEAE | | 3874 | | | 1 |
| | Cissus | 4659 | | | 1 |
| VIOLACEAE | | 3830 | | | 1 |
| SPECIMENS NOT CLASSIFIED | | | | | |
| | | ----- | 30 | 15 | 77 |
| <hr/> | | | | | |
| Number of observations | | | 90 | 71 | 221 |
| Per cent of total | | | 41 | 32 | |

The difficulty in identifying seedlings and in relating them to mature trees has been recognized. Richards⁽²⁶⁾ cites "very striking differences in the form and structure of the leaves (and often their arrangement) between young and mature individuals of tree". Seedlings developing from collected seeds for the current study differed greatly from the mature forms in both structure and arrangement. Figures B-1 through B-15, which show paired photographs of seedlings and the herbarium specimens of mature plants, are provided to illustrate these differences.

Observations

The work reported here answers few, if any, questions about forest ecology. On the other hand, some of the problems and difficulties associated with work in the tropical forest are made apparent. For example:

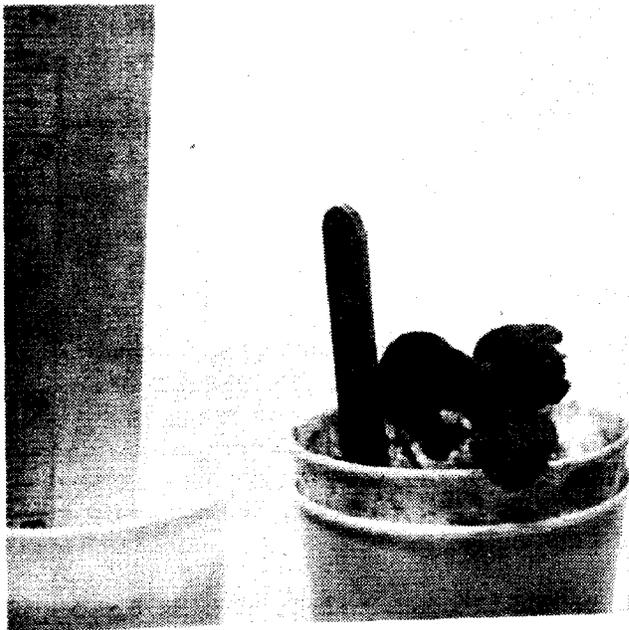
a. Progressive changes in leaf form and plant structure as plants age, preclude the development and use of any known form of dichotomous key based on vegetative characteristics of individuals.

b. Without prior observations to establish the relationships between seeds, seedlings, and mature trees, any attempt to observe processes of forest succession would be almost impossible.

c. Times of germination and rates of growth of seedlings maintained under artificial conditions do not parallel the behavior of seeds and seedlings in the natural environment.

Much more should be known about the behavior of tree seeds in tropical forest environments. These attempts to grow seedlings in pots indicate strongly that seed germination is influenced by interactions between the seed and the forest environment. Adequate knowledge of factors important in tropical forest ecology should include known facts on the effect of light, heat, moisture, acidity, and reaction to microorganisms. Larger animal forms may also play a part in seed behavior as well as dispersal. Bird or other animal passage may influence both germination and dispersal. Insect "damage" could cause an otherwise dormant seed to germinate. A number of these factors are more or less influenced by human activity.

Continued work might well have long-range importance to the military. The defoliation of forested areas will greatly disturb normal processes of forest succession because growth requiring abundant light will be abnormally encouraged. The effects of fire will have direct bearing on seed germination as well as an indirect influence through forest floor and canopy changes.



Photographed 4 months 10 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: VERAGUAS
MYRSINACEAE
Ardisia.

Canazas, in brush forest.
12' tall, 3" dbh, fruit black.

Coll. Edwin L. Tyson.

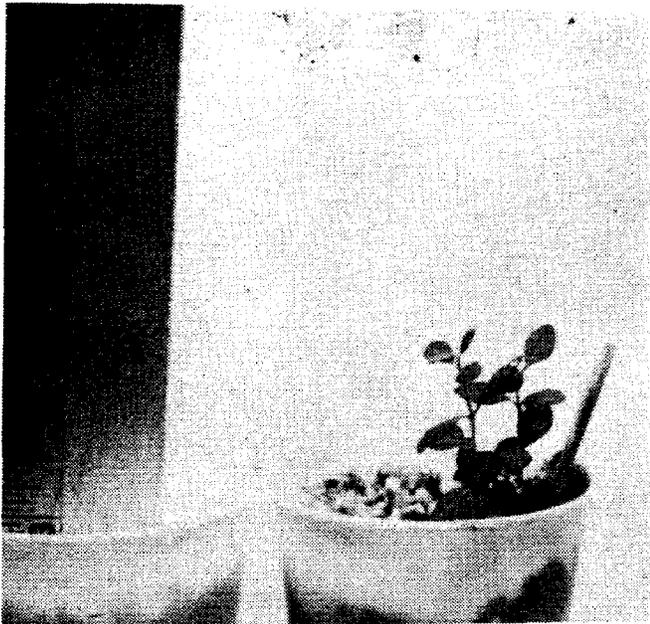
Det.

Seedling Photo: E. Hutton.

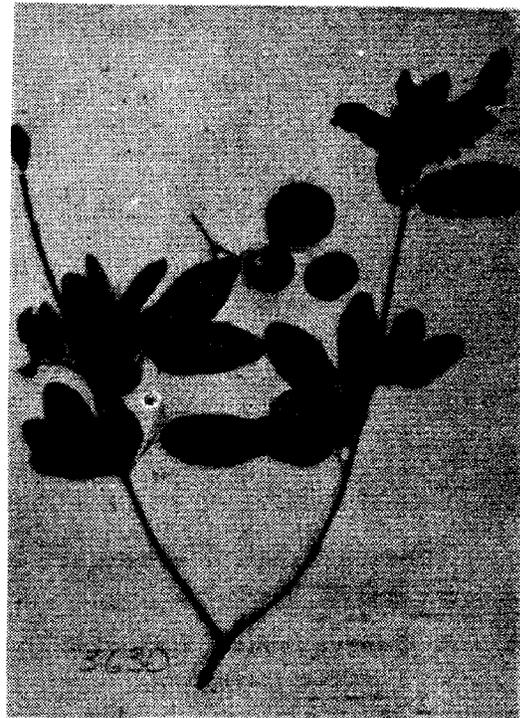
No. 3605

ETC-RE Label 1
1 Apr 67

FIGURE B-1. SPECIMEN NO. 3605



Photographed 4 months 11 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: VERAGUAS
MYRTACEAE
 Psidium guajava L.

Canazas.
20' tall, 6" dbh, fruit yellow.

Coll. Edwin L. Tyson.

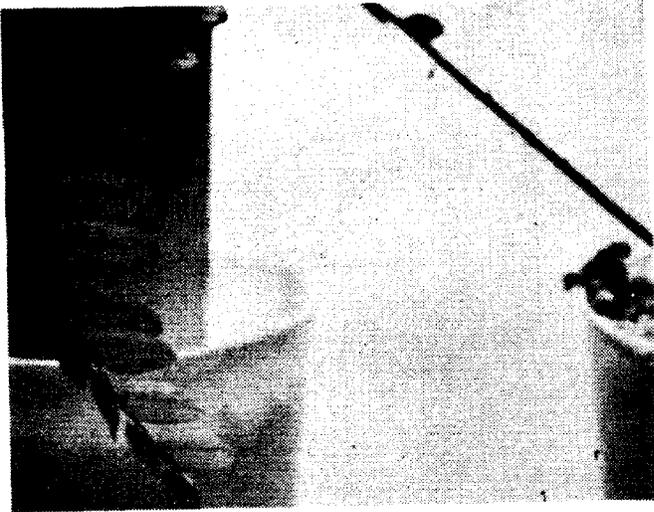
Det. J.D. Dwyer.

Seedling Photo: E. Hutton.

No. 3630

ETC-RE Label 1
1 Apr 67

FIGURE B-2. SPECIMEN NO. 3630



Photographed 4 months 12 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: CANAL ZONE
LYTHRACEAE
Adenaria floribunda HBK.

Road from Fort Sherman to Fort San Lorenzo.
8' tall, flowers white, primary succession.

Coll. Edwin L. Tyson & Kurt E. Blum. (Shrub.)

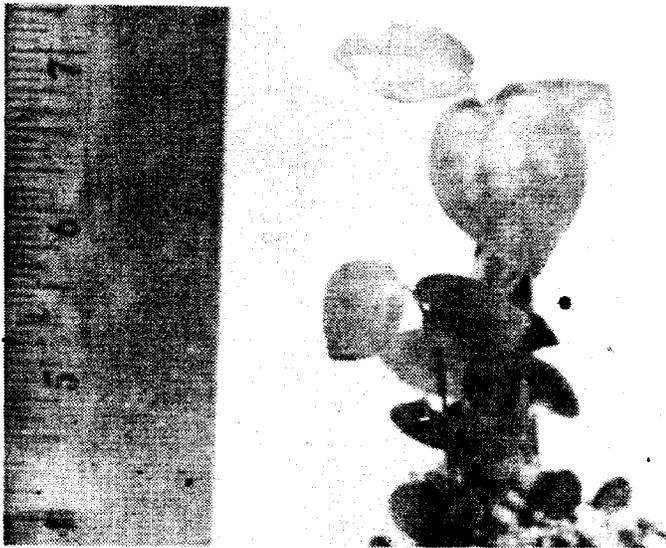
Det. J.D. Dwyer, 1966.

Seedling Photo: E. Hutton.

No. 3751

ETC-RE Label 1
1 Apr 67

FIGURE B-3



Photographed 4 months 11 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: CANAL ZONE
PIPERACEAE
Piper

Fort Clayton, old hospital area.
10' tall, many stemmed, plant bell-shaped.

Coll. Edwin L. Tyson & Kurt E. Blum.

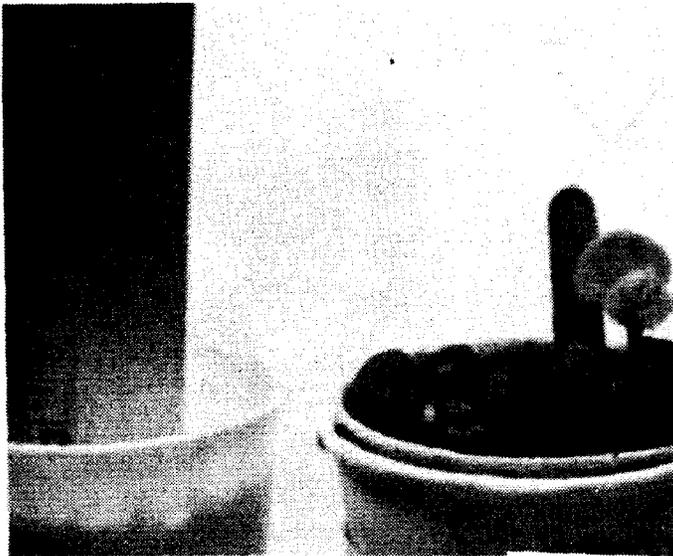
Det.

Seedling Photo: E. Hutton.

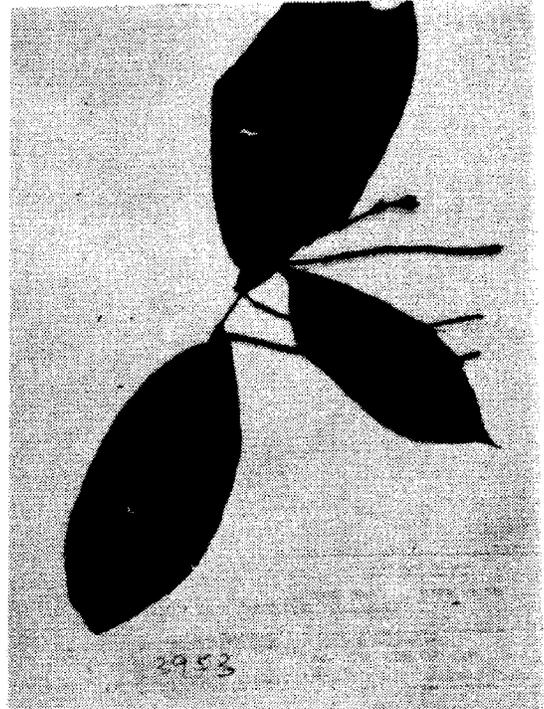
No. 3890

ETC-RE Label 1
1 Apr 67

FIGURE B-4



Photographed 3 months 29 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: CANAL ZONE
PIPERACEAE
Piper.

12 miles S. Colon on Rio Providencia.
8' tall, forest shade.

Coll. Edwin L. Tyson & Kurt E. Blum.

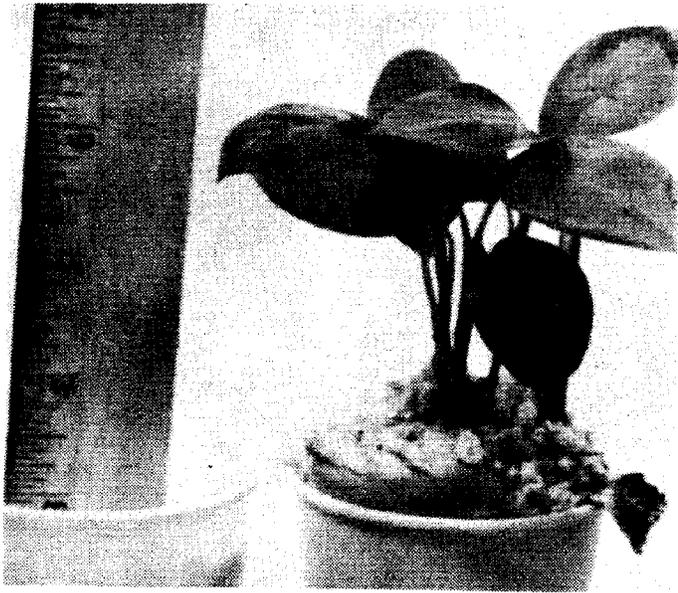
Det.

Seedling Photo: E. Hutton.

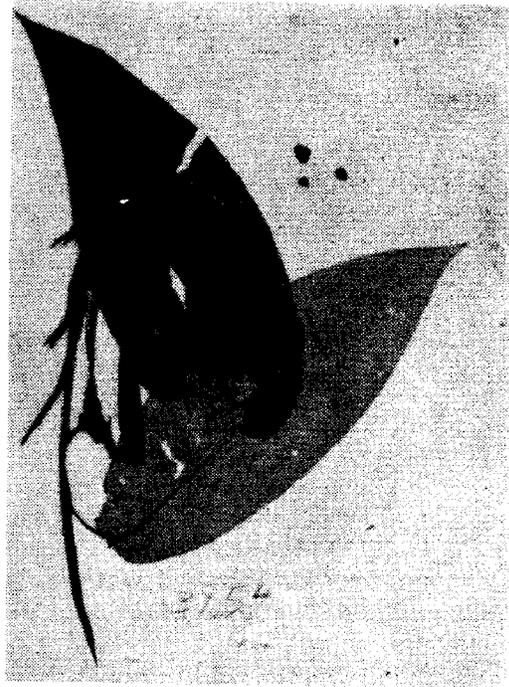
No. 3953

ETC-RE Label 1
1 Apr 67

FIGURE B-5



Photographed 4 months 5 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA

PROVINCE: CANAL ZONE

ARACEAE

12 miles S. Colon on Rio Providencia.
3' tall, deep shade, fr. orange.

Coll. Edwin L. Tyson & Kurt E. Blum.

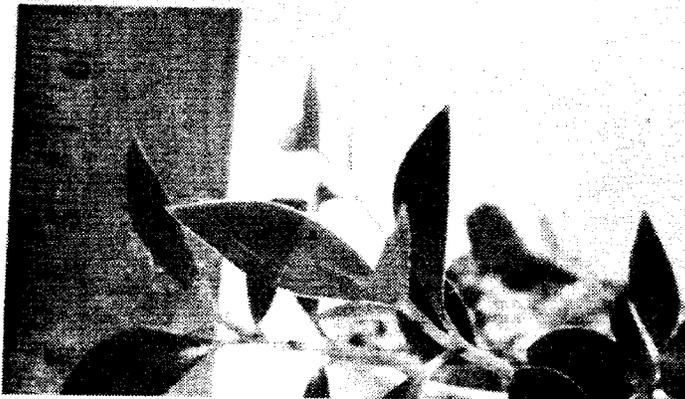
Det.

Seedling Photo: E. Hutton.

No. 3954

FIGURE B-6

B-15



Photographed 3 months 28 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: PANAMA

CLUSIACEAE

Clusia.

One mile S. El Valle, 2500' elevation.
15' tall, 3" dbh, fruit red-brown, sap milky.

Coll. Edwin L. Tyson, F.R. Fosberg et al.

Det.

No. 3964

Seedling Photo: E. Hutton.

ETC-RE Label 1
1 Apr 67

FIGURE B-7



Photographed 3 months 16 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: CANAL ZONE
MORACEAE
Ficus obtusifolia HBK.

Curundu near gate to Panama City.
60' tall, 20" dbh. Tree spreading from low
Coll. Edwin L. Tyson. (limbs.)

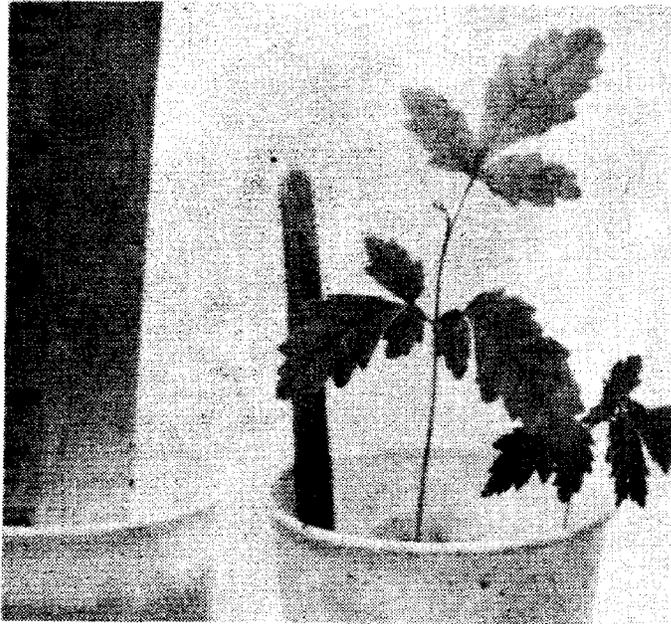
Det. Seedling Photo: E. Hutton.

No. 4018

ETC-RE Label 1
1 Apr 67

FIGURE B-8

B-17



Photographed 1 month 26 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA

PROVINCE: VERAGUAS

SAPINDACEAE

Allophylus Occidentalis (Sw.) Radkl.

5 miles E. Santiago.

Shrub 10' tall, fruit orange.

Coll. Edwin L. Tyson, C. Kupfer & H. Smith.

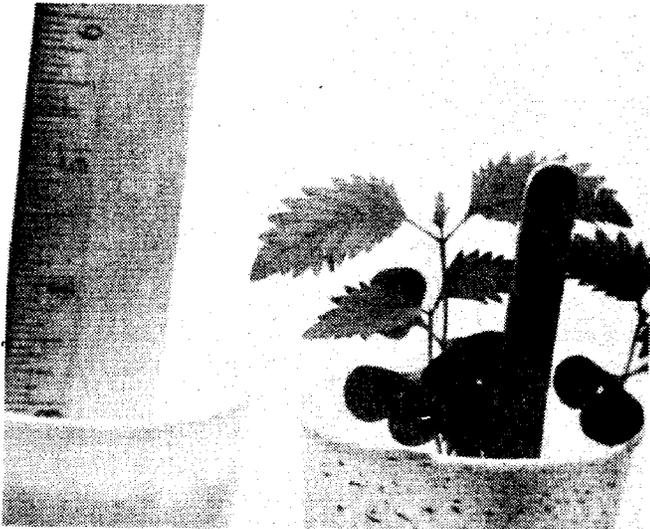
Det.

No. 4283

Seedling Photo: E. Hutton.

ETC-RE Label 1
1 Apr 67

FIGURE B-9



Photographed 1 month 26 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA PROVINCE: CANAL ZONE

BIGNONIACEAE

Tabebuia.

Tree 35' tall; inflorescence yellow flowers
with corolla yellow at base dull carmine red at
apex, fruits brown; Curundu Survival School
(Area.

Coll. Edwin L. Tyson, J.D. Dwyer.

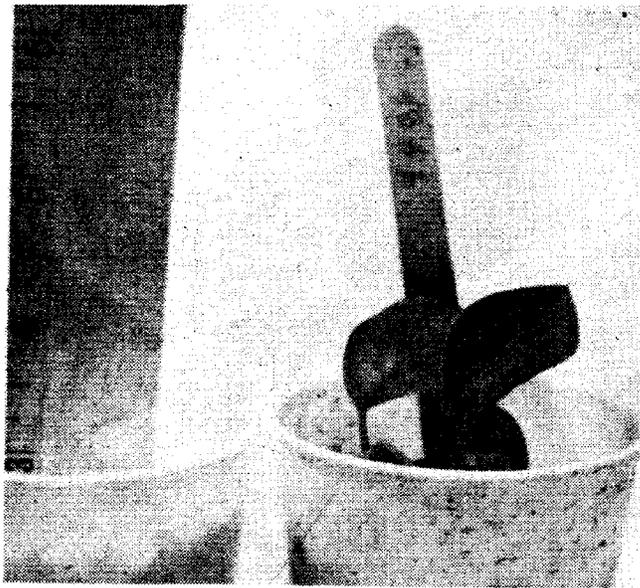
Det.

Seedling Photo: E. Hutton.

No. 4456

ETC-RE Label 1
1 Apr 67

FIGURE B-10



Photographed 1 month 26 days
after planting



US ARMY TROPIC TEST CENTER
Fort Clayton, Canal Zone

COUNTRY: PANAMA
ARACEAE

PROVINCE: CANAL ZONE

2' tall. Fruits bright red.
12 miles S. Colon.

Coll. Edwin L. Tyson, J.D. Dwyer & Kurt E. Blum.

Det.

Seedling Photo: E. Hutton.

No. 4486

ETC-RE Label 1
1 Apr 67

FIGURE B-11

VEGETATION INVENTORY*

An inventory of live shrubs and trees present in the Albrook Forest Observational Site (17PPV 602964) was prepared in June 1965. The inventory showed graphically the location of trees and shrubs within a square divided into 36 10-by-10-meter plots. The inventory was repeated in June 1966 and the revised tabulations were published as an appendix to Semi-annual Report # 1 and 2, Environmental Data Base for Regional Studies in the Humid Tropics, dated October 1966.

The format of this second revision of the inventory which was completed in January 1967 was changed and all entries consist of numbers arranged in tabular form. Location of trees and shrubs, girth at 120 cm. above ground, height to first branch, and overall height are all listed numerically under appropriate tabular headings. Trees are also grouped numerically, by reference to numbered drawings, into seven representative shapes. The change of format of the inventory enables accumulation of more information with equal or less effort and will permit machine analyses of accumulated data to reveal the occurrence of growth, emergence of new specimens, and other changes which take place with passage of time.

The first page of the inventory is a topographic map of the 60-by-60-meter grid of the observational area. Corners of the 36 10-by-10-meter plots within the area have letter-number designations to locate the position and orientation of the plot within the grid. Letters and numbers indicate north-south and east-west locations respectively.

Pages immediately following the map contain names of the more common species of trees found in the area. The approximate coverage of the high and middle canopies is indicated in the diagrams which follow the list of names. Each of the 36 tables which follow the diagrams contain information about one 10-by-10-meter plot. Each table is numbered to permit its identification within the grid area. For example, the first table G7G6F7F6 represents the upper left hand plot in the grid. Numbers in the "X-Y" column are keyed according to the scheme shown here (in which two trees from the first table, G7G6F7F6, are plotted).

The description of the Cecropia tree above is continued in succeeding columns of the referenced table. Shape III is in reference to the seven (I through VII) representative drawings found at the back of the inventory. DBH CM indicates diameter in centimeters at breast height (120 cm. above ground); height to first branch and height overall are given in meters.

Blanks were left in the tables for entry of information which can be

* Prepared by Dr. Robert S. Hutton; Biological Scientist. Topographic map, canopy sketches, and list of trees are from second edition of Vegetation Inventory prepared by Hutton and Tyson.

obtained from the earlier inventory.

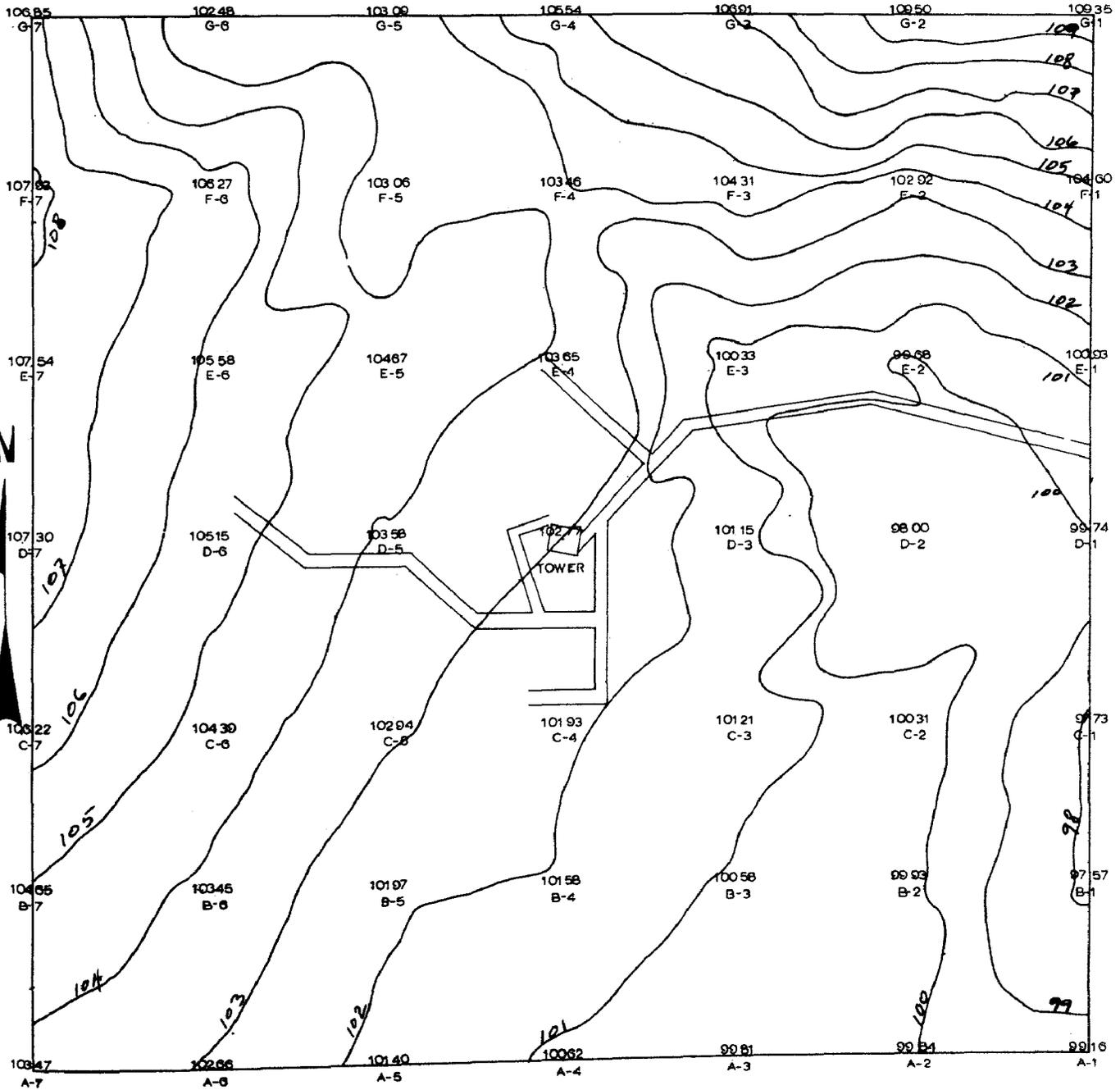
The Locator is intended to serve several purposes:

a. Copies are available for observers or visitors for use as required.

b. A master copy will be maintained to record notes concerning phenological events and corrections that are found necessary. Further revisions will be made as the need arises but will not necessarily be at regular intervals.

c. Copies will be provided to any investigator wishing to use the site to record location of points of interest and points that are not to be disturbed by other investigators.

Users are requested to furnish significant observations. Observations will be placed on the master copy as soon as received and will be included in revisions.



Grid Orientor
 Grid Stake Locations
 Ground Contours: 1 ft. interval
 Elevation in feet

10 Meters

List of Trees and Small Trees over One Inch in Diameter.

- Anacardium excelsum* (Bert. + Balb.) Sheels. (Anacardiaceae)
Alibertia edulis (L. Rich) A. Rich (Rubiaceae)
Andira enermis H.B.K. (Fabaceae)
Annona (1) *hayessii* Suff. (Annonaceae)
Annona (2) *purpurea* Moc. + Sessi (Annonaceae)
Aphelandra deppeana Schlecht. + Cham (Acanthaceae)
Bactris balanoidea (Oerst.) Wndl. (Phoenicaceae)
Banara guianensis Aubl. (Flacortiaceae)
Belotia panamensis Pittier (Tiliaceae)
Bursera simaruba Sarg. (Burseraceae)
Cavanillesia platanifolia H.B.K. (Bombacaceae)
Cecropia (1) *longipes* Pittier ? (Moraceae)
Cecropia (2) *obtusifolia* Bertol. (Moraceae)
Cecropia (3) *peltata* L. (Moraceae)
Chrysophyllum cainito L. (Sapotaceae)
Conostegia speciosa (Melastomaceae)
Copaifera panamensis (Britton) Standley
Cordia alliodora (Ruiz + Pan) Roem + Schult (Boraginaceae)
Costus villosissimus Jacq. (Costaceae)
Croton panamensis (Klotzsch) Muell. Arg (Euphorbiaceae)
Cupania cinerea Poepp + Endll. (Sapindaceae)
Ficus aff. *hemsleyana* Standl.
Genipa caruta var *americana* (Rubiaceae)
Guazuma ulmifolia Lam. (Sterculiaceae)
Heliconia platystochys Baker. (Musaceae)

Helicteres guazumifolia H.B.K. (Sterculiaceae)
Hirtella (1) *racemosa* L. (Rosaceae)
Hirtella (2) *triandra* Swartz. (Rosaceae)
Inga (1) *hayessii* Bents. (Mimosaceae)
Inga (2) *oerstediana* Willd. (Mimosaceae)
Lacistema aggregatum (Berg.) Rusby (Lacistemaceae)
Lafoensia puniceifolia DC. (Lythraceae)
Luehea seemanii Triana + Planch. (Tiliaceae)
Miconia (1) *argentea* (Swartz) Don. (Melastomaceae)
Miconia (2) *impetolaris* (Swartz) DC. (Melastomaceae)
Nectandra sp. (Lauraceae)
Palicourea guianensis Aubl. (Rubiaceae)
Piper (1) *aduncum* L. (Piperaceae)
Piper (2) *reticulatum* L. (Piperaceae)
Phoebe costaricana Mez + Pittier (Lauraceae)
Pittoniotis trichantha Griseb (Rubiaceae)
Posequeria latifolia (Rudge) Roem + Schult. (Rubiaceae)
Rourea glibra H.B.K. (Connaraceae)
Sloanea sp. (Eleocarpaceae)
Spondias mombin L. (Anacardiaceae)
Tabebuia pentaphylla (L.) Hemsl. (Bignoniaceae)
Talisia nervosa Radlk. (Sapindaceae)
Trema micrantha (L.) Blume (Ulmaceae)
Xylopia frutescens Aubl. (Annonaceae)

Identifying Numbers of Tagged Shrubs.

Alibertia edulis (L. Ridh.) A. Rich (Rubiaceae)

1785, 1789-1791, 1797-1800, 1882, 1884-B, 1885, 1887-1888, 1890-1892,
1894, 1898-1903, 1906-1907, 1912, 1914, 1921-1922, 1929, 1935, 2513.

Ardesia siebertii Lundel (Myrsinaceae)

1904

Conostegia speciosa Naud. (Melostomaceae)

1784, 1895

Hirtella racemosa Lam. (Amygdalaceae=Rosaceae)

1915, 2515, 2518

Ouratea wrightii (Van Tiegh.) Riley (Ochnaceae)

1874

Palicourea guianensis Aubl. (Rubiaceae)

1782, 1788, 1795, 1876, 1883, 1884, 1889, 1905, 1909-1911, 1930

Piper (1) *adunctum* L. (Piperaceae)

2512

Piper (2) *nov. sp.* (Piperaceae)

1920, 1933

Psychotria (1) *cuspidata* Bredem (Rubiaceae)

1786-1787, 1793, 1796, 1802, 1877-1879, 1919, 1922-B, 1923, 1925-1928,
1931, 1934

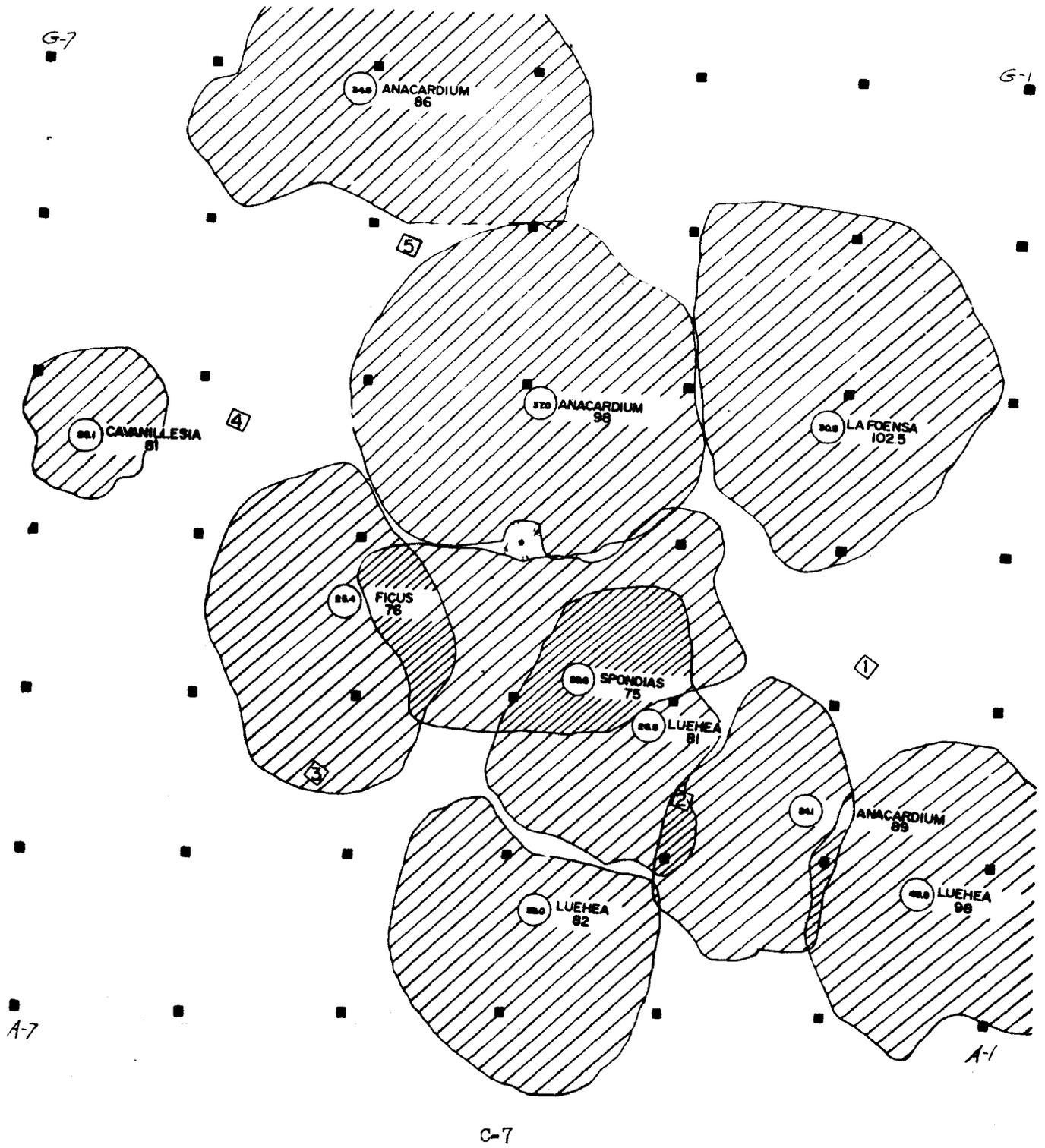
Psychotria (2) *horizontalis* Swartz (Rubiaceae)

1780, 1801

Psychotria (3) *undata* Benth. (Rubiaceae)

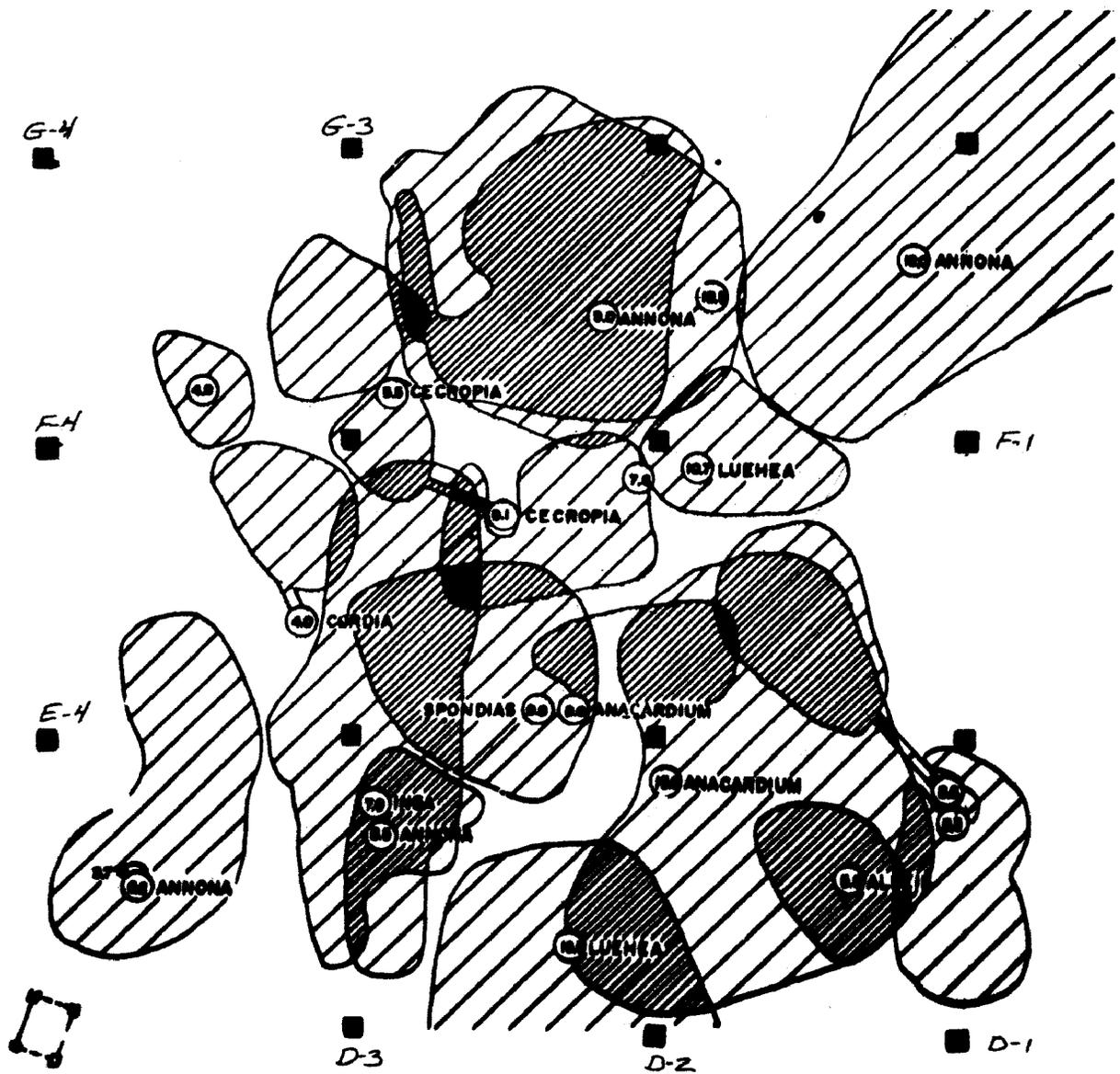
1783, 1792, 1875, 1881, 1886, 1893, 1913, 1916-1918, 2514, 2516

UPPER CANOPY COVERAGE



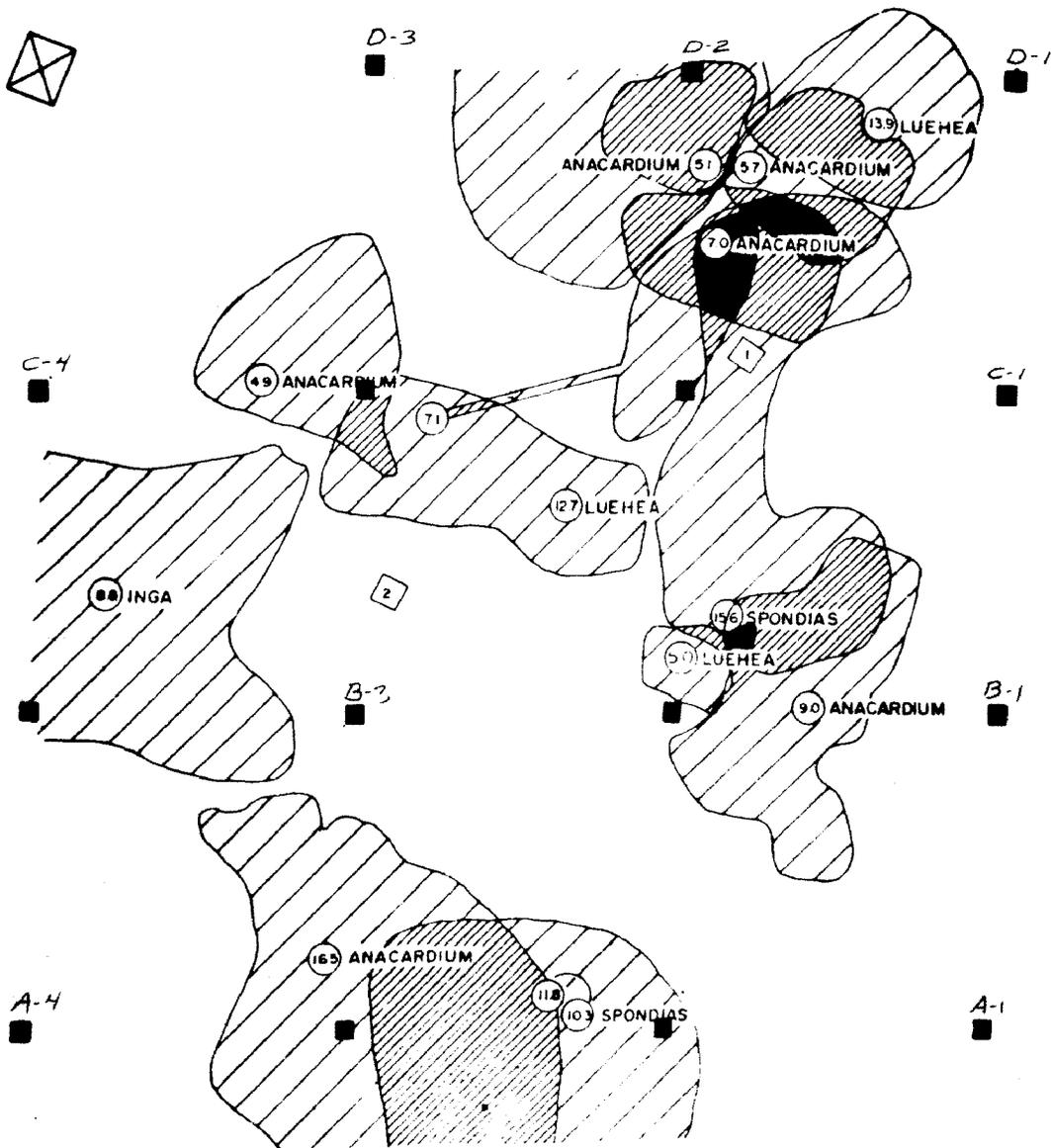
LOWER CANOPY COVERAGE

NE Quadrant



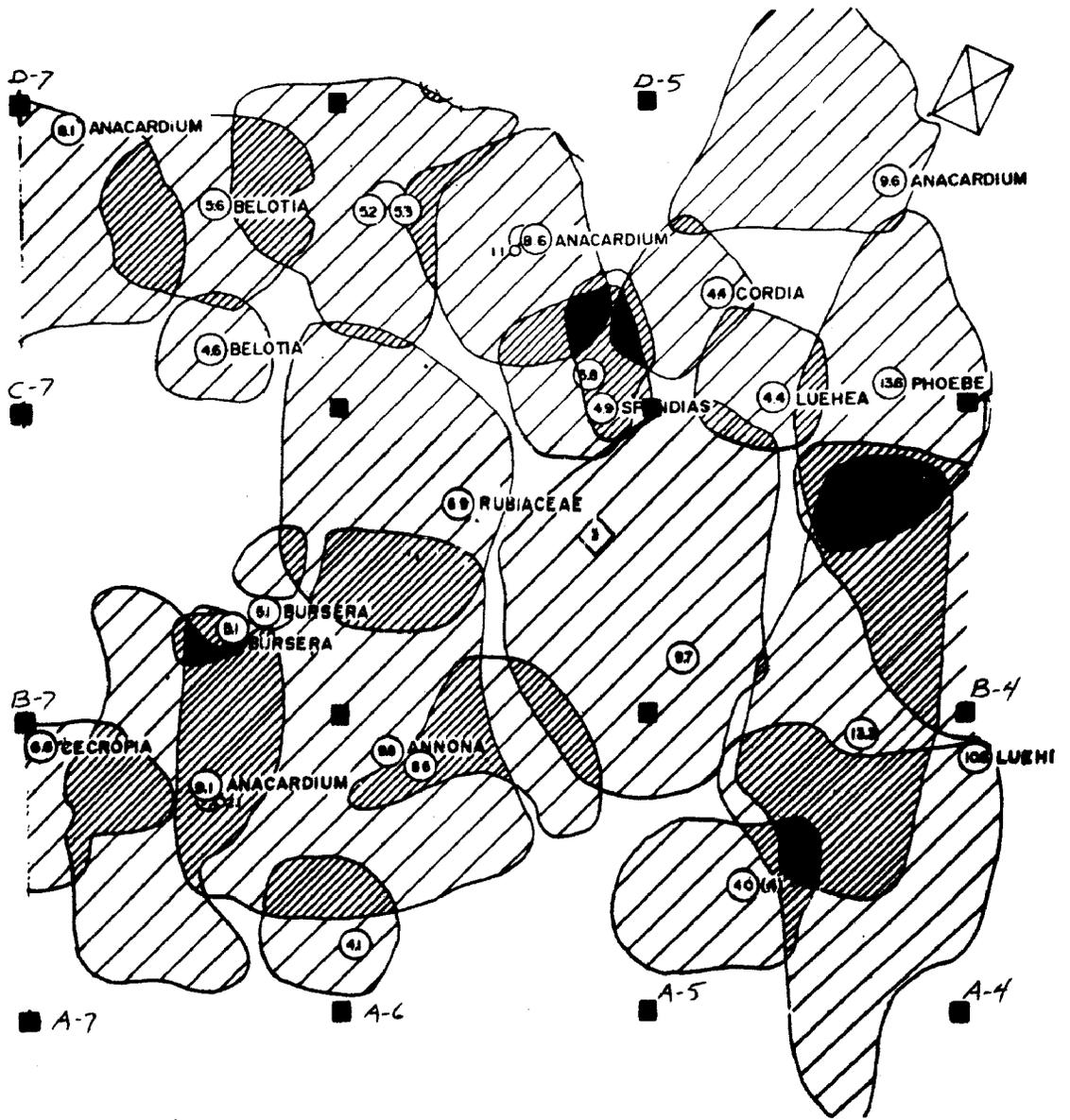
LOWER CANOPY COVERAGE

SE Quadrant



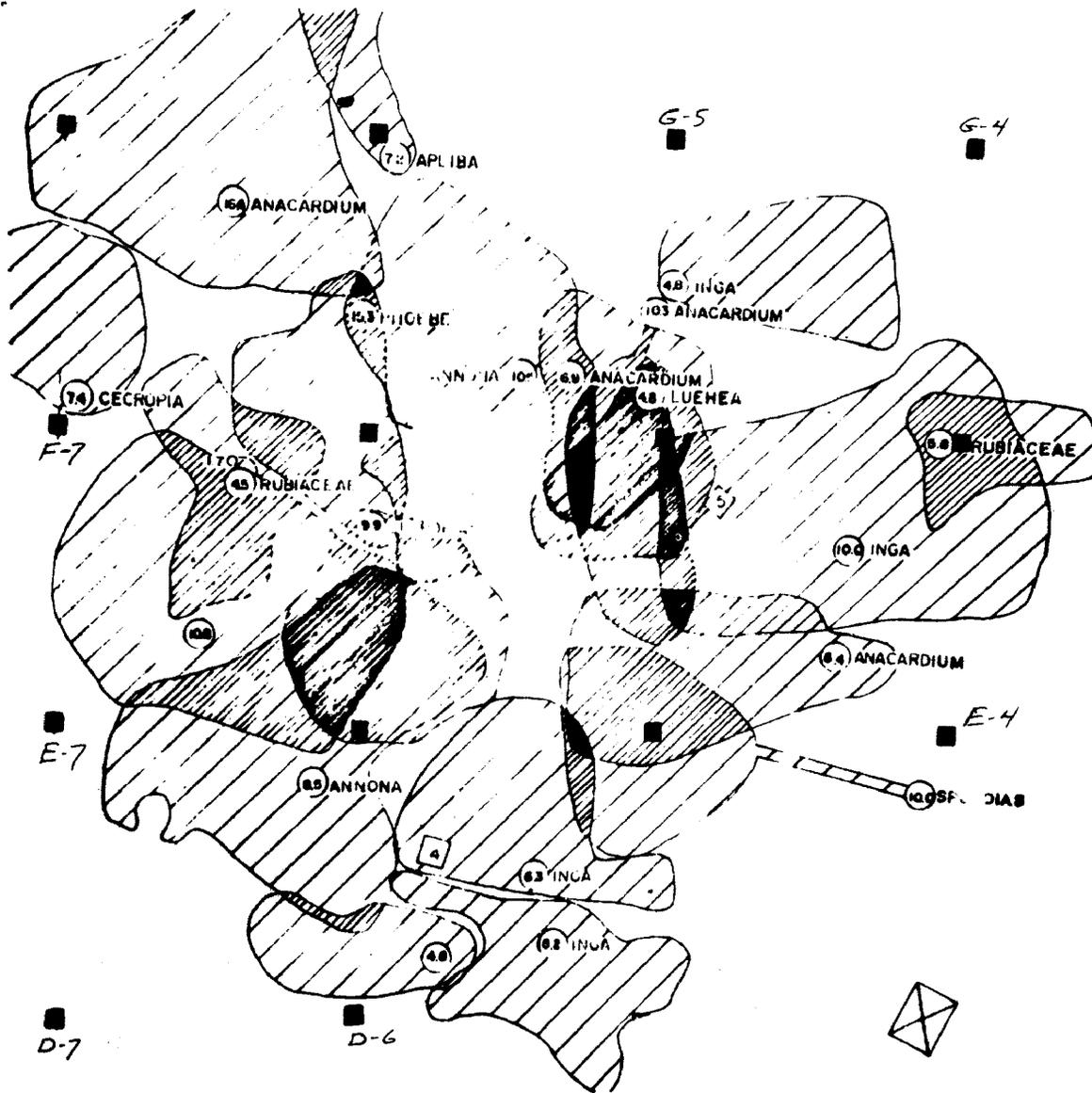
LOWER CANOPY COVERAGE

SW Quadrant



LOWER CANOPY COVERAGE

NW Quadrant



| G7 G6 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---------------|------------|-------|---------------|---------------|---------------|---------------|---------------|-----|---------|
| F7 F6 | C M | | | M | | M | | | | |
| X Y | 1 Jun 1966 | | | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 0 | 1 | Cecropia | III | 18.8 | 20 | - | 12.5 | - | 16. | |
| 0 | 3 | Belotia | III | 3.3 | 5.5 | - | 2.8 | - | 6 | |
| 1 | 3 | Croton | | | | | | | | Chopped |
| 2 | 1 | | II | 3.3 | | | | | | Dead |
| 2 | 3 | | | | | | | | | Dead |
| 3 | 3 | | V | 3.5 | 3.7 | - | 2.0 | - | 4.2 | |
| 3 | 7 | | I | 4.6 | 4.8 | - | 2.5 | - | 3.6 | |
| 4 | 2 | Croton | IV | 2.54 | 2.7 | - | 1.2 | - | 4.5 | |
| 5 | 7 | Anacardium | I | 4 | 4.0 | - | 8 | - | 20 | |
| 9 | 4 | Phoebe | III | 3.8 | 4.4 | - | 3.9 | - | 5.4 | |
| 9 | 4 | Phoebe | I | 38.8 | 41.6 | - | 2.9 | - | 22 | |

| G6 | G5 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|-------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| F6 | F5 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 8 | Tabebuia | I | 4.8 | 5.0 | - | 2.5 | - | 3.9 | |
| 1 | 9 | Guazuma | IV | 18.3 | 19.0 | - | 8 | - | 16.5 | |
| 3 | 7 | Anacardium | I | 7.6 | 8.4 | - | 3 | - | 6.9 | |
| 5 | 2 | Annona | I | 24.5 | 27.2 | - | 5.4 | - | 20.5 | |
| 6 | 2 | Anacardium | I | 17.5 | 17.5 | - | 3.6 | - | 15 | |
| 6 | 7 | Sapindaceae | I | 9.5 | 9.5 | - | 3.6 | - | 9 | |
| 6 | 8 | Anacardium | I | 6.04 | 6.3 | - | 3 | - | 6.6 | |
| 8 | 5 | | I | 4 | 4 | - | 1.5 | - | 2.7 | |
| 9 | 1 | Luehea | I | 12.2 | 12.3 | - | 3.9 | - | 11 | |
| 9 | 8 | Anacardium | I | 88.3 | 86.7 | - | 10 | - | 33.5 | |

| G5 G4 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|------------|-------------|-------|------------|------------|--------------|------------|------------|-----|---------|
| F5 F4 | C M | | | M | | M | | | | |
| X Y | 1 Jun 1966 | | | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 0 | 4 | Anacardium | I | 25.8 | 25.8 | - | 1.2 | - | 3.3 | Dead |
| 0 | 5 | Inga | I | | | | | | | |
| 0 | 7 | | VII | 3.0 | 3.1 | - | 3.6 | - | 4.5 | |
| 0 | 7 | | VII | M | 3.7 | - | 3 | - | 5.7 | |
| 0 | 8 | | VII | 3.7 | 3.7 | - | 3.6 | - | 4.5 | |
| 1 | 8 | | VII | 4.1 | 5 | - | 5.4 | - | 6.4 | |
| 1 | 8 | | VII | 3.8 | 4.4 | - | 3.9 | - | 6 | |
| 1 | 8 | | VII | 3.4 | 3.4 | - | 4.5 | - | 5.7 | |
| 1 | 9 | | VII | 3.1 | 3.1 | - | 4.8 | - | 6 | |
| 2 | 7 | | VII | 3.1 | 3.1 | - | 1.5 | - | 2.8 | |
| 2 | 7 | | VII | 3.7 | 3.7 | - | 4.3 | - | 4.5 | |
| 2 | 8 | | VII | 3.1 | 3.1 | - | 4.5 | - | 5.7 | |
| 2 | 8 | | VII | 3.4 | 3.4 | - | 4.8 | - | 6 | |
| 2 | 8 | | VII | 3.7 | 3.7 | - | 4.8 | - | 6 | |
| 2 | 8 | | VII | 3.5 | 3.7 | - | 3.3 | - | 4.8 | |
| 2 | 9 | | VII | 3.1 | 3.1 | - | 4.5 | - | 5.7 | |
| 3 | 2 | Pittonoitis | I | 5.3 | 5.6 | - | 1.8 | - | 4.8 | |
| 3 | 7 | | VII | 3.7 | 3.7 | - | 1.2 | - | 3 | |
| 3 | 8 | | VII | 3.7 | 3.7 | - | .8 | - | 2.8 | |
| 3 | 9 | | VII | 2.7 | 2.7 | - | 4.2 | - | 5.7 | |
| 3 | 8 | | VII | 3.7 | 3.7 | - | 4.8 | - | 6 | |
| 3 | 8 | | VII | 4 | 4 | - | 2.8 | - | 4.5 | |
| 3 | 9 | | VII | 3.3 | 3.7 | - | 4.5 | - | 5.4 | |
| 3 | 9 | | VII | 3.8 | 4.7 | - | 5.4 | - | 6.4 | |
| 4 | 9 | | VII | 3.0 | 3.7 | - | 1.8 | - | 3.6 | |
| 5 | 1 | | IV | * | 2.4 | - | .8 | - | 2.0 | |
| 6 | 1 | Cupania | III | 4.1 | 4.1 | - | 2.5 | - | 4.5 | |
| 6 | 2 | Posequeria | IV | * | 3.5 | - | .4 | - | 2.8 | |
| 6 | 7 | | V | 4 | 4 | - | 1.5 | - | 3.9 | |
| 6 | 7 | | V | 3 | 3 | - | 1.8 | - | 1.8 | |
| 6 | 8 | | V | 3.4 | 3.4 | - | 1.8 | - | 4.2 | |
| 7 | 5 | | V | 2.5 | 2.5 | - | 1.2 | - | 2.0 | |
| 7 | 5 | | V | Dead | | | | | | |
| 7 | 7 | | V | 3.0 | 3.2 | - | 1.5 | - | 1.5 | |
| 7 | 7 | | V | 3.5 | 4 | - | 2.1 | - | 4.5 | |

| G5 G4 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|-------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| F5 F4 | | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 7 | 7 | | V | 4.3 | 4.6 | - | 2.1 | - | 4.5 | |
| 7 | 7 | | V | 4 | 4 | - | 2.1 | - | 4.5 | |
| 7 | 8 | | V | 4.2 | 4.2 | - | 1.9 | - | 4.5 | |
| 7 | 8 | | V | 4 | 4 | - | 2.0 | - | 4.8 | |
| 7 | 8 | | V | 4 | 4 | - | 2.1 | - | 4.5 | |
| 7 | 9 | | V | 3.7 | 3.7 | - | 2.0 | - | 4.5 | |
| 9 | 1 | Pittonoitis | I | 14.7 | 14.7 | - | 2.0 | - | 7.6 | |

| G4 G3 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|----|----------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------------|
| F4 | F3 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 | 7 | | III | M | 2.6 | - | .5 | - | 1.8 | |
| 1 | 8 | | V | 3.5 | 4.7 | - | 2.5 | - | 3.6 | |
| 1 | 9 | | V | 4.1 | 4.7 | - | 2.1 | - | 4.8 | |
| 1 | 9 | | V | M | 4.2 | - | 1.8 | - | 5.1 | |
| 2 | 2 | | | M | | | | | | Missing |
| 2 | 8 | Croton | III | 3.5 | 4.8 | - | 5.7 | - | 6.9 | |
| 2 | 8 | | V | 4.1 | 4.1 | - | 2.0 | - | 5.4 | |
| 3 | 2 | | | M | | | | | | Missing |
| 3 | 4 | | III | M | 2.5 | - | 1.2 | - | 2.8 | |
| 3 | 6 | Flacourtiaceae | III | 4.3 | 6.2 | - | 3.6 | - | 6.6 | |
| 4 | 5 | | V | 3.8 | 4.7 | - | 1.5 | - | 5.4 | |
| 4 | 6 | | V | | | | | | | Dead |
| 4 | 6 | | V | M | 3.0 | - | 1.8 | - | 3.3 | |
| 4 | 8 | Ficus | III | 3.8 | 4.5 | - | 2.8 | - | 4.5 | |
| 5 | 0 | Flacourtiaceae | IV | 2.3 | 3.2 | - | 1.2 | - | 4.5 | |
| 5 | 0 | Banara | I | 5.1 | 5.1 | - | 2.8 | - | 5.4 | |
| 5 | 4 | Cordia | III | 3.2 | 3.2 | - | 1.8 | - | 4.8 | |
| 5 | 4 | | V | M | 4 | - | 1.8 | - | 3.9 | |
| 5 | 5 | | V | M | 2.4 | - | 1.5 | - | 3.6 | |
| 5 | 5 | | V | M | 4.5 | - | 3 | - | 5.7 | |
| 5 | 6 | | V | 3.7 | 3.7 | - | 2.0 | - | 3.9 | |
| 5 | 7 | | III | M | 3.3 | - | 2.8 | - | 4.5 | |
| 5 | 9 | | V | M | 3 | - | 2.1 | - | 4.8 | |
| 5 | 9 | | V | 3.3 | 4 | - | 2.1 | - | 5.1 | |
| 6 | 0 | | III | M | 3.7 | - | 4.5 | - | 4.5 | |
| 7 | 1 | | | M | | | | | | Missing |
| 7 | 4 | | I | | 6.0 | - | .9 | - | 2.5 | Chopped but living |
| 7 | 9 | | I | M | 3.4 | - | 3 | - | 6.4 | |
| 8 | 8 | Cordia | I | 2.5 | 5.6 | - | 2.5 | - | 4.2 | |
| 9 | 8 | | II | M | 2.0 | - | .8 | - | 3.6 | |

| G3 G2 | | SPECIES | SHAPE | D B M | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| F3 | F2 | | | C | M | M | M | M. | M. | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 0 | Helicteres | II | 2.5 | 3.0 | - | | - | 2.5 | |
| 0 | 5 | | IV | M | 3.6 | - | .8 | - | 2.3 | |
| 0 | 7 | | III | M | 2.2 | - | 1.8 | - | 2.8 | |
| 0 | 9 | | I | M | 4 | - | .7 | - | 6 | |
| 1 | 1 | Cecropia | III | 13.9 | 15.1 | - | 13.5 | - | 18.5 | |
| 1 | 7 | Palicourea | I | 7.8 | 9.5 | - | 1.2 | - | 6 | |
| 2 | 5 | Annonaceae | III | 8.3 | 9.5 | - | 5 | - | 15 | |
| 2 | 9 | | III | 2.5 | 5.6 | - | 1.2 | - | 7.6 | |
| 3 | 1 | Posegueria | II | 3.5 | 4.6 | - | 1.8 | - | 3 | |
| 3 | 2 | | VII | 5 | 5 | - | 1.2 | - | 2.8 | |
| 3 | 2 | | VII | M | 4.7 | - | 3.6 | - | 5.4 | |
| 4 | 1 | | VII | 3.4 | 3.4 | - | 5.1 | - | 6 | |
| 4 | 1 | | VII | 3.7 | 3.7 | - | 2.5 | - | 5.4 | |
| 4 | 2 | | VII | 3.7 | 3.7 | - | .8 | - | 3.3 | |
| 4 | 2 | | VII | 4.6 | 4.7 | - | 1.8 | - | 4.2 | |
| 4 | 9 | Miconia | II | 2.5 | 3.7 | - | .3 | - | 4.2 | |
| 4 | 9 | | II | M | 2.7 | - | | - | 2.5 | |
| 5 | 0 | | VII | M | 5 | - | 1.2 | - | 3.6 | |
| 5 | 0 | | VII | M | 4.4 | - | 2.8 | - | 3.6 | |
| 5 | 0 | | VII | M | 3.4 | - | 4.5 | - | 4.5 | |
| 5 | 1 | | VII | | 2.1 | - | 1.8 | - | 2.7 | |
| 5 | 8 | Miconia | I | 2.8 | 2.8 | - | 1.8 | - | 3.9 | |
| 6 | 0 | | VII | M | 3.7 | - | 4.5 | - | 6 | |
| 6 | 0 | | VII | M | 4.4 | - | 6 | - | 7.6 | |
| 6 | 4 | Hirtella | II | 3.3 | 4 | - | | - | 3.6 | |
| 7 | 0 | | VII | M | 4.4 | - | 4.2 | - | 6 | |
| 7 | 3 | Annona | I | 22.2 | 22.2 | - | 6 | - | 10 | |
| 7 | 9 | | I | M | 1.9 | - | 1.2 | - | 4.2 | |
| 7 | 9 | Psychotria | IV | * | 2.5 | - | 1.8 | - | 3.6 | |
| 8 | 0 | | VII | M | 4.4 | - | 1.5 | - | 3 | |
| 8 | 8 | Piper | III | * | 2.6 | - | 1.8 | - | 3.6 | |
| 9 | 9 | | I | M | 2.2 | - | 1.5 | - | 2.8 | |

| G2 | G1 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS | |
|----|----|---------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|-----------------------|
| F2 | F1 | | | C M | | M | | M | | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 0 | 9 | | I | M | 2.0 | - | 1.2 | - | 3 | | |
| 1 | 2 | | I | M | 2.3 | - | 1.5 | - | 3.9 | | |
| 2 | 1 | | I | M | 2.6 | - | .8 | - | 3.6 | | |
| 2 | 4 | | I | | 46.9 | | 50.3 | - | 13 | - | 23 |
| 2 | 7 | Miconia | III | | 3.5 | | 3.6 | - | 5.1 | - | 6.3 |
| 2 | 7 | | | M | | | | - | | | Missing or chopped |
| 2 | 9 | | I | M | 2.0 | - | .8 | - | | | 3.3 |
| 4 | 8 | Miconia | I | | 7.1 | | 7.8 | - | 4.8 | - | 7.6 |
| 7 | 3 | Posequeria | III | | 4.8 | | 5.0 | - | 2.8 | - | 4.5 |
| 7 | 7 | Chrysopaullum | I | | 2.5 | | 3 | - | 1.8 | - | 4.5 |
| 8 | 3 | | III | | 5.1 | | 8.4 | - | 3.6 | - | 6 |
| 8 | 5 | Annona | I | | 29.9 | | 29.9 | - | 8 | - | 15 |

| F7 | F6 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|-------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------------|
| E7 | E6 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 4 | | II | M | 4.4 | - | .9 | - | .9 | Chopped or missing |
| 0 | 5 | Nectanda | I | | 2.8 | 2.8 | - | 1.2 | - | |
| 1 | 1 | Anacardium | I | | 3.8 | 4.4 | - | 2.0 | - | 5.4 |
| 1 | 7 | Hirtella | I | | | | | | | Dead |
| 1 | 9 | Croton | IV | | 3.5 | 4.1 | - | .5 | - | 3.6 |
| 2 | 0 | | V | M | | 4.5 | - | 1.2 | - | 2.0 |
| 2 | 8 | | III | M | | 2.3 | - | 2.5 | - | 3 |
| 3 | 0 | Rubiaceae | III | | 5.3 | 6.2 | - | 3.9 | - | 6.4 |
| 3 | 3 | Sapindaceae | I | | 27.4 | 28.5 | - | 2.5 | - | 20 |
| 3 | 7 | Posequeria | III | | 3.5 | 5.0 | - | 2.0 | - | 4.5 |
| 5 | 2 | Anacardium | I | | 4.8 | 5 | - | 2.0 | - | 3.3 |
| 5 | 8 | Pittoniotis | I | | 11.3 | 11.7 | - | 1.7 | - | 10 |
| 5 | 9 | Pittoniotis | I | | 4.3 | 5.3 | - | 1.7 | - | 3.9 |
| 6 | 3 | | I | | 8.5 | 9.6 | - | 1.9 | - | 9 |
| 9 | 7 | Cecropia | III | | 24.4 | 24.4 | - | 23 | - | 32 |
| 9 | 8 | | IV | M | | 2.5 | - | .8 | - | 2.5 |

| F6 | F5 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|-----------|-------|---------------|---------------|---------------|---------------|---------------|---------------|-----------|
| E6 | E5 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 | 7 | Andira | II | 4.6 | 4.9 | - | .5 | - | 7.6 | |
| 1 | 7 | | II | 7.8 | 8.2 | - | .5 | - | 7.6 | |
| 1 | 7 | | II | 5.8 | 6.3 | - | .5 | - | 7.6 | |
| 2 | 3 | | M | | 2.6 | - | 1.2 | - | 1.2 | |
| 2 | 7 | Andira | II | 2.5 | 3.0 | - | .5 | - | 7.6 | |
| 2 | 7 | | II | 3.8 | 4.1 | - | .5 | - | 7.6 | |
| 3 | 5 | | III | | | | | | | Was dying |
| 3 | 5 | | IV | M | 3.4 | - | .8 | - | 3.6 | |
| 3 | 0 | Belotia | III | 2.5 | 4.7 | - | 4.2 | - | 6 | |
| 4 | 6 | | I | M | 2.4 | - | 1.5 | - | 2.5 | |
| 6 | 3 | Copaifera | III | 4.1 | 4.7 | - | 5.4 | - | 6.9 | |
| 6 | 5 | | IV | 2.8 | 2.8 | - | .7 | - | 4.2 | |
| 6 | 6 | | I | M | 2.4 | - | .8 | - | 3.3 | |
| 7 | 2 | Spondias | I | 3.0 | 3.6 | - | 2.8 | - | 4.8 | |
| 7 | 5 | | V | M | 2.8 | - | 2.0 | - | 3 | |
| 7 | 5 | | V | M | 4.1 | - | 2.0 | - | 3.9 | |
| 7 | 5 | | V | M | 4.4 | - | 2.8 | - | 6 | |
| 7 | 5 | | V | M | 4.0 | - | 2.8 | - | 5.4 | |
| 8 | 5 | | I | M | 3.0 | - | 1.2 | - | 3 | |
| 9 | 8 | Nectandra | II | 4.2 | 4.2 | - | | - | 3.9 | |

| F5 F4 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---------------|------------|-------|---------------|---------------|---------------|---------------|---------------|------|---------|
| E5 E4 | C M | | | M | | M | | | | |
| X Y | 1 Jun 1966 | | | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 1 | 6 | Luemea | II | 4.6 | 5.4 | - | 1.8 | - | 2.8 | |
| 1 | 6 | | II | 3.5 | 4.6 | - | 2.8 | - | 4.8 | |
| 2 | 8 | Ficus | I | 6.0 | 6.3 | - | 2.8 | - | 4.5 | |
| 4 | 6 | Pasequeria | I | 5.1 | 5.4 | - | 1.8 | - | 4.5 | |
| 6 | 3 | Anacardium | I | 16.2 | 17.5 | - | 4.5 | - | 19 | |
| 6 | 6 | Inga | I | 22.4 | 22.4 | - | 2.8 | - | 13.5 | |
| 8 | 9 | | I | M | 15.1 | - | 1.8 | - | 11 | |

| F4 F3 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS | |
|-------|---------------|----------------|-------|---------------|---------------|---------------|---------------|---------------|-----|---------|--|
| E4 E3 | C M | | | M | | M | | | | | |
| X Y | 1 Jun 1966 | | | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | | |
| 1 | 4 | | III | M | 2.6 | - | .8 | - | 3 | | |
| 2 | 0 | | VII | M | 1.8 | - | .8 | - | 2.8 | | |
| 2 | 0 | | VII | M | 1.8 | - | .8 | - | 3.6 | | |
| 3 | 6 | Flacourtiaceae | I | | 5.6 | 6.3 | - | 1.8 | - | 6.9 | |
| 6 | 9 | Cecropia | III | | 2.5 | 3.7 | - | 6 | - | 6 | |
| 8 | 2 | | III | * | 2.0 | - | 1.5 | - | 2.5 | | |
| 8 | 3 | Cordia | III | | 10.1 | 12.4 | - | 6.5 | - | 12.5 | |
| 8 | 6 | | I | M | 2.4 | - | 1.5 | - | 4.5 | | |
| 9 | 8 | | I | M | 3 | - | 1.9 | - | 6 | | |

| F3 F2 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| E3 | E2 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 5 | Luehea | I | 6.8 | 7 | - | 2.5 | - | 7.6 | |
| 1 | 3 | Anacardium | IV | 8.0 | 8.4 | - | 1.9 | - | 6.5 | |
| 2 | 5 | Anacardium | I | 6.6 | 9.4 | - | 2.0 | - | 6 | |
| 2 | 5 | Anacardium | I | 9.3 | 11.3 | - | 2.8 | - | 5.5 | |
| 4 | 9 | | VII | M | 4.4 | - | 1.8 | - | 3.3 | |
| 4 | 9 | | VII | M | 3.7 | - | 1.5 | - | 2.8 | |
| 4 | 9 | | VII | M | 3.7 | - | .8 | - | 2.5 | |
| 5 | 6 | Cecropia | III | 22.6 | 22.6 | - | 20 | - | 25 | |
| 5 | 9 | | VII | 3.8 | 4.4 | - | 3.3 | - | 5.4 | |
| 6 | 0 | Spondias | I | 2.5 | 25 | - | 3.9 | - | 14.5 | |
| 6 | 4 | | I | M | 3.0 | - | 1.3 | - | 3 | |
| 6 | 5 | | I | M | 3.6 | - | 1.8 | - | 3.3 | |
| 6 | 9 | | VII | 4.3 | 4.4 | - | .8 | - | 3.9 | |
| 7 | 0 | Anacardium | I | 11.3 | 11.3 | - | 3.9 | - | 16.5 | |
| 9 | 7 | | I | 19.3 | 19.6 | - | 11 | - | 5.1 | |

| F2 F1 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|----|---------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| E2 | E1 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 | 8 | Luehea | | | | | | | | Dead |
| 2 | 1 | | I | 2.2 | 2.2 | - | 1.5 | - | 3.9 | |
| 4 | 5 | | IV | M | 2.2 | - | .3 | - | 3.6 | |
| 5 | 5 | | VII | 5.1 | *5.10 | - | .9 | - | 2.8 | |
| 5 | 5 | | VII | M | 1.4 | - | 2.8 | - | 3.6 | |
| 5 | 1 | Anacardium | I | 6.6 | 6.6 | - | 3.3 | - | 6.6 | |
| 5 | 6 | | VII | M | 1.0 | - | 2.0 | - | 3.6 | |
| 6 | 1 | | I | M | 4.4 | - | 1.2 | - | 4.2 | |
| 7 | 6 | Piper | III | 2.8 | 3.0 | - | 3.3 | - | 5.4 | |
| 8 | 1 | Alibertia | II | 4.1 | 5 | - | | - | 6 | |
| 8 | 7 | Chrysophyllum | I | 4.6 | 4.8 | - | 3 | - | 6 | |

| E7 | E6 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|--------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| D7 | D6 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 | 0 | Belotia | III | 3.5 | 4.9 | - | 4.5 | - | 6.5 | |
| 1 | 5 | | V | 3.5 | 3.6 | - | 1.8 | - | 3.5 | |
| 1 | 5 | | V | 3.5 | 4 | - | 2.0 | - | 3.5 | |
| 1 | 5 | | V | Dead | 3.6 | - | 3.3 | - | 3.3 | Dead |
| 1 | 5 | | V | 3.1 | 3.1 | - | 1.8 | - | 3.6 | |
| 1 | 6 | | V | 2.3 | 2.3 | - | 1.5 | - | 2.7 | |
| 2 | 5 | | V | Dead | 3.4 | - | 1.8 | - | 3 | Dead |
| 2 | 6 | | V | 3.7 | 3.7 | - | 2.0 | - | 4.2 | |
| 2 | 6 | | V | Dead | 3.4 | - | 2.0 | - | 2.0 | Dead |
| 3 | 1 | Belotia | III | 4.6 | 6.7 | - | 3 | - | 8.4 | |
| 3 | 2 | | I | M | 2 | - | 1.5 | - | 4.2 | |
| 3 | 7 | Cavanillesia | VI | 66.3 | 70.1 | - | 18 | - | 24 | |
| 3 | 7 | Cecropia | I | 7.6 | 10.1 | - | 10 | - | 15 | |
| 4 | 4 | | V | Dead | 3.6 | - | 1.5 | - | 3.3 | Dead |
| 4 | 4 | | V | 4.1 | | - | 1.2 | - | 1.2 | |
| 4 | 4 | | V | 3.2 | 3.2 | - | 1.5 | - | 3.3 | |
| 5 | 0 | Belotia | III | 4.1 | 5.7 | - | 3.5 | - | 7.2 | |
| 5 | 3 | Cecropia | III | 5.1 | 9.5 | - | 14 | - | 14.5 | |
| 5 | 3 | Belotia | III | 2.5 | 3.2 | - | 4.5 | - | 6.0 | |
| 6 | 4 | Croton | III | 2.1 | 3 | - | 2.0 | - | 5.6 | |
| 8 | 8 | Annona | T | 12.3 | 12.3 | - | 4.4 | - | 16.5 | |
| 3 | 8 | | | M | | | | | | Missing |

| E6 | E5 | D6 | D5 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|----|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| | | | | | | C | M | M | M | M | M | |
| X | Y | | | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 8 | | | | II | M | 3.6 | - | .5 | - | 2 | |
| 1 | 8 | | | | VII | | | | | | | Dead |
| 2 | 3 | | | Annonaceae | I | 12.1 | 12.1 | - | 8 | - | 16.5 | |
| 4 | 9 | | | | V | M | 3.0 | - | 1 | - | 3.5 | |
| 5 | 9 | | | | V | M | 3.0 | - | 1 | - | 3.5 | |
| 6 | 3 | | | Inga | I | 19 | 19 | - | 8 | - | 12 | |
| 6 | 5 | | | Inga | I | 16 | 16.1 | - | 3.5 | - | 13 | |
| 9 | 4 | | | Luehea | I | 5.1 | 7 | - | 1 | - | 5.5 | |

| E5 | E4 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| D5 | D4 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 8 | Posequeria | I | 2.5 | 5.6 | - | 1.3 | - | 4.5 | |
| 1 | 4 | | I | M | 7.8 | - | 1 | - | 4.5 | |
| 3 | 6 | | | Dead | 9.7 | - | 2 | - | 2.5 | Dead |
| 4 | 5 | | IV | M | 2.0 | - | 1 | - | 2.5 | |
| 5 | 0 | | VII | M | 3.7 | - | 1 | - | 3 | |
| 5 | 1 | | VII | 3.0 | 3.1 | - | 1 | - | 2.5 | |
| 5 | 2 | | VII | M | 3.1 | - | 3.5 | - | 4.5 | |
| 5 | 2 | | VII | 3.7 | 3.7 | - | 3.5 | - | 5 | |
| 5 | 2 | | VII | 5 | 5 | - | 4.3 | - | 1 | |
| 5 | 3 | | VII | 4.4 | 4.4 | - | 1.3 | - | 2.5 | |
| 5 | 3 | | VII | M | 4 | - | 4.5 | - | 6 | |
| 6 | 3 | | VII | 2.7 | 2.7 | - | 1 | - | 2 | |
| 6 | 3 | | VII | M | 2.8 | - | 2.5 | - | 4.5 | |
| 6 | 3 | | VII | 3.7 | 3.7 | - | 3.5 | - | 5.5 | |
| 6 | 4 | | VII | M | 2.5 | - | 1 | - | 2 | |
| 7 | 7 | | I | | 2.8 | - | 1 | - | 3 | |
| 8 | 5 | Hirtella | I | 2.2 | 2.2 | - | 2 | - | 3.5 | |
| 9 | 7 | Spondias | III | 2.5 | 25 | - | 11 | - | 15 | |

| E4 | E3 | D4 | D3 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|----|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|--------------------|
| | | | | | | C M | | M | | M | | |
| X | Y | | | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 2 | | | | III | M | 2 | - | 3 | - | 3.5 | |
| 0 | 3 | | | | III | M | 2.6 | - | 3.7 | - | 4.0 | |
| 0 | 9 | | | Anacardium | I | 93.2 | 98.0 | - | 4.3 | - | 3.0 | |
| 0 | 9 | | | | II | M | 2 | - | | - | 3 | |
| 1 | 5 | | | | III | M | 4 | - | 3.5 | - | 4.5 | |
| 3 | 5 | | | Annona | IV | 15.7 | 17.7 | - | 4.0 | - | 7 | |
| 3 | 5 | | | Annona | IV | 9.3 | 9.3 | - | 3 | - | 5.3 | |
| 3 | 7 | | | Alibertia | III | * | 3.7 | - | 2.5 | - | 5.0 | |
| 3 | 6 | | | | IV | M | 2.3 | - | 1 | - | 2.5 | |
| 4 | 2 | | | Palicourea | I | * | 2.8 | - | 1 | - | 2.5 | |
| 4 | 4 | | | | I | M | 2.5 | - | 1 | - | 3 | |
| 5 | 7 | | | Posequeria | | | | | | | | Dead or Chopped |
| 7 | 6 | | | Palicourea | IV | * | 1.8 | - | 1 | - | 2.5 | |
| 8 | 1 | | | Annona | I | 3.0 | 3.4 | - | 3 | - | 4.5 | |
| 8 | 3 | | | Anacardium | I | 3.0 | 3.1 | - | 1 | - | 3 | |

| E3 | E2 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|-----------|-------|---------------|---------------|---------------|---------------|---------------|---------------|------------|
| D3 | D2 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 7 | Inga | I | 17.8 | 21.0 | - | 5.4 | - | 14 | |
| 1 | 6 | Annona | I | 19.0 | 19.0 | - | 4.5 | - | 16 | |
| 5 | 1 | | VII | M | 3.4 | - | 3.6 | - | 4.2 | |
| 5 | 2 | | VII | 3 | 3.7 | - | 6.4 | - | 7.2 | |
| 5 | 2 | | VII | 2.8 | 3.7 | - | 3.9 | - | 4.5 | |
| 5 | 2 | | VII | 4 | 4 | - | 3.6 | - | 5.4 | |
| 5 | 2 | | VII | 3.8 | 4 | - | 4.5 | - | 6 | |
| 5 | 2 | | VII | 3.5 | 4 | - | 1.2 | - | 3.6 | |
| 6 | 1 | | VII | M | 3.7 | - | 3.9 | - | 5.4 | |
| 6 | 2 | | VII | 3.0 | 3.1 | - | 6 | - | 7.6 | |
| 6 | 2 | | VII | 3.3 | 3.7 | - | 5.4 | - | 6.6 | |
| 6 | 3 | | VII | 3.3 | 3.4 | - | 6 | - | 6.9 | |
| 6 | 3 | | VII | 3.3 | 3.7 | - | 6 | - | 7.2 | |
| 6 | 3 | | VII | 3.1 | 3.1 | - | 5.7 | - | 6.9 | |
| 6 | 3 | | VII | 4.4 | 4.4 | - | 4.8 | - | 6 | |
| 6 | 3 | | VII | 3.5 | 3.7 | - | 6 | - | 6.9 | |
| 6 | 3 | | II | 4.6 | 5.5 | - | 4.5 | - | 6 | |
| 6 | 4 | | VII | 5 | 5 | - | 1.2 | - | 3.6 | |
| 7 | 2 | | VII | 3.0 | 3.1 | - | 4.5 | - | 6 | |
| 7 | 3 | Luehea | III | 42.9 | 43.2 | - | 13 | - | 23 | |
| 8 | 8 | Lafoesnia | I | 77.4 | 78.4 | - | 11 | - | 36 | |
| 9 | 6 | | | | | | | | | Not Inside |

| D7 D6 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|------------------|
| C7 C6 | | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 | 3 | Nectandra | II | 2.6 | 2.6 | - | | - | 3.6 | |
| 1 | 4 | Hirtella | II | 3.4 | 3.4 | - | | - | 3.9 | |
| 1 | 9 | Anacardium | I | 20.4 | 20.8 | - | 8.5 | - | 10 | |
| 3 | 0 | | II | M | 1.8 | - | | - | 2.8 | |
| 3 | 3 | Nectandra | I | 4.1 | 4.8 | - | 3.6 | - | 5.4 | |
| 3 | 3 | | | | | | | | | Dead or dying |
| 4 | 0 | Hirtella | II | 2.5 | 3.0 | - | | - | 3.9 | |
| 4 | 5 | Conostegia | II | 2.8 | 3 | - | 2.8 | - | 4.2 | |
| 5 | 1 | Belotia | III | 10.1 | 10.1 | - | 6 | - | 12 | |
| 5 | 2 | | I | M | 1.8 | - | 3.3 | - | 6 | |
| 5 | 6 | Belotia | III | 14.2 | 18.9 | - | 6.3 | - | 12 | |
| 5 | 6 | Conostegia | I | * | 1.8 | - | .4 | - | 1.8 | |
| 7 | 0 | Croton | | | | | | | | Dead or dying |
| 8 | 3 | Andira | I | 8.8 | 9.4 | - | 4.5 | - | 6.9 | |
| 8 | 3 | | I | 2.5 | 3.2 | - | 2.8 | - | 3.6 | |

| E2 | E1 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|---------------|-------|------------|------------|--------------|------------|------------|------------|---------|
| D2 | D1 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 6 | | III | * | 5.5 | - | 5.4 | - | 6.6 | |
| 0 | 8 | Anacardium | I | | 32.1 | 32.1 | - | 4.5 | - | 36 |
| 1 | 2 | | VII | | 3.5 | 4.4 | - | 4.5 | - | 6 |
| 1 | 3 | | | Dead | | | | | | Dead |
| 1 | 3 | | | Dead | | | | | | Dead |
| 1 | 0 | | | | 3.5 | | | | | Missing |
| 1 | 6 | | VII | M | | 3.1 | - | .5 | - | 1.8 |
| 1 | 9 | Chrysophyllum | I | * | | 2.3 | - | .8 | - | 3.9 |
| 2 | 2 | | | Dead | | | | | | Dead |
| 2 | 5 | | VII | M | | 2.7 | - | 4.2 | - | 6 |
| 2 | 7 | | VII | M | | 3.7 | - | 5.1 | - | 5.1 |
| 2 | 7 | | VII | M | | 3.7 | - | 1.5 | - | 2.0 |
| 2 | 7 | | VII | M | | 3.1 | - | 5.7 | - | 5.7 |
| 3 | 1 | | VII | | 2.5 | 2.7 | - | 1.8 | - | 3.6 |
| 3 | 1 | | VII | | 3.7 | 3.7 | - | 4.2 | - | 5.4 |
| 3 | 1 | | VII | | | 3.1 | - | 4.2 | - | 4.5 |
| 3 | 2 | | VII | | | | | | | Dead |
| 3 | 2 | | VII | | 3.7 | 3.7 | - | 4.2 | - | 6 |
| 3 | 3 | | VII | | 3.0 | 3.4 | - | 6 | - | 7.6 |
| 3 | 7 | | VII | M | | 3.4 | - | .7 | - | 3.6 |
| 3 | 8 | | VII | M | | 3.7 | - | 3.9 | - | 6 |
| 4 | 1 | | VII | | 3.7 | 3.7 | - | 5.1 | - | 6 |
| 4 | 7 | | VII | M | | 3.1 | - | .5 | - | 3.6 |
| 4 | 8 | | I | * | | 2.3 | - | .5 | - | 3.6 |
| 5 | 0 | | VII | | 3.7 | 3.7 | - | 1.7 | - | 3.6 |
| 5 | 1 | | | | | | | | | Missing |
| 5 | 2 | | I | M | | 28.4 | - | | - | 4.5 |
| 5 | 5 | | VII | M | | 2.7 | - | | - | 1.5 |
| 5 | 5 | | VII | M | | 3.4 | - | .8 | - | 1.8 |
| 5 | 6 | | VII | M | | 2.1 | - | .5 | - | 1.8 |
| 5 | 6 | | VII | M | | 3.7 | - | .7 | - | 1.8 |
| 6 | 0 | | VII | | 3.7 | 3.7 | - | 3.9 | - | 4.5 |
| 6 | 1 | | VII | | 3.0 | 3.7 | - | 4.2 | - | 5.7 |
| 6 | 1 | | VII | | 4.1 | 4.4 | - | 6 | - | 8.2 |
| 6 | 5 | Genipa | III | | 14.2 | 14.3 | - | 4.2 | - | 17.5 |
| 7 | 1 | | VII | | 4.1 | 5 | - | 2.8 | - | 4.2 |
| 8 | 6 | | IV | M | | 1.9 | - | .3 | - | 1.8 |
| 9 | 4 | | IV | M | | 3.6 | - | .4 | - | 4.2 |
| 9 | 5 | Annona | I | | 6.0 | 6.2 | - | 1.2 | - | 6 |
| 9 | 6 | | I | Dying | | | | | | Chopped |
| 9 | 7 | | III | | 20.9 | 21.0 | - | 13 | - | 17.5 |
| 9 | 7 | | III | | 21.7 | 22.0 | - | 12 | - | 21.5 |
| 9 | 7 | Annona | I | M | | 1.8 | - | .5 | - | .8 |

| D6 D5 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS. |
|-------|----|-------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|----------|
| 06 | C5 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 0 | Copaifera | III | 5.5 | 5.8 | - | 2.8 | - | 6 | |
| 0 | 6 | | I | 13.1 | 13.1 | - | 7 | - | 10 | |
| 0 | 7 | | III | M | 2.4 | - | 3.3 | - | 5.7 | |
| 1 | 6 | | I | 13.4 | 13.5 | - | 8 | - | 11 | |
| 5 | 5 | Anacardium | I | 21.7 | 23.2 | - | 3.6 | - | 12.5 | |
| 7 | 1 | Sapindaceae | I | 14.7 | 15.1 | - | 7 | - | 12.5 | |
| 7 | 7 | | III | 6.0 | 6.0 | - | 5.4 | - | 6 | |
| 8 | 0 | Spondias | I | 12.1 | 12.1 | - | 6 | - | 9.5 | |
| 8 | 5 | Ficus | I | 64.4 | 71.3 | - | 6.4 | - | 26.5 | |

| D5 D4 | | | D B H | | FIRST BRANCH | | HEIGHT | | |
|-------|---------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|------------------|
| C5 C4 | SPECIES | SHAPE | C M | | M | | M | | REMARKS |
| X Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 1 1 | Croton | | | | | | | | Dead or dying |
| 1 4 | Palicourea | I | * | 3.0 | - | 1.2 | - | 4.5 | |
| 2 3 | Cordia | III | 10.9 | 10.9 | - | 10 | - | 14 | |
| 2 6 | Alibertia | I | * | 2.6 | - | 1.8 | - | 3.3 | |
| 3 3 | | I | * | 2.7 | - | 1.2 | - | 3.3 | |
| 3 4 | Ardesia | I | 2.5 | 3.0 | - | .8 | - | 1.8 | |
| 5 5 | | VII | 3.7 | 3.7 | - | 1.8 | - | 4.2 | |
| 5 7 | Alibertia | I | * | 2.8 | - | 1.5 | - | 2.8 | |
| 6 6 | | VII | M | 3.4 | - | 1.8 | - | 3.6 | |
| 6 6 | | VII | 3.7 | 3.7 | - | .8 | - | 2.8 | |
| 7 0 | Phoebe | I | 34.5 | 35.1 | - | 11.5 | - | 26.0 | |
| 7 6 | Anacardium | I | 19.0 | 19.0 | - | 6 | - | 20.5 | |
| 8 6 | Inga | I | 9.8 | 9.9 | - | 6 | - | 12 | |
| 8 6 | Inga | I | 7.6 | 8.2 | - | 6 | - | 10 | |
| 9 2 | Chrysophyllum | I | 6.6 | 6.8 | - | 3.3 | - | 6.9 | |

| D4 D3 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS | |
|-------|---|---------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|------|
| C4 C3 | | | | C M | | M | | M | | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 0 | 0 | Lauraceae | IV | | 3.1 | - | .8 | - | 3.9 | | |
| 0 | 3 | Alibertia | I | * | 2.4 | - | 1.2 | - | 3.9 | | |
| 3 | 7 | Chrusophyllum | I | | 2.8 | | 3.0 | - | 1.5 | - | 4.2 |
| 3 | 8 | Spondias | I | M | 64.8 | - | 14 | - | | | 26.5 |
| 3 | 8 | | VII | | 3.0 | | 3.4 | - | 4.2 | - | 5.4 |
| 3 | 8 | | VII | | 4.4 | | 4.4 | - | 2.8 | - | 4.5 |
| 3 | 9 | | I | * | 2.6 | - | 2.5 | - | | | 3.9 |
| 6 | 0 | Anacardium | I | | 12.3 | | 12.9 | - | 4.2 | - | 4.2 |
| 6 | 0 | Copaifera | I | | 7.6 | | 8.0 | - | 4.5 | - | 6.9 |
| 8 | 2 | Annona | I | | 3.0 | | 3.4 | - | 2.5 | - | 4.2 |
| 8 | 8 | | VII | | 2.5 | | 2.5 | - | 3 | - | 3 |
| 8 | 8 | | VII | | 3.1 | | 3.1 | - | 2.5 | - | 2.5 |
| 8 | 8 | | VII | | 3.5 | | 3.7 | - | 3.3 | - | 4.5 |
| 8 | 8 | | VII | M | 3.1 | | 3.1 | - | 2.8 | - | 3.6 |
| 9 | 4 | | I | | 3 | | 3 | - | 2.8 | - | 4.8 |

| D3 | D2 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|--------------|-------|-------|-------|--------------|-------|--------|-------|-----------------|
| C3 | C2 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun | 1 Jan | 4 Jun | 1 Jan | 4 Jun | 1 Jan | |
| | | 1966 | 1967 | 1967 | 1967 | 1967 | 1967 | 1967 | | |
| 1 | 7 | Psychotria | | | | | | | | Dead or Chopped |
| 2 | 0 | | VII | 5 | 5 | - | 3.6 | - | 5.1 | |
| 2 | 0 | | VII | 2.5 | 2.5 | - | 1.2 | - | 3.3 | |
| 2 | 0 | Apocynaceae | I | 4.5 | 4.5 | - | 1.5 | - | 4.2 | |
| 2 | 2 | | I | M | 2.8 | - | .3 | - | .8 | |
| 3 | 0 | | VII | 2.5 | 2.5 | - | .3 | - | 3.6 | |
| 3 | 0 | | VII | 3.1 | 3.1 | - | 3.6 | - | 4.2 | |
| 3 | 0 | | VII | M | 2.5 | - | 3.6 | - | 4.2 | |
| 3 | 0 | | VII | M | 2.5 | - | 1.2 | - | 3.3 | |
| 3 | 6 | Alibertia | II | * | 2.0 | - | .8 | - | 2.8 | |
| 3 | 8 | | VII | 4.3 | 4.4 | - | 3.9 | - | 5.7 | |
| 3 | 8 | | VII | 3.7 | 3.7 | - | 3.6 | - | 4.5 | |
| 3 | 8 | | VII | 4.6 | 5 | - | 4.5 | - | 6.4 | |
| 3 | 8 | | VII | 3.1 | 3.1 | - | 6 | - | 7.6 | |
| 3 | 9 | | III | 4.6 | 4.8 | - | 4.5 | - | 6 | |
| 4 | 5 | Alibertia | I | 2.2 | 2.2 | - | 1.2 | - | 3.6 | |
| 4 | 8 | | VII | 3.7 | 3.7 | - | 5.4 | - | 7.6 | |
| 4 | 8 | | VII | 3.1 | 3.1 | - | 1.2 | - | 3 | |
| 4 | 8 | | VII | 3.7 | 3.7 | - | 5.4 | - | 6.9 | |
| 4 | 8 | | VII | 3.1 | 3.1 | - | 3.9 | - | 4.5 | |
| 5 | 6 | | VII | 2.5 | 2.5 | - | 3.9 | - | 4.5 | |
| 5 | 7 | | VII | 3.3 | 3.7 | - | 3.9 | - | 5.4 | |
| 6 | 1 | | IV | M | 2.0 | - | .8 | - | 4.2 | |
| 6 | 1 | | I | M | 2.2 | - | 1.2 | - | 3.6 | |
| 6 | 4 | Hirtella | II | 2.2 | 2.2 | - | .3 | - | 1.5 | |
| 6 | 5 | | VII | M | 1.2 | - | .3 | - | 2.8 | |
| 6 | 5 | | VII | 3.5 | 3.7 | - | 3.6 | - | 4.2 | |
| 6 | 6 | | VII | 3.1 | 3.1 | - | 3.9 | - | 4.5 | |
| 6 | 6 | | VII | 2.5 | 2.5 | - | 5.4 | - | 6.6 | |
| 6 | 6 | | VII | 2.5 | 2.5 | - | 2.5 | - | 3.6 | |
| 7 | 3 | | IV | M | 2.2 | - | 1.5 | - | 3.9 | |
| 7 | 5 | | VII | M | 1.2 | - | 4.2 | - | 6 | |
| 7 | 5 | | VII | 4.1 | 5 | - | 4.5 | - | 6 | |
| 7 | 5 | | VII | 2.5 | 2.5 | - | 1.2 | - | 4.2 | |
| 7 | 6 | | VII | 3.8 | 4.4 | - | 4.5 | - | 5.1 | |
| 8 | 0 | Pit toniotis | I | 3.0 | 3.4 | - | 1.8 | - | 4.2 | |
| 8 | 1 | | I | M | 2.0 | - | 1.9 | - | 3.9 | |
| 8 | 1 | | I | M | 2.4 | - | 1.5 | - | 3.9 | |
| 8 | 7 | | VII | 2.5 | 2.5 | - | .3 | - | 2.8 | |
| 8 | 8 | | VII | 3.5 | 3.7 | - | 4.2 | - | 6 | |

| D2 | D1 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|-------------|-------|-------|-------|--------------|-------|--------|-------|-----------------|
| C2 | C1 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun | 1 Jan | 4 Jun | 1 Jan | 4 Jun | 1 Jan | |
| | | 1966 | 1967 | 1967 | 1967 | 1967 | 1967 | | | |
| 0 | 2 | Annona | II | * | 2.4 | - | - | - | 4.2 | |
| 0 | 4 | Anacardium | IV | | 17.8 | 19.4 | - | 3.9 | 14 | |
| 0 | 7 | | III | | 12.5 | 12.5 | - | 7 | 14 | |
| 0 | 8 | | VII | M | | 3.7 | - | .8 | 3.6 | |
| 1 | 7 | Anacardium | VII | | 3.7 | 3.7 | - | 1.2 | 3.6 | |
| 1 | 8 | | VII | M | | 2.5 | - | .8 | 2.0 | |
| 1 | 8 | | VII | M | | 3.7 | - | 4.2 | 6 | |
| 1 | 9 | | VII | | 3.2 | 3.2 | - | 6 | 6.4 | |
| 2 | 7 | | III | | 14.4 | 15.9 | - | 1.8 | 11.5' | |
| 2 | 9 | | VII | | 3.6 | 3.6 | - | 7.2 | 8.4 | |
| 3 | 2 | Croton | IV | | 2.8 | 3.2 | - | .3 | 4.5 | |
| 3 | 4 | Posequeria | III | | 8.1 | 8.6 | - | 4.5 | 6.6 | |
| 3 | 7 | | VII | M | | 3.7 | - | 4.2 | 5.7 | |
| 3 | 7 | | VII | | 3.7 | 3.7 | - | 1.8 | 4.2 | |
| 3 | 7 | | VII | | 3.7 | 3.7 | - | 1.5 | 3.9 | |
| 3 | 8 | | VII | M | | 3.7 | - | 1.2 | 3.9 | |
| 3 | 8 | | VII | | 4.1 | 4.4 | - | 5.7 | 8.2 | |
| 3 | 8 | | VII | | 3.7 | 3.7 | - | 3.6 | 4.5 | |
| 5 | 0 | | I | M | | 2.4 | - | .8 | 3.6 | |
| 5 | 1 | | I | M | | 2.4 | - | .5 | 4.2 | |
| 5 | 3 | | III | M | | 2.6 | - | .8 | 1.2 | |
| 5 | 7 | | I | | 4.6 | 4.6 | - | 1.8 | 4.5 | |
| 5 | 8 | | VII | | 3.5 | 3.7 | - | 4.2 | 5.4 | |
| 5 | 9 | | VII | | 4.3 | 4.4 | - | 5.7 | 7.6 | |
| 5 | 9 | | VII | | 3.3 | 3.7 | - | 4.5 | 6 | |
| 6 | 0 | | I | M | | 2.0 | - | .8 | 3.6 | |
| 6 | 8 | Luehea | IV | | 35.3 | 36.5 | - | 6.6 | 16 | |
| 6 | 9 | | VII | M | | 3.7 | - | 1.8 | 3.6 | |
| 7 | 2 | | IV | M | | 2.8 | - | - | 3.6 | |
| 7 | 5 | Alibertia | III | * | | 1.8 | - | 3 | 4.2 | |
| 7 | 5 | Palicourea | I | | 2.5 | 2.6 | - | .5 | 3.9 | |
| 7 | 5 | | | M | | | - | - | | Missing chopped |
| 8 | 1 | Pittoniotis | I | | 2.5 | 2.8 | - | .3 | 4.5 | |
| 8 | 2 | Anacardium | I | M | | 2.4 | - | .8 | 3.6 | |
| 8 | 6 | | I | | 3.3 | 3.6 | - | 3.6 | 4.5 | |
| 8 | 7 | Miconia | I | | 2.5 | 2.8 | - | 1.8 | 5.4 | |
| 8 | 7 | Psychotria | IV | * | | 1.6 | - | 3 | 3.6 | |
| 9 | 0 | | I | | 2.5 | 3.4 | - | 2.8 | 3.9 | |
| 9 | 1 | | III | M | | 1.8 | - | .3 | 3.9 | |
| 9 | 3 | | IV | | 2.8 | 3.4 | - | 3 | 6 | |

| C7 C6 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|--------------------|
| B7 B6 | | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 4 | Miconia | I | 3.5 | 23.2 | - | 1.5 | - | 20 | |
| 1 | 5 | Costus | III | 4.2 | 4.2 | - | 2.5 | - | 3.6 | |
| 1 | 6 | Costus | III | 4.0 | 4.0 | - | 2.5 | - | 3.3 | |
| 2 | 2 | Hirtella | I | 3.3 | 4.5 | - | 1.5 | - | 3 | |
| 2 | 6 | | | | | | | | | Dead or Chopped |
| 3 | 2 | | III | M | 2.7 | - | 3.3 | - | 4.2 | |
| 3 | 4 | Posequeria | | | | | | | | Chopped Dead |
| 4 | 3 | | I | 4.2 | 4.2 | - | .8 | - | 3.3 | |
| 4 | 7 | Belotia | III | | | | | | | Dead |
| 5 | 7 | Trema | III | | | | | | | Dead |
| 5 | 8 | Belotia | III | 5.5 | 8.6 | - | 6.5 | - | 10.5 | |
| 5 | 8 | Croton | III | 2.7 | 2.7 | - | 3.9 | - | 4.8 | |
| 5 | 8 | | III | 2.8 | 2.8 | - | 2.8 | - | 4.5 | |
| 5 | 9 | Belotia | III | 2.5 | 3.2 | - | 8.5 | - | 11.5 | |
| 6 | 2 | Bursera | III | 12.9 | 14.3 | - | 6 | - | 8 | |
| 6 | 2 | Bursera | III | 12.5 | 12.5 | - | 6 | - | 10 | |
| 7 | 8 | | III | M | 6.2 | - | 9 | - | 10 | |
| 7 | 9 | Belotia | III | 4.8 | 9 | - | 7 | - | 13 | |
| 8 | 5 | Costus | III | 2.4 | 2.4 | - | 1.2 | - | 1.9 | |
| 8 | 5 | Costus | III | M | 2.0 | - | 2.8 | - | 3.3 | |
| 8 | 5 | Costus | III | M | 2.0 | - | 3 | - | 3.6 | |
| 8 | 6 | | III | 2.5 | 2.5 | - | 1.2 | - | 3.6 | |
| 9 | 9 | Annona | II | 3.0 | 3.4 | - | .2 | - | 5.1 | |

| C6 C5 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|-----|------------|-------|-------|------------|--------------|-----|------------|------|---------|
| B6 B5 | X Y | | | C M | 1 Jun 1966 | 1 Jan 1967 | M | 1 Jan 1967 | M | |
| 0 | 6 | Nectandra | II | 3.0 | 3.1 | - | | - | 3.6 | |
| 0 | 9 | | I | M | 5.8 | - | 3 | - | 5.4 | |
| 3 | 3 | Posequeria | II | 2.5 | 3 | - | | - | 2.8 | |
| 3 | 7 | Rubiaceae | I | 17.5 | 19 | - | 4.5 | - | 13.5 | |
| 5 | 1 | Inga | I | 4.1 | 4.2 | - | 1.2 | - | 2.8 | |
| 6 | 9 | | III | M | 12.4 | - | 7 | - | 12.5 | |

| C5 C4 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|---------------|---------------|---------------|---------------|---------------|---------------|-------|---------|
| B5 B4 | | | | 1 Jun | 1 Jan | 4 Jun | 1 Jan | 4 Jun | 1 Jan | |
| X | Y | | | C M | C M | M | M | M | M | |
| | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 1 | 1 | | | 25.4 | - | 6.4 | - | 15.5 | | |
| 1 | 1 | | III | 3.8 | 4.4 | - | 2.5 | - | 5.1 | |
| 2 | 5 | | I | M | 3.0 | - | 1.2 | - | 2.3 | |
| 3 | 9 | Luehea | I | 11.0 | 17.1 | - | 2.8 | - | 7.6 | |
| 4 | 1 | Randia | I | 2.8 | 3.0 | - | .8 | - | 4.2 | |
| 4 | 1 | Hirtella | II | 2.5 | 3.0 | - | .2 | - | 5.1 | |
| 5 | 2 | Alibertia | I | * | 1.8 | - | .7 | - | 3.3 | |
| 6 | 0 | Randia | I | 2.8 | 3.0 | - | 2.0 | - | 4.5 | |
| 7 | 7 | Posequeria | II | 2.5 | 3.4 | - | .3 | - | 5.1 | |
| 8 | 4 | | VII | 2.8 | 3.1 | - | .7 | - | 2.8 | |
| 8 | 4 | | VII | | | | | | Dead | |
| 9 | 6 | | III | M | 2.4 | - | 2.0 | - | 3.6 | |

| C4 C3 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| B4 B3 | | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 3 | | I | 2.5 | 2.6 | - | 1.9 | - | 3.6 | |
| 0 | 5 | | III | M | 2.1 | - | 2.0 | - | 2.8 | |
| 1 | 4 | Anacardium | I | 8.3 | 8.5 | - | 3.3 | - | 6.6 | |
| 2 | 3 | Inga | I | 22.0 | 22.0 | - | 6 | - | 22 | |
| 3 | 0 | | III | M | 2.7 | - | 1.8 | - | 2.8 | |
| 3 | 6 | Lafoensia | I | 5.1 | 5.2 | - | 2.5 | - | 7.6 | |
| 3 | 7 | Rubiaceae | I | 3.3 | 3.4 | - | .7 | - | 4.2 | |
| 4 | 3 | | II | M | 2.8 | - | .7 | - | 2.5 | |
| 6 | 2 | Anacardium | I | 6.3 | 6.8 | - | 2.8 | - | 5.4 | |
| 6 | 9 | Anacardium | I | M | 12.7 | - | 3 | - | 12.5 | |
| 7 | 8 | Luehea | I | 67.3 | 68.3 | - | 14 | - | 28 | |
| 8 | 5 | Palicourea | III | 2.5 | 3.0 | - | 2.5 | - | 5.4 | |

| C3 C2 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|----|------------|-------|---------------|---------------|---------------|---------------|---------------|------------------|---------|
| B3 | B2 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 6 | | 2.5 | | - | | - | | Missing | |
| 2 | 4 | | II M | 2.8 | - | .8 | - | 4.2 | | |
| 2 | 6 | | V M | 3 | - | 2.8 | - | 5.4 | | |
| 2 | 8 | Xylopia | III | 18.0 | 18.5 | - | 14 | - | 18.5 | |
| 3 | 6 | | VII | 3.0 | 3.1 | - | 3.9 | - | 5.4 | |
| 3 | 7 | | VII | 3.3 | 4.4 | - | 3.3 | - | 4.5 | |
| 4 | 2 | | VII | 3.3 | 3.7 | - | 3.6 | - | 4.2 | |
| 4 | 3 | | VII | 4.1 | 4.4 | - | 3.6 | - | 4.8 | |
| 4 | 3 | | VII | 2.5 | 2.5 | - | 4.5 | - | 3.6 | |
| 4 | 3 | | VII | 2.5 | 2.5 | - | 1.5 | - | 3.6 | |
| 4 | 4 | | VII | 3.7 | 3.7 | - | 3.9 | - | 4.8 | |
| 4 | 4 | | VII | 4.1 | 4.4 | - | 1.5 | - | 3.6 | |
| 4 | 5 | | III | | | | | | Dead or dying | |
| 4 | 6 | | VII | 3.1 | 3.1 | - | 4.2 | - | 6 | |
| 4 | 7 | | VII | | | | | | Dead or dying | |
| 4 | 7 | | VII | 3.7 | 3.7 | - | 4.2 | - | 5.4 | |
| 4 | 7 | | VII | 2.5 | 2.5 | - | 1.2 | - | 3 | |
| 4 | 8 | | VII M | 2.5 | 2.5 | - | 1.2 | - | 3.3 | |
| 5 | 1 | | I | 2.5 | 3.0 | - | 3.3 | - | 5.4 | |
| 5 | 3 | | VII | 3.7 | 3.7 | - | 3.9 | - | 5.7 | |
| 5 | 8 | | VII | 3.7 | 3.7 | - | 4.2 | - | 6 | |
| 5 | 4 | | VII | 3 | 3.1 | - | 4.5 | - | 4.8 | |
| 5 | 5 | | VII | 3.5 | 3.7 | - | 4.5 | - | 5.4 | |
| 5 | 7 | | VII | 3.0 | 3.1 | - | 4.2 | - | 4.8 | |
| 5 | 7 | | VII | 2.8 | 3.1 | - | 1.8 | - | 4.5 | |
| 6 | 4 | | VII | 2.8 | 3.7 | - | 2.8 | - | 3.6 | |
| 6 | 4 | | VII | 2.8 | 3.1 | - | 4.5 | - | 5.1 | |
| 6 | 4 | | VII | | | | | | Dying | |
| 6 | 5 | | VII | 3.1 | 3.1 | - | 4.2 | - | 6 | |
| 6 | 6 | Luehea | I | 10.3 | 10.3 | - | 6 | - | 24 | |
| 6 | 6 | | VII | 3.1 | 3.1 | - | 3.9 | - | 4.5 | |
| 6 | 6 | | VII | 3.3 | 3.7 | - | 4.5 | - | 6 | |
| 6 | 6 | | VII M | | 3.7 | - | 3.6 | - | 4.2 | |
| 6 | 6 | | VII M | | 3.1 | - | 3.6 | - | 4.5 | |
| 6 | 7 | | VII M | | 3.7 | - | 3.3 | - | 4.2 | |
| 6 | 7 | | VII | 2.5 | 2.5 | - | .8 | - | 3 | |
| 7 | 3 | Anacardium | I | 61.0 | 61.0 | - | 12 | - | 34 | |
| 9 | 6 | | II M | | 3.6 | - | | - | 2.5 | |

| C2 | C1 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS | |
|----|----|----------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|-------------------|-----|
| B2 | B1 | | | C M | | M | | M | | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 0 | 1 | Luehea | I | * | 22.0 | - | - | - | 5.4 | Dead or broken | |
| 0 | 1 | | | | | | | | | | |
| 0 | 1 | | I | M | 2.4 | - | 1.2 | - | 3.6 | Missing | |
| 0 | 7 | Rourea | | | 3.8 | - | - | - | - | | |
| 1 | 3 | Spondias | I | | 39.2 | 39.2 | - | 10.5 | - | 25 | |
| 1 | 5 | Talisia | III | | 4.1 | 4.8 | - | 4.8 | - | 6 | |
| 1 | 9 | Vine | | | * | | | | | | |
| 4 | 0 | Anacardium | I | | 23 | 23 | - | 6.9 | - | 15 | |
| 4 | 0 | | II | M | | 2.2 | - | .5 | - | 2.8 | |
| 3 | 8 | | | | 2.4 | 2.4 | - | .8 | - | 2.5 | |
| 4 | 3 | | III | | 4.8 | 5.2 | - | 4.2 | - | 6 | |
| 4 | 4 | Lacistema | I | | 2.8 | 3.4 | - | 2.0 | - | 4.2 | |
| 5 | 6 | | VII | | 3.5 | 3.7 | - | 2.8 | - | 4.2 | |
| 5 | 6 | | VII | | 3.5 | | - | .8 | - | 1.8 | |
| 6 | 0 | Miconia | IV | | 2.5 | | - | .5 | - | 3.3 | |
| 7 | 3 | | II | M | | 2.4 | - | 1.8 | - | 3.6 | |
| 7 | 3 | | II | M | | 2.4 | - | 1.5 | - | 3.6 | |
| 7 | 1 | Lafoensia | I | | 2.8 | 3.4 | - | 1.2 | - | 3.6 | |
| 7 | 8 | | I | | 2.6 | 2.6 | - | 1.6 | - | 3.6 | |
| 7 | 9 | | I | M | | | - | .5 | - | 4.5 | |
| 7 | 9 | | I | M | | 2.8 | - | .8 | - | 5.1 | |
| 8 | 2 | Flacourtiaceae | I | | 3.5 | 4.8 | - | 1.5 | - | 4.5 | |
| 8 | 5 | | | | | | | | | Chopped | |
| 8 | 6 | | VII | | 2.8 | 5.6 | - | 1.8 | - | | 3.9 |
| 8 | 7 | | VII | | 4.3 | 5 | - | 1.8 | - | | 5.1 |

| B7 B6 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|-------|------------|------------|--------------|------------|------------|------------|---------|
| A7 A6 | | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 1 | | M | | | | | | | Missing |
| 0 | 8 | | M | 3.2 | - | 3 | - | 4.5 | | |
| 0 | 8 | | 4.1 | 4.2 | - | 2.8 | - | 4.2 | | |
| 0 | 8 | | 4 | 4 | - | 2.5 | - | 4.8 | | |
| 0 | 8 | | M | 4 | - | 2.8 | - | 5.1 | | |
| 0 | 8 | | M | 4.2 | - | 1.8 | - | 4.5 | | |
| 0 | 9 | Cecropia | III | 16.8 | 17.5 | - | 8 | - | 19 | |
| 1 | 8 | | V | 3.0 | 4 | - | 3 | - | 5.1 | |
| 1 | 3 | Croton | II | 3.5 | 4.2 | - | | - | 3.3 | |
| 1 | 8 | | M | 4 | - | 3 | - | 5.1 | | |
| 1 | 8 | | V | 3.0 | 4.4 | - | .8 | - | 4.8 | |
| 2 | 7 | Croton | I | | | | | | | Dead |
| 3 | 1 | Inga | III | 4 | 4 | - | 3.9 | - | 5.1 | |
| 3 | 9 | Piper | I | 2.5 | 2.7 | - | .8 | - | 3.3 | |
| 5 | 1 | | VII | 2.7 | 2.7 | - | 5.4 | - | 6.9 | |
| 5 | 1 | | VII | 3.1 | 3.1 | - | 3.6 | - | 5.7 | |
| 5 | 2 | | | 2.8 | 3.4 | - | 3 | - | 4.5 | |
| 5 | 2 | | VII | | | | | | | Dead |
| 5 | 7 | Anacardium | I | 23.2 | 25 | - | 2.7 | - | 18 | |
| 6 | 1 | | VII | 3.7 | 3.7 | - | 3.9 | - | 6 | |
| 6 | 1 | | VII | 2.8 | 3.4 | - | .8 | - | 2.8 | |
| 6 | 2 | | VII | 2.5 | 3.7 | - | 3.6 | - | 5.4 | |
| 6 | 2 | | VII | 2.7 | 2.7 | - | 4.8 | - | 5.4 | |
| 6 | 2 | | VII | 3.7 | 3.7 | - | 3 | - | 4.8 | |
| 6 | 3 | Copaifera | III | 4.6 | 5.0 | - | 3.3 | - | 3.9 | |

| B6 | B5 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|
| A6 | A5 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 2 | Andira | I | 10.3 | 10.5 | - | 2.8 | - | 6.9 | |
| 0 | 5 | | I | M | 3.4 | - | 1 | - | 2.5 | |
| 0 | 9 | Annona | I | 25 | 25 | - | 5.7 | - | 16 | |
| 1 | 2 | | IV | M | 1.8 | - | | - | 3.3 | |
| 2 | 1 | | | | | | | | | Dead |
| 2 | 4 | | VII | 3.7 | 3.7 | - | 2.0 | - | 3 | |
| 2 | 8 | | I | 21 | 21 | - | 48 | - | 14.5 | |
| 3 | 3 | | VII | 3.3 | 3.7 | - | 3 | - | 4.2 | |
| 3 | 3 | | VII | 3.4 | 3.4 | - | 3.6 | - | 4.5 | |
| 3 | 4 | | VII | 3.4 | 3.4 | - | 3.6 | - | 5.1 | |
| 3 | 5 | | VII | 3.7 | 3.7 | - | 3 | - | 4.2 | |
| 3 | 5 | | VII | 3.1 | 3.1 | - | 1 | - | 2.9 | |
| 3 | 5 | | VII | 2.7 | 2.7 | - | 1.8 | - | 3 | |
| 3 | 7 | Lafoesia | III | 7.1 | 8.2 | - | 3.6 | - | 5.4 | |
| 4 | 4 | | VII | 3.0 | 3.7 | - | 2.5 | - | 3.9 | |
| 4 | 4 | | VII | 3.1 | 3.1 | - | 3 | - | 5.4 | |
| 4 | 4 | | VII | 2.5 | 2.5 | - | 2.5 | - | 3.9 | |
| 4 | 8 | Posequeria | I | 3.0 | 3.0 | - | 1.2 | - | 3.9 | |
| 6 | 4 | | I | 2.8 | 3 | - | 1.8 | - | 3.3 | |
| 6 | 5 | | I | 3.0 | 3 | - | .8 | - | 2.8 | |
| 8 | 9 | Anacardium | I | 4.8 | 5.1 | - | .8 | - | 4.5 | |
| 9 | 2 | Croton | I | 1.8 | 1.8 | - | .8 | - | 2.8 | |
| 9 | 8 | | | | | | | | | Does not exist |

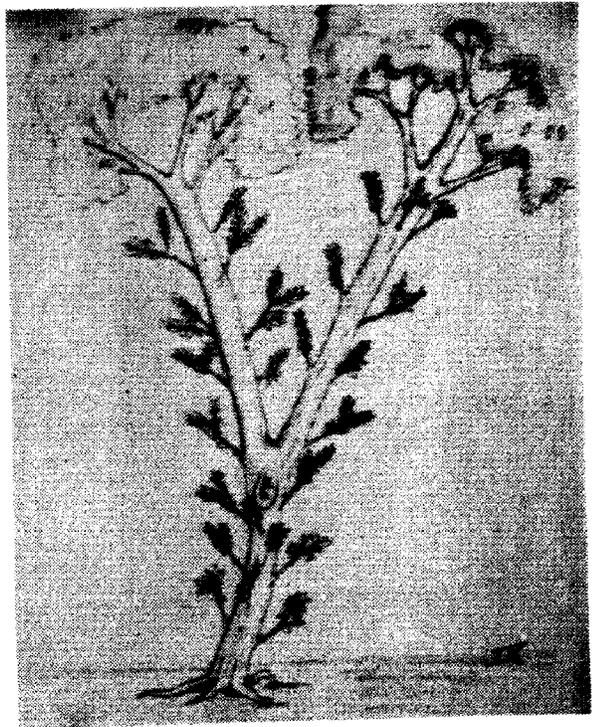
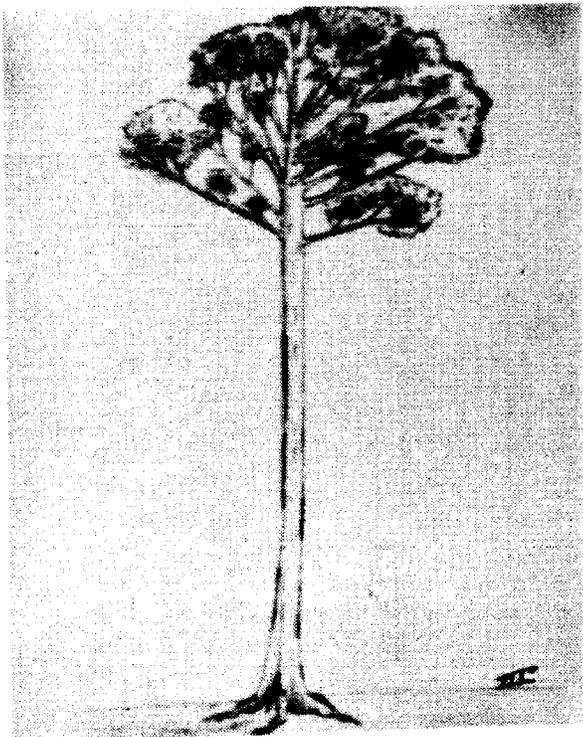
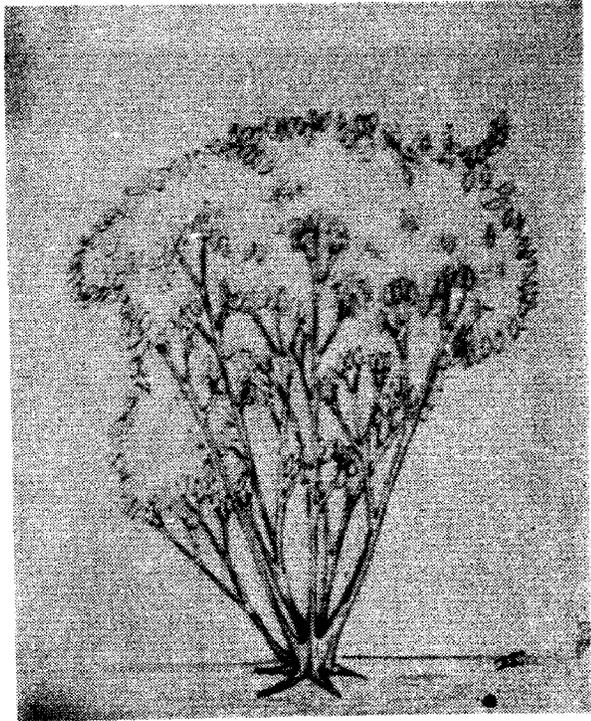
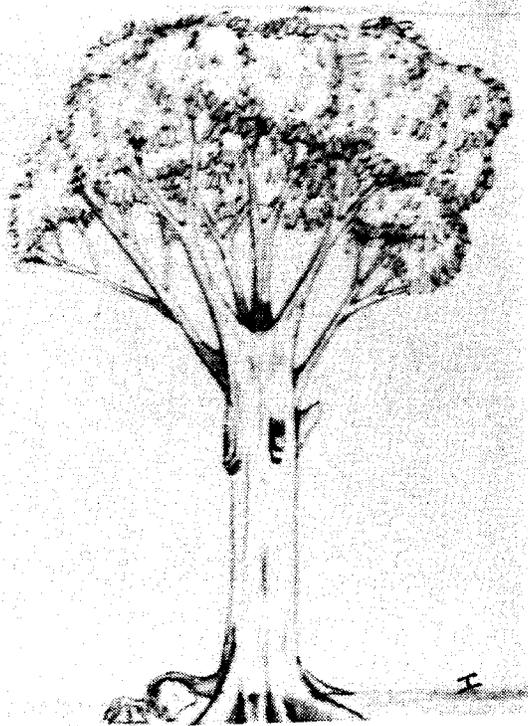
| B5 | B4 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|----------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| A5 | A4 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 4 | | I | M | 2.7 | - | .8 | - | 3.3 | |
| 0 | 4 | | | | | | | | | Dead |
| 0 | 8 | | I | M | 2.4 | - | 1.2 | - | 4.5 | |
| 0 | 8 | | I | M | 9.2 | - | .8 | - | 6.6 | |
| 1 | 0 | | V | | 3.5 | - | 3 | - | 5.4 | |
| 1 | 1 | | V | | 3.1 | - | 1.8 | - | 3.6 | |
| 1 | 2 | | I | M | 3.1 | - | 1.5 | - | 3 | |
| 1 | 2 | | IV | M | 2.1 | - | .3 | - | 2.5 | |
| 1 | 3 | | IV | M | 3.0 | - | .5 | - | 1.8 | |
| 2 | 0 | | V | | 4.1 | - | 2.0 | - | 5.4 | |
| 2 | 0 | | V | | 4.1 | - | 3 | - | 5.1 | |
| 2 | 1 | | V | | 3.2 | - | 1.9 | - | 4.5 | |
| 2 | 1 | | I | | 3.4 | - | 3.3 | - | 6 | |
| 2 | 6 | | IV | | 4 | - | .3 | - | 3.3 | |
| 3 | 4 | Lafoensia | III | | 10.1 | - | 10 | - | 12 | |
| 4 | 9 | | II | M | 4.0 | - | 1.5 | - | 1.7 | |
| 8 | 1 | | I | M | 2.5 | - | .5 | - | 2.8 | |
| 6 | 8 | Spondias | I | | 33.3 | - | 12 | - | 24.5 | |
| 9 | 5 | Flacourtiaceae | III | | 4.6 | - | 4.8 | - | 5.4 | |

| B4 B3 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---|------------|-------|-------|-------|--------------|-------|--------|-------|---------|
| A4 A3 | | | | 1 Jun | 1 Jan | 4 Jun | 1 Jan | 4 Jun | 1 Jan | |
| X | Y | | | 1966 | 1967 | 1967 | 1967 | 1967 | 1967 | |
| 0 | 7 | Luehea | I | 26.8 | 26.8 | - | 6 | - | 13.5 | |
| 1 | 4 | Annona | III | 2.5 | 4.9 | - | 4.5 | - | 6 | |
| 1 | 9 | | III | 9.6 | 9.9 | - | 6 | - | 8.4 | |
| 2 | 3 | | I | M | 3.4 | - | 1.5 | - | 3.9 | |
| 2 | 6 | Luehea | I | 71.0 | 74.3 | - | 12 | - | 26 | |
| 2 | 6 | | III | M | 2.8 | - | 3 | - | 4.8 | |
| 4 | 6 | Anacardium | I | 4.6 | 5.2 | - | 2.8 | - | 4.8 | |
| 9 | 2 | Anacardium | I | 41.9 | 45.8 | - | 3.3 | - | 28 | |

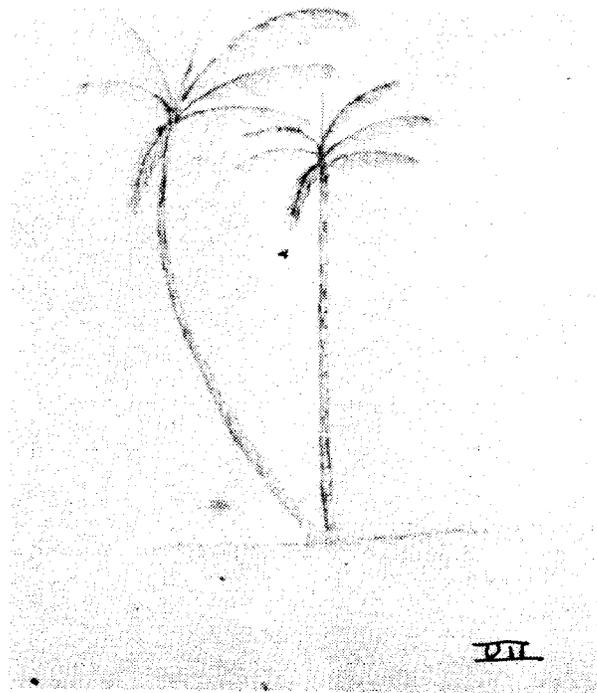
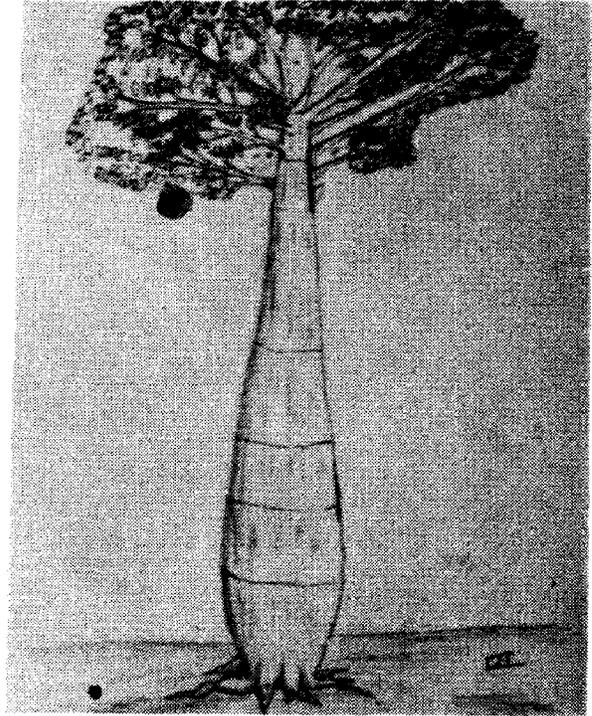
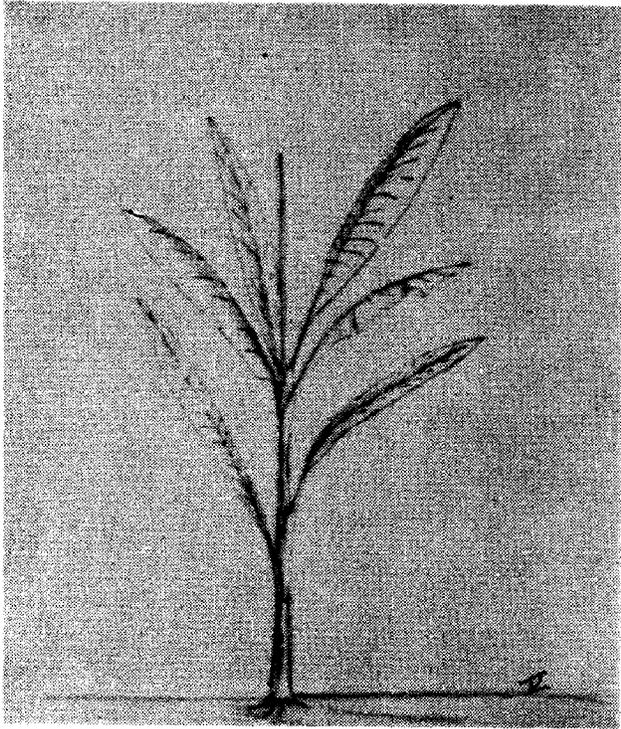
| B3 B2 | | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|-------|---------------|-------------------|-------|---------------|---------------|---------------|---------------|---------------|-----|---------|
| A3 A2 | C M | | | M | | M | | | | |
| X Y | 1 Jun 1966 | | | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | | |
| 2 | 4 | Miconia or Luehea | I | M | 2.2 | - | 6 | - | 9 | |
| 3 | 8 | | I | | | | | | | Dead |
| 5 | 4 | | VII | 5 | 5 | - | 3.3 | - | 4.5 | |
| 5 | 4 | | VII | 3.5 | 4.4 | - | 1.2 | - | 3.6 | |
| 5 | 5 | | VII | 3.1 | 3.1 | - | 3.9 | - | 4.5 | |
| 6 | 1 | Spondias | I | 26.1 | 32.5 | - | 9.5 | - | 22 | |
| 6 | 1 | Spondias | I | 29.9 | 35.1 | - | 9.5 | - | 22 | |
| 6 | 4 | | VII | 3.5 | 3.7 | - | .8 | - | 3.3 | |
| 6 | 4 | | VII | 3.7 | 3.7 | - | 1.5 | - | 3.9 | |
| 8 | 0 | | I | 5.1 | 7.8 | - | 3.9 | - | 6.6 | |
| 8 | 6 | Hirtella | II | 2.5 | 3 | - | .3 | - | 4.5 | |

| B2 | B1 | SPECIES | SHAPE | D B H | | FIRST BRANCH | | HEIGHT | | REMARKS |
|----|----|--------------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------|
| A2 | A1 | | | C M | | M | | M | | |
| X | Y | | | 1 Jun 1966 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | 4 Jun 1967 | 1 Jan 1967 | |
| 0 | 0 | Andira | I | 4.3 | 4.6 | - | 2.5 | - | 4.2 | |
| 3 | 6 | | | | | | | | | Dead |
| 5 | 2 | Piper | II | 3.2 | 3.2 | - | .8 | - | 3.9 | |
| 5 | 2 | | III | 2.2 | 2.2 | - | 1.8 | - | 3.3 | |
| 5 | 4 | Annona | III | 2.3 | 2.6 | - | 3.3 | - | 3.9 | |
| 5 | 8 | Luehea | I | 125. | 125. | - | 14 | - | 28.5 | |
| 7 | 3 | Copaifera | I | 2.5 | 3 | - | 3 | - | 3.9 | |
| 7 | 4 | | I | * | 3 | - | .8 | - | 3.6 | |
| 8 | 5 | "Quipo" | III | M | 3.0 | - | 3.6 | - | 4.2 | |
| 8 | 7 | Cavanillesia | I | M | 2.4 | - | 1.5 | - | 3 | |
| 9 | 6 | | I | 2.8 | 2.8 | - | 1.8 | - | 3.6 | |
| 9 | 7 | | I | M | 4 | - | 1.5 | - | 3.9 | |

DRAWINGS REPRESENTING SHAPES OF TREES IN ALBROOK FOREST.



DRAWINGS REPRESENTING SHAPES OF TREES IN ALBROOK FOREST.



- APPENDIX D -

DAILY OCCURRENCE OF COEFFICIENT OF HAZE

Time of Occurrence of Minimum, Maximum, and Daily Means of the Coefficient
of Haze (COH) Units per 1000 Linear Feet at Chiva Chiva

Note: "Hour" refers to start of one-hour periods during which
the indicated value was obtained

| Date | Minimum - Hour | | Maximum - Hour | | Mean |
|------|----------------|------|----------------|------|-------|
| 1966 | | | | | |
| Apr. | | | | | |
| 1 | 0.637 | 1615 | 2.688 | 2115 | 1.259 |
| 2 | 0.708 | 1915 | 1.698 | 0515 | 1.270 |
| 4 | 0.208 | 2100 | 1.610 | 1400 | 0.518 |
| 5 | 0.134 | 1800 | 0.774 | 1400 | 0.370 |
| 6 | 0.128 | 0200 | 0.642 | 0000 | 0.313 |
| 11 | 0.170 | 0900 | 1.768 | 1700 | 0.666 |
| 12 | 0.283 | 0800 | 1.270 | 1600 | 0.654 |
| 13 | 0.255 | 0300 | 3.260 | 1600 | 0.817 |
| 14 | 0.142 | 0900 | 1.270 | 0600 | 0.488 |
| 15 | 0.156 | 1021 | 0.920 | 1321 | 0.401 |
| 18 | 0.212 | 1925 | 0.534 | 1525 | 0.357 |
| 19 | 0.212 | 0525 | 0.424 | 0625 | 0.339 |
| 20 | 0.254 | 1720 | 0.707 | 1120 | 0.455 |
| 21 | 0.255 | 2345 | 0.920 | 1345 | 0.496 |
| 22 | 0.184 | 0845 | 0.538 | 0645 | 0.341 |
| 23 | 0.054 | 1705 | 0.357 | 1305 | 0.151 |
| 24 | 0.018 | 1105 | 0.178 | 1705 | 0.087 |
| 25 | 0.036 | 0500 | 0.071 | 0700 | 0.056 |
| 28 | 0.022 | 2035 | 0.536 | 1235 | 0.169 |
| 29 | 0.128 | 0035 | 0.228 | 0135 | 0.146 |
| May | | | | | |
| 3 | 0.032 | 2215 | 0.139 | 1215 | 0.083 |
| 4 | 0.086 | 0015 | 0.500 | 0415 | 0.241 |
| 5 | 0.018 | 1150 | 0.139 | 1950 | 0.073 |
| 6 | 0.071 | 0350 | 0.182 | 1255 | 0.106 |
| 7 | 0.050 | 1055 | 0.171 | 1255 | 0.096 |
| 8 | 0.028 | 1055 | 0.136 | 0255 | 0.076 |
| 9 | 0.007 | 1045 | 0.107 | 0855 | 0.066 |
| 10 | 0.054 | 1445 | 0.203 | 1645 | 0.133 |
| 11 | 0.107 | 0045 | 0.350 | 0445 | 0.210 |
| 12 | 0.032 | 1500 | 0.214 | 1100 | 0.073 |
| 13 | 0.0 | 0300 | 0.071 | 1700 | 0.035 |
| 14 | 0.0 | 0100 | 0.071 | 0300 | 0.041 |
| 15 | 0.007 | 0700 | 0.064 | 2300 | 0.042 |
| 16 | 0.018 | 2300 | 0.089 | 0300 | 0.052 |
| 17 | 0.028 | 0100 | 0.132 | 0700 | 0.094 |

| Date | Minimum - Hour | | Maximum - Hour | | Mean |
|-------------|----------------|------|----------------|------|-------|
| May | | | | | |
| 19 | 0.054 | 1250 | 0.178 | 1850 | 0.120 |
| 20 | 0.018 | 0650 | 0.118 | 0050 | 0.060 |
| 21 | 0.0 | 0900 | 0.064 | 0100 | 0.028 |
| 22 | 0.0 | 1500 | 0.107 | 0100 | 0.046 |
| 23 | 0.0 | 1700 | 0.125 | 1900 | 0.057 |
| 24 | 0.086 | 0100 | 0.216 | 1300 | 0.139 |
| 25 | 0.054 | 1245 | 0.286 | 0000 | 0.127 |
| 26 | 0.036 | 0445 | 0.114 | 2045 | 0.071 |
| 27 | 0.075 | 0645 | 0.125 | 1700 | 0.100 |
| 28 | 0.050 | 0700 | 0.128 | 0100 | 0.074 |
| 29 | 0.028 | 0500 | 0.125 | 2300 | 0.058 |
| 30 | 0.036 | 2100 | 0.171 | 1300 | 0.120 |
| 31 | 0.028 | 1645 | 0.221 | 0100 | 0.088 |
| Jun. | | | | | |
| 1 | 0.004 | 1640 | 0.157 | 0845 | 0.073 |
| 2 | 0.032 | 0040 | 0.214 | 0840 | 0.086 |
| 3 | 0.028 | 0240 | 0.182 | 2040 | 0.101 |
| 4 | 0.032 | 0840 | 0.064 | 1840 | 0.044 |
| 5 | 0.018 | 1040 | 0.128 | 1640 | 0.051 |
| 6 | 0.0 | 0040 | 0.175 | 1555 | 0.049 |
| 7 | 0.004 | 0155 | 0.143 | 2300 | 0.063 |
| 8 | 0.0 | 0500 | 0.164 | 1100 | 0.069 |
| 9 | 0.039 | 1648 | 0.114 | 0635 | 0.053 |
| 23 | 0.021 | 1600 | 0.086 | 1800 | 0.059 |
| 24 | 0.0 | 0200 | 0.064 | 0800 | 0.029 |
| 25 | 0.004 | 0700 | 0.094 | 0300 | 0.046 |
| 26 | 0.0 | 0300 | 0.077 | 1700 | 0.028 |
| 27 | 0.0 | 1800 | 0.167 | 2400 | 0.068 |
| 28 | 0.043 | 0200 | 0.214 | 2000 | 0.128 |
| 29 | 0.0 | 1700 | 0.257 | 0200 | 0.094 |
| 30 | 0.004 | 0300 | 0.205 | 1350 | 0.093 |
| Jul. | | | | | |
| 1 | 0.0 | 0750 | 0.120 | 0550 | 0.042 |
| 2 | 0.0 | 1200 | 0.077 | 1000 | 0.024 |
| 3 | 0.0 | 0200 | 0.103 | 1200 | 0.028 |
| 4 | 0.0 | 1000 | 0.056 | 1200 | 0.020 |
| 5 | 0.0 | 1200 | 0.086 | 1615 | 0.037 |
| 6 | 0.0 | 0015 | 0.077 | 0815 | 0.024 |
| 7 | 0.0 | 0400 | 0.026 | 0200 | 0.005 |
| 13 | 0.032 | 1940 | 0.072 | 2340 | 0.053 |
| 14 | 0.0 | 0940 | 0.072 | 1540 | 0.026 |
| 15 | 0.0 | 0400 | 0.040 | 0800 | 0.020 |
| 19 | 0.0 | 2135 | 0.108 | 1535 | 0.059 |

| Date | Minimum - Hour | Maximum - Hour | Mean |
|------|----------------|----------------|-------|
| Jul. | | | |
| 20 | 0.0 0635 | 0.056 0135 | 0.030 |
| 21 | 0.063 2043 | 0.065 2243 | 0.064 |
| 22 | 0.035 1243 | 0.112 1800 | 0.078 |
| 23 | 0.019 0800 | 0.068 0200 | 0.055 |
| 25 | 0.040 1550 | 0.068 1950 | 0.055 |
| 26 | 0.016 1350 | 0.072 1150 | 0.046 |
| 27 | 0.023 1940 | 0.088 1740 | 0.056 |
| 28 | 0.014 0540 | 0.121 1940 | 0.086 |
| 29 | 0.0 1550 | 0.093 1340 | 0.048 |
| 30 | 0.0 1950 | 0.072 0350 | 0.045 |
| 31 | 0.009 0150 | 0.088 1550 | 0.049 |
| Aug. | | | |
| 1 | 0.0 2150 | 0.074 0150 | 0.033 |
| 2 | 0.004 1350 | 0.063 1150 | 0.034 |
| 3 | 0.014 0310 | 0.140 1420 | 0.050 |
| 4 | 0.0 0425 | 0.091 1225 | 0.033 |
| 5 | 0.051 0835 | 0.280 1235 | 0.098 |
| 6 | 0.014 0900 | 0.112 1300 | 0.045 |
| 7 | 0.040 1100 | 0.126 1900 | 0.079 |
| 8 | 0.021 1545 | 0.096 0100 | 0.060 |
| 9 | 0.005 2137 | 0.112 0145 | 0.043 |
| 10 | 0.016 1337 | 0.121 1137 | 0.060 |
| 11 | 0.002 1615 | 0.058 2215 | 0.030 |
| 12 | 0.016 1015 | 0.133 1215 | 0.042 |
| 13 | 0.0 1515 | 0.086 0315 | 0.030 |
| 14 | 0.019 0115 | 0.133 2315 | 0.044 |
| 15 | 0.021 2350 | 0.123 1115 | 0.067 |
| 16 | 0.005 1530 | 0.112 1150 | 0.036 |
| 17 | 0.0 0930 | 0.091 1735 | 0.029 |
| 18 | 0.0 0935 | 0.098 1335 | 0.048 |
| 19 | 0.002 1730 | 0.102 2330 | 0.057 |
| 20 | 0.0 1930 | 0.107 1730 | 0.057 |
| 21 | 0.0 0130 | 0.096 1930 | 0.052 |
| 22 | 0.0 1530 | 0.070 0530 | 0.043 |
| 23 | 0.0 0330 | 0.107 1130 | 0.048 |
| 24 | 0.0 1130 | 0.077 0130 | 0.038 |
| 25 | 0.002 1015 | 0.186 1618 | 0.052 |
| 26 | 0.026 0418 | 0.121 0618 | 0.075 |
| 27 | 0.016 1700 | 0.058 2300 | 0.038 |
| 28 | 0.006 2100 | 0.097 1300 | 0.035 |
| 29 | 0.010 1740 | 0.085 2140 | 0.050 |
| 30 | 0.004 0140 | 0.116 1405 | 0.047 |
| 31 | 0.0 0805 | 0.107 1620 | 0.040 |

| Date | Minimum | Hour | Maximum | Hour | Mean |
|------|---------|------|---------|------|-------|
| Sep. | | | | | |
| 1 | 0.017 | 0020 | 0.107 | 1020 | 0.071 |
| 2 | 0.019 | 1812 | 0.116 | 1218 | 0.056 |
| 3 | 0.0 | 0800 | 0.078 | 0200 | 0.034 |
| 4 | 0.0 | 0400 | 0.078 | 2200 | 0.036 |
| 5 | 0.019 | 1630 | 0.107 | 2030 | 0.057 |
| 6 | 0.025 | 0430 | 0.097 | 0030 | 0.063 |
| 7 | 0.025 | 2035 | 0.175 | 0807 | 0.070 |
| 8 | 0.0 | 0035 | 0.068 | 0235 | 0.029 |
| 9 | 0.016 | 0630 | 0.146 | 1430 | 0.063 |
| 10 | 0.010 | 1835 | 0.107 | 0235 | 0.056 |
| 11 | 0.016 | 1635 | 0.097 | 1235 | 0.042 |
| 12 | 0.027 | 0435 | 0.064 | 1500 | 0.042 |
| 13 | 0.019 | 0900 | 0.116 | 1944 | 0.064 |
| 14 | 0.027 | 1344 | 0.146 | 2137 | 0.068 |
| 15 | 0.043 | 2337 | 0.194 | 0137 | 0.087 |
| 16 | 0.010 | 2155 | 0.142 | 1555 | 0.064 |
| 17 | 0.006 | 1755 | 0.077 | 0155 | 0.039 |
| 18 | 0.0 | 0755 | 0.057 | 0355 | 0.024 |
| 19 | 0.020 | 0155 | 0.193 | 1130 | 0.056 |
| 20 | 0.030 | 1330 | 0.118 | 0730 | 0.075 |
| 21 | 0.0 | 1815 | 0.142 | 0415 | 0.076 |
| 22 | 0.045 | 0815 | 0.071 | 0015 | 0.059 |
| 23 | 0.017 | 1945 | 0.172 | 2345 | 0.079 |
| 24 | 0.029 | 1545 | 0.105 | 0345 | 0.072 |
| 25 | 0.027 | 1545 | 0.153 | 1145 | 0.063 |
| 26 | 0.0 | 1145 | 0.096 | 1545 | 0.048 |
| 27 | 0.0 | 0945 | 0.038 | 0345 | 0.024 |
| 28 | 0.084 | 2110 | 0.213 | 1710 | 0.123 |
| 29 | 0.020 | 0010 | 0.123 | 2110 | 0.072 |
| 30 | 0.044 | 1910 | 0.148 | 1755 | 0.086 |
| Oct. | | | | | |
| 1 | 0.033 | 0755 | 0.123 | 1800 | 0.060 |
| 2 | 0.0 | 0400 | 0.190 | 2200 | 0.066 |
| 3 | 0.008 | 1000 | 0.107 | 2230 | 0.059 |
| 4 | 0.008 | 0230 | 0.090 | 0030 | 0.056 |
| 5 | 0.031 | 0300 | 0.056 | 0500 | 0.041 |
| 6 | 0.016 | 1000 | 0.082 | 0700 | 0.052 |
| 7 | 0.038 | 1130 | 0.072 | 1920 | 0.052 |
| 8 | 0.036 | 0520 | 0.067 | 0320 | 0.044 |
| 9 | 0.0 | 1720 | 0.052 | 0320 | 0.024 |
| 10 | 0.025 | 1830 | 0.167 | 1630 | 0.058 |
| 11 | 0.0 | 1030 | 0.085 | 2155 | 0.052 |
| 12 | 0.028 | 0555 | 0.156 | 1555 | 0.072 |
| 13 | 0.045 | 0955 | 0.483 | 1555 | 0.139 |

| Date | Minimum | - Hour | Maximum | - Hour | Mean |
|------|---------|--------|---------|--------|-------|
| Oct. | | | | | |
| 14 | 0.0 | 1535 | 0.156 | 0155 | 0.065 |
| 15 | 0.011 | 1335 | 0.078 | 0735 | 0.047 |
| 16 | 0.011 | 2135 | 0.106 | 0335 | 0.051 |
| 17 | 0.026 | 0535 | 0.081 | 2335 | 0.052 |
| 18 | 0.061 | 0335 | 0.156 | 2335 | 0.102 |
| 19 | 0.026 | 1723 | 0.099 | 2323 | 0.062 |
| 20 | 0.021 | 1533 | 0.155 | 2242 | 0.082 |
| 21 | 0.021 | 1242 | 0.192 | 1503 | 0.096 |
| 22 | 0.007 | 1903 | 0.060 | 0303 | 0.029 |
| 23 | 0.014 | 0903 | 0.085 | 1703 | 0.035 |
| 24 | 0.014 | 1940 | 0.139 | 1340 | 0.043 |
| 25 | 0.0 | 0340 | 0.078 | 1830 | 0.034 |
| 26 | 0.0 | 0030 | 0.140 | 1726 | 0.056 |
| 27 | 0.018 | 0526 | 0.135 | 1126 | 0.065 |
| 28 | 0.026 | 0830 | 0.114 | 1030 | 0.059 |
| 29 | 0.0 | 1200 | 0.064 | 0400 | 0.025 |
| 30 | 0.006 | 0800 | 0.037 | 0200 | 0.018 |
| 31 | - | - | 0.057 | 2235 | - |
| Nov. | | | | | |
| 1 | 0.014 | 1435 | 0.142 | 1035 | 0.074 |
| 2 | 0.021 | 2240 | 0.170 | 1040 | 0.069 |
| 3 | 0.0 | 1240 | 0.057 | 0040 | 0.026 |
| 4 | 0.0 | 0633 | 0.031 | 0033 | 0.020 |
| 5 | 0.0 | 1345 | 0.036 | 2345 | 0.015 |
| 6 | 0.0 | 1545 | 0.043 | 0745 | 0.018 |
| 7 | 0.0 | 0945 | 0.135 | 1545 | 0.042 |
| 8 | 0.014 | 1835 | 0.074 | 1435 | 0.052 |
| 9 | 0.028 | 0235 | 0.037 | 0035 | 0.031 |
| 10 | 0.018 | 2335 | 0.213 | 0535 | 0.066 |
| 11 | 0.0 | 1230 | 0.057 | 2230 | 0.021 |
| 12 | 0.0 | 1230 | 0.057 | 1630 | 0.035 |
| 13 | 0.0 | 2230 | 0.043 | 1630 | 0.022 |
| 14 | 0.014 | 0230 | 0.036 | 0430 | 0.022 |
| 15 | 0.0 | 2335 | 0.128 | 1735 | 0.055 |
| 16 | 0.014 | 0535 | 0.121 | 0135 | 0.042 |
| 17 | 0.0 | 1620 | 0.043 | 0020 | 0.025 |
| 18 | 0.0 | 0420 | 0.045 | 0220 | 0.021 |
| 19 | 0.0 | 0924 | 0.040 | 0124 | 0.021 |
| 20 | 0.0 | 0924 | 0.038 | 1724 | 0.016 |
| 21 | 0.0 | 1324 | 0.033 | 0924 | 0.015 |
| 22 | 0.0 | 0724 | 0.064 | 1635 | 0.034 |
| 23 | 0.004 | 2035 | 0.114 | 0235 | 0.033 |
| 24 | 0.0 | 0035 | 0.045 | 0435 | 0.020 |
| 25 | 0.0 | 0235 | 0.028 | 2025 | 0.016 |

| Date | Minimum | - Hour | Maximum | - Hour | Mean |
|------|---------|--------|---------|--------|-------|
| Nov. | | | | | |
| 26 | 0.0 | 1225 | 0.031 | 2025 | 0.017 |
| 27 | 0.0 | 1225 | 0.071 | 1725 | 0.029 |
| 28 | 0.0 | 1425 | 0.057 | 0025 | 0.023 |
| 29 | 0.0 | 0715 | 0.068 | 1315 | 0.022 |
| 30 | 0.0 | 1514 | 0.041 | 0515 | 0.019 |
| Dec. | | | | | |
| 1 | 0.003 | 1228 | 0.085 | 2028 | 0.044 |
| 2 | 0.0 | 1836 | 0.036 | 0828 | 0.017 |
| 3 | 0.0 | 1036 | 0.034 | 0836 | 0.018 |
| 4 | 0.0 | 2036 | 0.074 | 0236 | 0.029 |
| 5 | 0.006 | 0236 | 0.106 | 0636 | 0.038 |
| 6 | 0.0 | 0836 | 0.128 | 1436 | 0.041 |
| 7 | 0.0 | 1236 | 0.045 | 0436 | 0.018 |
| 8 | 0.001 | 0035 | 0.082 | 1435 | 0.040 |
| 9 | 0.0 | 1645 | 0.106 | 0635 | 0.038 |
| 10 | 0.0 | 1245 | 0.082 | 0245 | 0.036 |
| 11 | 0.0 | 1445 | 0.047 | 2245 | 0.017 |
| 12 | 0.003 | 0645 | 0.056 | 1540 | 0.021 |
| 13 | 0.0 | 0950 | 0.052 | 0350 | 0.020 |
| 14 | 0.0 | 0950 | 0.036 | 2035 | 0.019 |
| 15 | 0.003 | 0835 | 0.023 | 0235 | 0.012 |
| 16 | 0.0 | 0435 | 0.050 | 0835 | 0.018 |
| 17 | 0.0 | 0435 | 0.023 | 0235 | 0.013 |
| 18 | 0.0 | 0835 | 0.028 | 0235 | 0.010 |
| 19 | 0.0 | 1045 | 0.031 | 2245 | 0.016 |
| 20 | 0.0 | 1245 | 0.040 | 0045 | 0.020 |
| 21 | 0.0 | 0430 | 0.033 | 1830 | 0.015 |
| 22 | 0.017 | 0030 | 0.036 | 1030 | 0.024 |
| 23 | 0.0 | 1630 | 0.037 | 0030 | 0.018 |
| 24 | 0.0 | 1230 | 0.024 | 0830 | 0.012 |
| 25 | 0.0 | 0030 | 0.021 | 2230 | 0.009 |
| 26 | 0.0 | 1230 | 0.043 | 1430 | 0.025 |
| 27 | 0.0 | 1434 | 0.044 | 0634 | 0.016 |
| 28 | 0.0 | 0034 | 0.017 | 2230 | 0.008 |
| 29 | 0.0 | 1230 | 0.036 | 1030 | 0.018 |
| 30 | 0.0 | 1030 | 0.028 | 0830 | 0.010 |
| 31 | 0.0 | 0830 | 0.028 | 0630 | 0.013 |
| 1967 | | | | | |
| Jan. | | | | | |
| 1 | 0.026 | 0430 | 0.057 | 1030 | 0.042 |
| 2 | 0.034 | 0030 | 0.085 | 2230 | 0.059 |
| 3 | 0.048 | 1635 | 0.081 | 0430 | 0.065 |
| 4 | 0.028 | 1435 | 0.071 | 0035 | 0.051 |

| Date | Minimum - Hour | | Maximum - Hour | | Mean |
|------|----------------|------|----------------|------|-------|
| Jan. | | | | | |
| 5 | 0.011 | 1234 | 0.031 | 0034 | 0.023 |
| 6 | 0.0 | 1243 | 0.040 | 0843 | 0.017 |
| 7 | 0.0 | 1617 | 0.031 | 2017 | 0.015 |
| 8 | 0.006 | 1217 | 0.037 | 0817 | 0.015 |
| 9 | 0.0 | 1620 | 0.017 | 0817 | 0.010 |
| 10 | 0.0 | 1220 | 0.036 | 2017 | 0.014 |
| 11 | 0.0 | 1418 | 0.054 | 2138 | 0.022 |
| 12 | 0.0 | 0338 | 0.038 | 2045 | 0.017 |
| 13 | 0.0 | 1616 | 0.028 | 2016 | 0.013 |
| 14 | 0.0 | 0416 | 0.026 | 1416 | 0.013 |
| 15 | 0.004 | 0016 | 0.028 | 2016 | 0.015 |
| 16 | 0.0 | 1720 | 0.050 | 0016 | 0.015 |
| 17 | 0.0 | 0320 | 0.021 | 1320 | 0.007 |
| 18 | 0.0 | 1020 | 0.094 | 2214 | 0.028 |
| 19 | 0.068 | 1620 | 0.111 | 1014 | 0.094 |
| 20 | 0.043 | 0620 | 0.099 | 0820 | 0.057 |
| 21 | 0.014 | 0814 | 0.052 | 2214 | 0.025 |
| 22 | 0.014 | 1814 | 0.040 | 0814 | 0.025 |
| 23 | 0.0 | 1414 | 0.028 | 0214 | 0.013 |
| 24 | 0.0 | 1615 | 0.045 | 2215 | 0.022 |
| 25 | 0.010 | 0015 | 0.048 | 2219 | 0.027 |
| 26 | 0.007 | 1526 | 0.037 | 1019 | 0.026 |
| 27 | 0.023 | 0126 | 0.045 | 1126 | 0.029 |
| 31 | 0.0 | 1135 | 0.040 | 2135 | 0.010 |
| Feb. | | | | | |
| 1 | 0.0 | 1620 | 0.023 | 2220 | 0.013 |
| 2 | 0.0 | 1807 | 0.055 | 1607 | 0.032 |
| 3 | 0.018 | 1610 | 0.067 | 2210 | 0.039 |
| 4 | 0.012 | 1210 | 0.053 | 0010 | 0.028 |
| 5 | 0.016 | 1810 | 0.053 | 0210 | 0.033 |
| 6 | 0.0 | 1210 | 0.044 | 0810 | 0.017 |
| 7 | 0.0 | 1550 | 0.053 | 0826 | 0.022 |
| 8 | 0.0 | 1150 | 0.084 | 2200 | 0.033 |
| 9 | 0.0 | 1400 | 0.077 | 0200 | 0.038 |
| 10 | 0.0 | 1722 | 0.056 | 2322 | 0.028 |
| 11 | 0.019 | 1522 | 0.070 | 0722 | 0.037 |
| 12 | 0.004 | 2322 | 0.049 | 0122 | 0.029 |
| 13 | 0.0 | 1615 | 0.023 | 1322 | 0.018 |
| 14 | 0.0 | 1546 | 0.049 | 1415 | 0.020 |
| 15 | 0.0 | 2154 | 0.053 | 0346 | 0.027 |
| 16 | 0.009 | 1617 | 0.028 | 1354 | 0.019 |
| 17 | 0.016 | 1815 | 0.049 | 2215 | 0.029 |
| 18 | 0.0 | 1615 | 0.056 | 0615 | 0.029 |
| 19 | 0.007 | 1015 | 0.035 | 0815 | 0.021 |

| <u>Date</u> | <u>Minimum - Hour</u> | | <u>Maximum - Hour</u> | | <u>Mean</u> |
|-------------|-----------------------|------|-----------------------|------|-------------|
| Feb. | | | | | |
| 20 | 0.0 | 1526 | 0.053 | 2126 | 0.027 |
| 21 | 0.026 | 0126 | 0.074 | 2214 | 0.038 |
| 22 | 0.0 | 1414 | 0.067 | 1814 | 0.039 |
| 23 | 0.6 | 6614 | 0.049 | 0814 | 0.030 |
| 24 | 0.018 | 1316 | 0.055 | 0116 | 0.035 |
| 25 | 0.007 | 1557 | 0.049 | 0757 | 0.025 |
| 26 | 0.005 | 0557 | 0.123 | 2157 | 0.055 |
| 27 | 0.014 | 1633 | 0.132 | 1357 | 0.072 |
| 28 | 0.018 | 0433 | 0.067 | 2116 | 0.037 |

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13. ABSTRACT

This report, the third in a series of semiannual progress reports of the Environmental Data Base Project, presents a resume of Project objectives and methods and descriptions of the operational sites.

The Climate section (Part IV) shows the data collected and instrumentation used with a description of automatic instrumentation planned. Analyses of daily temperature variations and a discussion of soil-surface temperature determination are presented.

The Soils and Hydrology section (Part V) presents analyses of soil-moisture profiles and soil-strength profiles and their interrelationships. Detailed information on soil profiles and physical characteristics is presented in an appendix.

The Vegetation section (Part VI) presents analyses of forest litter accumulation. Information on seedling characteristics and seed germination, and a revised vegetation inventory and plot for the Albrook Forest site are given in appendices.

The section dealing with Microbiology and Chemistry of the Atmosphere contains papers on: (a) airborne and surface deposited microorganisms; (b) observations of microbial populations of the forest soil; and (c) a discussion of atmospheric particulate matter.

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