FAO/SF: 11/COL

COLOMBIA GENERAL REPORT

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SOIL SURVEY OF THE LLANOS ORIENTALES

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GENERAL REPORT

UNITED NATIONS DEVELOPMENT PROGRAM
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

EXTERNAL TRANSLATION

FAO/SF: 11/COL

SOIL SURVEY OF THE LLANOS ORIENTALES

C O L O M B I A

VOLUME I

GENERAL REPORT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS SPECIAL FUND Rome, 1965

MR/27262

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(included at end of volume)

Land capability map (2 sheets)

Scale 1:500,000

INTRODUCTION

In 1956 the Mission of the International Bank for Reconstruction and Development proposed that the Government of Colombia should take the necessary measures to obtain more detailed information about the potential production of the vast and scarcely populated region of the Llanos Orientales. The Mission recommended that a soil survey and classification should be made of the areas easiest to settle. A preliminary study in the northeast of the Llanos had shown that the land had good physical characteristics, and growth experiments with various crops, e.g. sesame, rubber, cacao and rice, and been favorable. A small number of settlers had begun to cross the Andes passes and to till the soil and raise livestock in the Llanos Orientales. The Government of Colombia, endeavoring to guide the development of the Llanos Orientales along rational lines, requested the United Nations Special Fund to undertake a Project to carry out a soil survey and prepare information on land capability in an area of approximately 16.8 million hectares.

The survey area, representing approximately 11 percent of the total area of the country, is located at the foot of the Eastern Cordillera of the Andes and extends eastward over the plains, comprising part of the Departments of Meta, Boyacá and Cundinamarca, almost the whole of the Intendencia de Arauca, and part of the Comisaría del Vichada. Most of this area is covered by savanna vegetation, while 15 percent is forest. (See Maps I-1 and I-5).

The studies included investigations on soils, vegetation and livestock management. More detailed studies on hydrology, as well as a short economic survey to investigate the various factors which influence agricultural production, were carried out in the Meta Department.

1. Background

On 13 March 1959 the Government of Colombia submitted to the United Nations Special Fund a Project for a Soil Survey of the Llanos Orientales.

The preparation of this project began toward the end of 1958, with the collaboration of the Ministry of Agriculture, the Planning and Technical Services Administrative Department, and the Instituto Geográfico "Agustín Codazzi", assisted by several FAO experts.

The aim of the Project was to carry out a soil survey and establish land use capability classes on an area of approximately 16.8 million hectares in the northern part of the Llanos Orientales with the help of aerial photography. This was to meet Colombia's urgent need to obtain basic data on the country's resources for its agricultural development program.

Another aim worthy of special mention was to train Colombian technicians in the various methods of surveying agricultural and livestock resources.

The Project was approved by the Executive Board of the Special Fund on 2 December 1959 and the Food and Agriculture Organization of the United Nations was appointed Executing Agency. A detailed Plan of Operation was then prepared, which was signed on 1 September 1960 by the Special Fund, FAO, and the Government of Colombia. 1/ The Special Fund undertook to provide, through FAO, a team of international experts, to establish fellowships and to supply the equipment needed fo the Project over a period of three years at an estimated cost of US $370,500, while

1/ The Plan of Operation is contained in Appendix I-1 to this Volume.

the Colombian Government undertook to provide counterpart staff, equipment and services, at an estimated cost of US $317,800. Later the Project period was extended to three years and nine months, and Special Fund and Government contributions were raised to a total of US $415,440 and US $361,889 respectively.

After the Government's request had been approved by the Special Fund and the Plan of Operation signed, it was agreed to carry out a soil survey of 13 million hectares with a view to publishing a map at scale 1:250,000.

In addition to the soil survey supplemented by the chemical and physical characteristics of the soils, a general survey of natural vegetation - both savanna and forest - was carried out. A landscape map (scale 1:500,000) of an area of approximately 12 million hectares shows the distribution of the various classes of vegetation described in this report (Vol. III).

This survey also included an analysis of water resources in a strip some 150 kms long between the Ariari and Upía rivers, along the foot of the Cordillera to the River Metica. This area offers the best prospects for agricultural development.

Lastly, a survey was made of livestock conditions in the Llanos, thus completing the survey of natural resources forming the basis of agricultural and livestock production.

The survey, which is mainly descriptive, is an inventory of the permanent properties of the natural resources and was carried out by using appropriate scientific methods, many of which have only a remote connection with agricultural practice. For this reason, and in order to make the work directly useful, the observations as a whole have been interpreted and the land classified with reference to its agricultural properties. This part of the work, dealing with relations between soils and present and possible exploitation of resources, appears in full in the land capability classification, with a unit map showing the regional distribution of the various classes.

Interpretation should however take account of the economic possibilities of the area within the context of the general development and agricultural policy of the country. Any change in one or more economic factors would automatically affect this interpretation, and the land classifications in this report are no exception to this rule.

2. The Project and its execution

The execution of the Project began with the arrival of the first FAO expert on 2 January 1961, and included the following stages:

(a) Aerial photography of 4.5 million hectares to complete the existing coverage of the Llanos;

(b) Preliminary photo-interpretation of the whole region in order to delineate the major physiographic regions;

(c) Semi-detailed soil survey of 20 key areas, distributed over the various physiographic regions and totalling 381,550 hectares. These surveys included soil profile descriptions, correlation of soil boundaries with photo-interpretation data, and physical and chemical analysis of samples;

(d) Use of the basic data obtained in the key areas in order to establish the following:

(i) Soil association map of the complete survey area (scale 1:250,000);
(ii) Soil taxonomic classification based on common properties;
(iii) Land capability classification and map (scale 1:500,000).

(e) The vegetation survey, including savanna and forest inventories, began when the soil survey was completed. Management problems and vegetation types were discussed and a vegetation map was prepared (scale 1:500,000).

(f) In the last year of the Project a livestock survey was carried out in the Llanos, describing general management conditions in the survey area.

(g) In order to complete the information needed for the preparation of a development plan, hydrological and economic conditions in the Meta Department were studied.

3. Project personnel

The present surveys of soils, vegetation and other agricultural resources in the Llanos Orientales were carried out jointly by international and Colombian technicians. Specialists in photo-interpretation, soil classification, vegetation, animal husbandry, hydrology, soil chemistry and agricultural economy took part in the work. 1/

4. Training

Close co-operation between international staff and their Colombian counterparts during field operations secured adequate training in all the practical aspects of natural resources surveys. Modern methods of photo-interpretation, soil survey, soil classification, vegetation survey, hydrological and livestock management investigations were introduced and used in the field by Colombian personnel.

Besides this in-service training program, five of the best Colombian technicians were sent to universities in Europe and the United States to attend theoretical and practical training-courses.

5. Acknowledgments

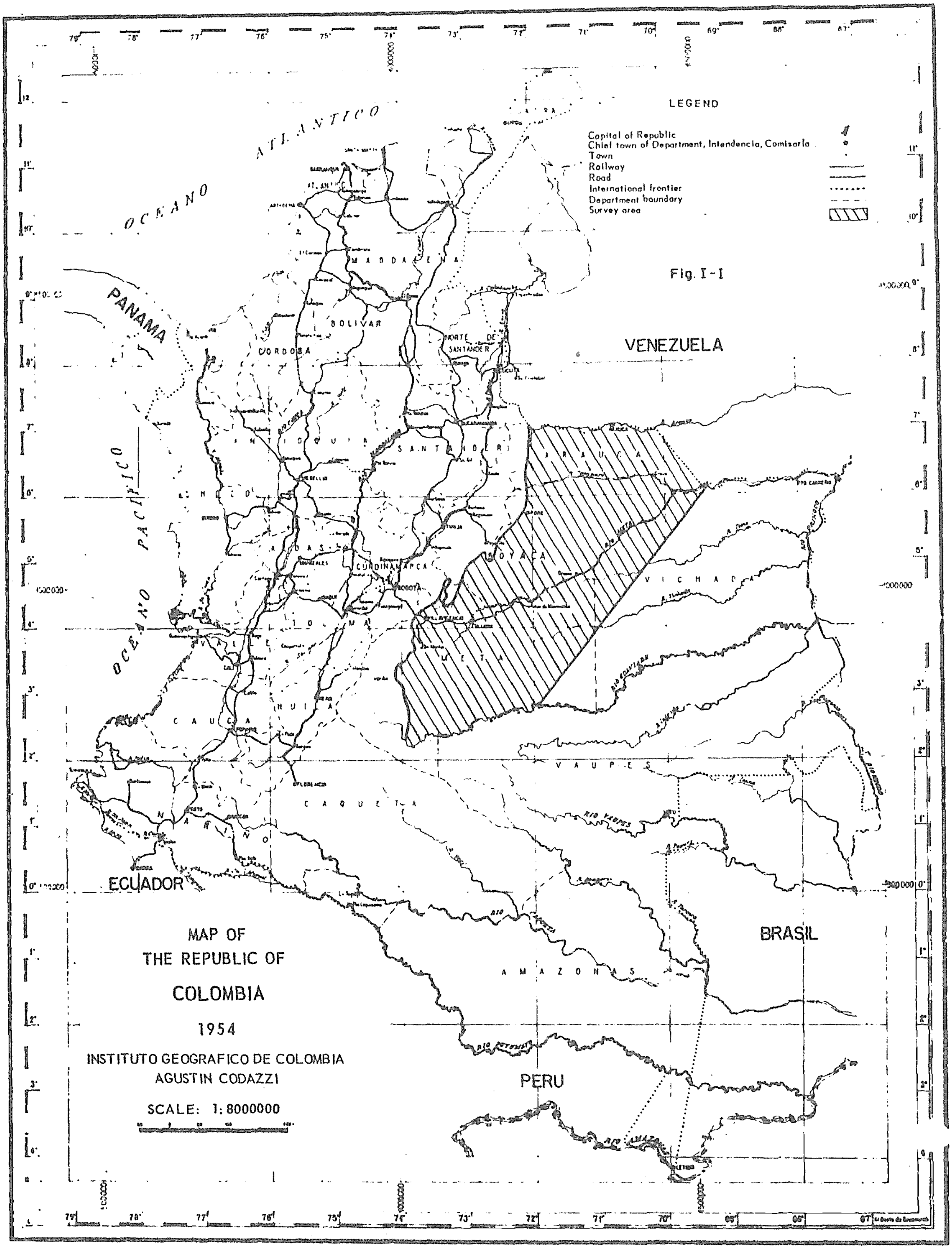
All this work was carried out by a team of international and Colombian technicians operating in an administrative unit entitled "Llanos Orientales Soil Survey Program". Although working in close co-operation with other agencies, this unit had its own budget, established partly by a law of the Colombian Congress and partly by the contribution of the United Nations Special Fund.

Other agencies also provided valuable assistance to the Program, and we should like to thank the Directors of the Planning and Technical Services Administrative Department of the Colombian Government, who co-ordinated the action taken by national agencies.

In the performance of specific tasks, we are deeply indebted to the Soil Laboratory of the Instituto Geográfico "Agustín Codazzi", for the analysis of soil samples; to the Forest Engineering Faculty of the Universidad Distrital Francisco José de Caldas, Bogotá, for photo-interpretation and forest inventory calculations; and to the Instituto de Ciencias Naturales of the Universidad Nacional, for the identification of plant species.

The Instituto Colombiano de la Reforma Agraria (INCORA) provided funds to enable the Program to accelerate soil survey work in the piedmont area. The Inter-American Geodesy Service (I.A.G.S.) provided air transport for various surveys.

1/ A full list of collaborators appears in Appendix I-2 to this report.


LEGEND
Capital of Republic
Chief town of Department, Intendencia, Comisaria
Town
Railway
Road
International frontier
Department boundary
Survey area
Fig. I-I
OCEANO ATLANTICO
OCEANO PACIFICO
PANAMA
VENEZUELA
ECUADOR
BRASIL
PERU
MAGDALENA
BOLIVAR
CORDOBA
NORTE DE SANTANDER
ANTIOQUIA
SANTANDER
ARAUCA
CHOCO
CALDAS
BOYACA
CUNDINAMARCA
VICHADA
TOLIMA
VALLE
META
HUILA
CAUCA
VAUPES
CAQUETA
NARIÑO
AMAZONAS
MAP OF
THE REPUBLIC OF
COLOMBIA
1954
INSTITUTO GEOGRAFICO DE COLOMBIA
AGUSTIN CODAZZI
SCALE: 1:8000000

Lastly, we wish to express our gratitude to all the inhabitants of the Llanos for the hospitality they extended to Program teams of field workers. To the Governors, Intendents and Mayors of administrative districts and to the Commanders of the Armed Forces we also offer our most sincere thanks for their assistance.

SUMMARY OF MAIN CONCLUSIONS AND RECOMMENDATIONS

1. The survey has shown that the productivity of most of the land in the Llanos Orientales can be increased by adequate management practices and by improving existing production methods, taking into account land capability.

2. The classification of the soil associations occurring in the Llanos Orientales into land capability classes indicates that the possibilities offered by the soils in the survey area for the development of farming systems are as follows:

Class I — Land suitable for cultivation - 106,250 hectares.

Class II — Land suitable for cultivation and livestock farming on cultivated pastures - 1,566,900 hectares.

Class III — Land suitable for grazing on natural savannas in combination with improved pastures and subsistence agriculture - 3,981,875 hectares.

Class IV — Land suitable for grazing on natural savannas in combination with forestry - 6,750,610 hectares.

Class V — Land suitable neither for agriculture nor for livestock, recommended for re-forestation or maintenance of natural vegetation - 215,000 hectares.

Class F — Forest reserves, which include units in Class IV and some of the forested high plains in Class III.

The general recommendations regarding the use and management of the soils in each Class and the map showing the regional distribution of these Classes are included in this Volume.

3. The soils which show the highest potential and on which the first agricultural development should take place are found in the recent alluvium. These soils, however, need protection against periodic flooding. Fundamentally such flooding is due to severe erosion affecting the valleys of the rivers rising in the Cordillera. It is recommended that the Government should take the necessary measures to protect the river basins of the Cordillera Oriental. For this purpose proper vegetation management and, wherever possible, control of felling and fire are recommended. In order to achieve these objectives the following steps are suggested:

(a) Detailed studies of possibilities of agricultural and forest development in the catchment basins and delineation of the areas suitable for such purposes, without prejudice to the primary purpose of water regulation and production;

(b) Soil and vegetation management studies in order to maintain optimum production and prevent the destruction of natural resources;

(c) Proper organization of forest exploitation and establishment of a reforestation program based on indigenous and imported quick-growing species of economic value;

(d) Creation of a technical assistance and supervisory service to secure the implementation of the above recommendations.

4. Large stretches of the Llanos contain soils of good physical characteristics, but suffer from severe nutrient deficiencies. It is considered that without adequate experimental work on the use of fertilizers, no recommendations can be made on ways of correcting the low nutrient status of the soils in the area. No exact data are available on the grazing capacity of the natural savannas nor on correct management methods. For these reasons the Government is recommended to strengthen its Agricultural Experimental Stations in the Llanos and concentrate on studies of the use of fertilizers, grassland management, and livestock selection. A preliminary plan of the research to be carried out on soil associations, including the main land capability classes, is given in this report.

5. Viewed on a long-term basis, the development of the Llanos may be thought to depend on the growth of small nuclei, formed spontaneously or planned, at places where good soils are plentiful. In this respect the first step toward improving the standard of living in the Llanos should be the construction of a road network, planned on the basis of the data supplied by the land capability map and the soil and vegetation maps, and taking into account the location of markets. The Government is accordingly recommended to accelerate road building.

6. A large part of the Llanos is suitable for extensive livestock farming. Livestock will for a long time constitute the basis of rural production. The most important problems connected with livestock production in the area are animal health, especially foot-and-mouth disease and parasites, provision of watering points, and the organization and improvement of animal transport, slaughterhouses and meat markets.

7. On the basis of the studies of the livestock and meat industry in the Llanos, the following action is recommended immediately: (i) an adequate number of wells with windmills should be built wherever necessary to provide water at strategic points in order to prevent parasitic infection and (ii) a general campaign should be organized to eliminate foot-and-mouth disease and to increase production of foot-and-mouth vaccine. Other recommendations for medium and long-term action include the establishment of trial and demonstration centers in selected regions of the Llanos Orientales survey area to carry out studies on practical problems such as grazing capacity, distance between watering and salting points, pasture rotation, effects of burning, introduction of new pasture and other problems peculiar to each region; studies of irrigation methods, using the rivers and streams of the Llanos Orientales and research on the possibility of draining flood land; increased assistance to livestock farmers in the construction and use of cattle dips for pest and insect control, and increased theoretical training in animal husbandry at University level, accompanied by greater practical training.

8. Most of the measures to improve agricultural and livestock production in the Llanos are connected with farm management, efficient use of natural and cultivated pasture, and pasture and livestock management. All these measures, which imply capital investment, cannot be carried out as long as the exact form of land tenure in the Llanos is unknown. The Government should therefore take the necessary action to establish a land census in the Llanos Orientales.

9. It is believed that the action recommended will be best achieved by setting up an organization to co-ordinate the activities of all Government agencies now operating in the Llanos Orientales and to cover the Departments, Intendencias and Comisarias constituting the administrative divisions of that area. This Organization should provide technical assistance to farmers, develop agricultural credit, arrange adequate marketing systems and co-ordinate development plans in accordance with the most urgent requirements of the region.

10. The vegetation study of the Llanos led to the preparation of a vegetation map. This map, together with the recommendations for the proper management of the various

types of vegetation in the Llanos Orientales for purposes of forestry or livestock production are included in Volume III, Section 1, of this report. Proper forest management to ensure sustained exploitation may be achieved by means of a selected felling program, imposing minimum diameters, and by planned reforestation to secure repopulation with species of high economic value. In present conditions and in view of the state of forest development in the Llanos, a minimum diameter of 35 cm is recommended. Native and introduced species best suited for reforestation are cachicamo, mahogany, caracolí, ceder, eucalyptus, pardillo and teak.

Proper management of the savannas, which will in future continue to be used as natural pastures, should take account of the grazing period and should include control of animal movement and establishment of improved pastures.

11. In view of the importance of a knowledge of water resources for the subsequent development of the region, it is suggested that a hydrometric service be organized in the Llanos.

This service would be responsible for systematic measurements to establish adequate hydrological statistics. Its work would be phased to take account of the actual situation and practical possibilities. Work should start at the places which would be of most interest in the light of existing development and which would offer greatest facilities. It would subsequently be extended as the economic importance of the area increases, and its pace would also depend on the efficiency of the hydrometric service, which would increase as greater practical experience as acquired in the varied conditions prevailing in the Llanos. In order to carry out field work, including systematic measurements and appraisals, establishment and control of fixed stations, and general river observation, it will be necessary to set up a mobile team of hydrometric experts. A detailed account, with an inventory and budget of the necessary equipment for this mobile team, and a phased plan of the work of the hydrometric service, will be found in Volume IV of this report.

GENERAL DESCRIPTION OF THE AREA

I. GEOGRAPHY, LOCATION OF SURVEY AREA

The eastern region of Colombia, i.e. the whole area east of the Cordillera Oriental of the Andes up to the frontiers of Venezuela, Brazil, Peru and Ecuador, forms part of the great watersheds of the Orinoco and the Amazon.

Ecologically this territory may be divided into two zones, viz.:

(1) the Llanos Orientales in the north, covered with savanna vegetation and forest, where the rivers drain toward the Orinoco (Orinoquía); and

(2) the Amazon Zone in the south, covered with tropical forest and forming part of the Amazon watershed (Colombian Amazonia).

The survey area comprises the western part of the Llanos Orientales, from the Venezuelan boundary with the Intendencia de Arauca in the north to the Sierra de la Macarena and the River Guayabero in the south. The western limit is roughly the 500 meter contour in the ramifications of the Cordillera Oriental. The eastern limit is marked by a straight line drawn from the meeting-point of the boundaries of the Intendencia de Arauca, the Comisaría de Vichada and the Republic of Venezuela on the River Meta to a point on the River Guaviare about 60 km below San José de Guaviare. Its geographical position is between 2° and 7° N and between 69° and 74° W (see Fig.I-1).

The reason for selecting this area for the survey was because it is this part of the relatively isolated eastern region of Colombia which has begun to develop most intensively, owing to better communications with the center and greater population density. Moreover, the aerial photographic survey had already covered a good part of the territory by the time the survey started.

The area covers some 13 million hectares, or about 11 percent of the total area of Colombia. It contains part of the Departments of Meta, Boyacá and Cundinamarca, almost the whole of the Intendencia de Arauca and part of the Comisaría del Vichada. The part of the Boyacá Department is the region known as Casanare, which used to form a separate political division. The areas corresponding to each political division are roughly as follows:

Department of Meta	5,314,000 hectares
Department of Boyacá	4,295,000 hectares
Department of Cundinamarca	187,000 hectares
Intendencia de Arauca	2,183,000 hectares
Comisaría del Vichada	1,021,000 hectares
Total	13,000,000 hectares

Unlike the west of the country, where the huge ramifications of the Cordillera de los Andes produce a highly varied topography and climate and where the majority of the population is concentrated, the Llanos Orientales cover a large area of comparatively flat land with few peaks, hills or ridges. The western limit of the area lies 500 meters above sea-level, while the River Meta on the eastern limit is 95 meters above sea-level.

Near the Cordillera slopes are fairly steep, but become more gentle to the east. The topography of the Llanos Orientales is more uniform than the western part of the country, but the complex river system provokes changes in vegetation and breaks the monotony of the landscape.

Although slopes are usually gentle, erosion still presents a danger and is in fact very severe in some places. Periodic flooding in the lowlands in the rainy season is also a general characteristic of the area.

The survey area is the most densely populated part of Eastern Colombia, but the figure is still very low in comparison with the west, the number of inhabitants per square kilometer being approximately 2.3. In the last few decades there has been some immigration from the interior of the country, especially into the Meta piedmont, which has the best links with consumption centers and the most fertile soil.

There are no recent official statistics of population in the area, but data obtained from various sources show that the population may be assessed at about 300,000, distributed as follows:

Department of Meta	225,000
Intendencia de Arauca	30,000
Department of Boyacá (Casanare)	30,000
Department of Cundinamarca and Comisaría del Vichada	30,000
Total	300,000

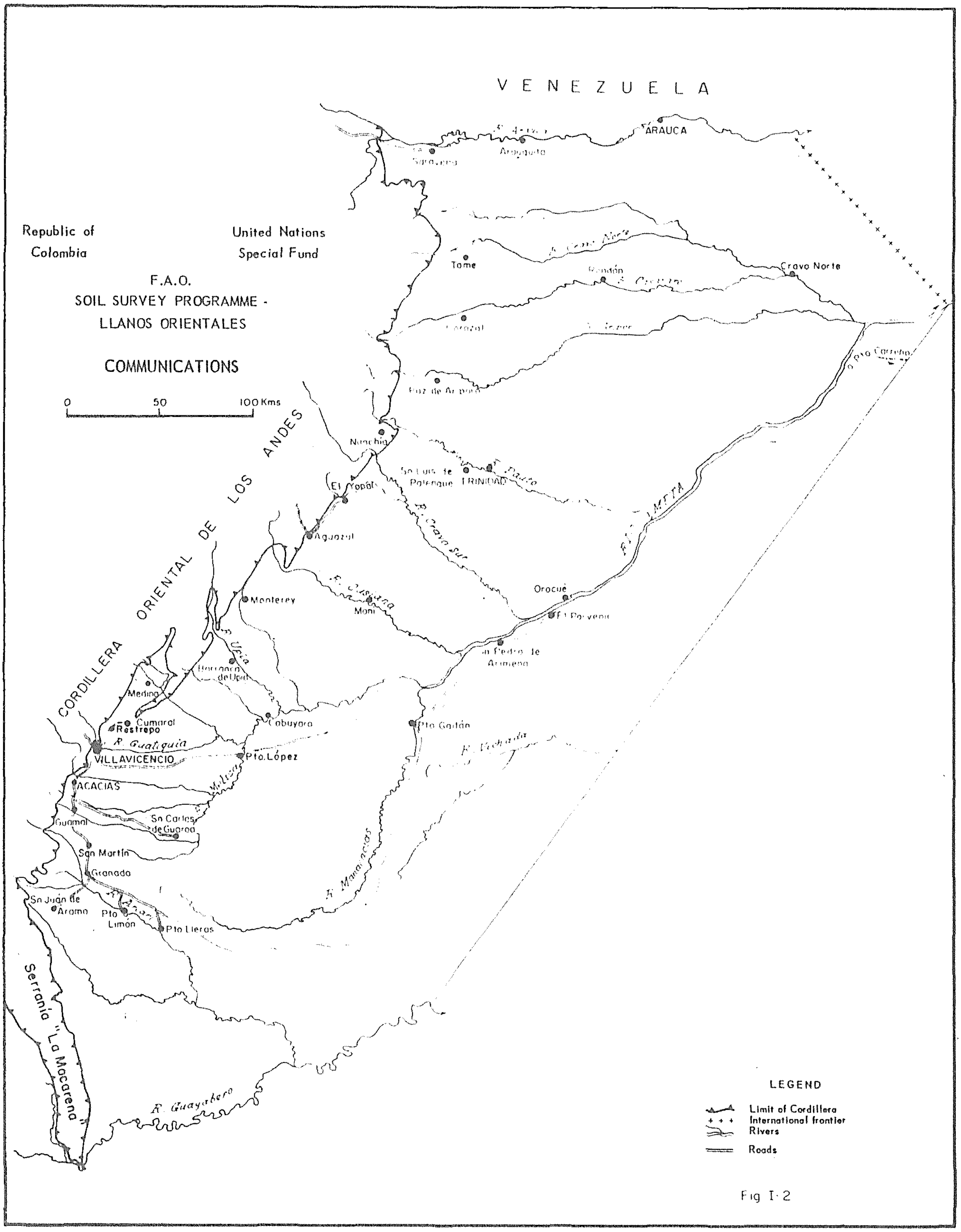

VENEZUELA
ARAUCA
Republic of Colombia
United Nations Special Fund
F.A.O.
SOIL SURVEY PROGRAMME -
LLANOS ORIENTALES
COMMUNICATIONS
0
50
100 Kms
Tame
Cravo Norte
CORDILLERA ORIENTAL DE LOS ANDES
TRINIDAD
Aguazul
Monterey
Orocué
Cumaral
Restrepo
VILLAVICENCIO
Pto. López
Cabuyaro
Pto Gaitán
ACACIAS
Guamal
San Martín
Granado
Pto Limón
Pto Lleras
Serranía "La Macarena"
R. Guayabero
R. Guatiquía
R. Manacacías
LEGEND
Limit of Cordillera
International frontier
Rivers
Roads

Fig I-2

There are no large towns; the biggest is Villavicencio with a population of about 35,000, which is the commercial center through which pass most of the goods in transit to the markets of the interior. Other towns of some importance are situated along the piedmont, e.g. Saravena, Tame, El Yopal, Medina, Cumaral, Restrepo, Guamal, Acacías, San Martín, Granada and San Juan de Arama. At points where the rivers begin to be navigable for medium-sized shipping, small ports have grown up, among them Arauca and Arauquita on the River Arauca; Cravo Norte on the River Casanare; Trinidad and San Luis de Palenque on the River Pauto; Orocué, Cabuyaro and Puerto Lopez on the River Meta; Puerto Gaitán on the River Manacacías; and Puerto Limón on the River Ariari.

Most of the population is engaged in livestock farming, crop farming, forestry and fishing, or in complementary activities such as transport, rice milling, etc.

The extremely extensive and primitive systems of livestock management in areas outside the piedmont require very little manpower and the inhabitants of the Llanos whose main occupation is "cattle" live on ranches long distances apart. The human population is very small in relation to the vast expense of territory and the huge number of animals to be tended.

Transport in the Llanos Orientales is very inadequate, but there are systems of air, land and river transport (see Fig. I-2).

Commercial aviation has developed considerably, both passenger transport and freight. There are regular air services connecting the cities of the interior e.g. Bogotá, Sogamoso and Cúcuta, with the main towns of the Llanos, e.g. Arauquita, Arauca, Tame, Saravena, Cravo Norte, Corozal, Paz de Ariporo, Nunchía, Trinidad, San Luis de Palenque, El Yopal, Agua Azul, Monterrey, Barranca de Upía, Villavicencio, San Martín, San José de Guaviare and many others outside the survey area. In addition there are air taxis - small aircraft carrying passengers and freight direct to the ranches. Almost all the main ranches have their own airstrips.

The road system is very elementary, a fact which has greatly limited the area's development. The only road connections with the west of the country are from Bogotá to Villavicencio and from Sogamoso to El Yopal. Both are liable to be cut by landslides. A road from Arauca to Pamplona in the Norte de Santander Department is in construction and is already in use between Pamplona and Saravena in the dry season.

There is a fairly good road running from north to south along the Meta piedmont and connecting up the main towns. A road open throughout the year runs eastwards into the interior of the Llanos from Villavicencio through Puerto López to El Porvenir, opposite Orocué; vehicles have to cross the Meta and Manacacías rivers on a long bridge. There are also various short roads, open all year, connecting the piedmont road with villages or ranches on either side of it. The total all-weather road network amounts to about 800 km, but is of very low specifications.

During the dry season (summer) it is possible to travel far over the Llanos following vehicle tracks, but these are interrupted by the lack of bridges. At some points there are rafts for ferrying vehicles over rivers or streams, but these are very few.

In summer livestock are driven from the breeding-ranches to the fattening-grounds near Villavicencio along old trails, often swimming across rivers. It takes about 60 days on average to drive store cattle from Arauca to Villavicencio. During the rainy season when the rivers are full, the cattle are put on rafts and take about 3 days to travel from Cravo Norte to Puerto López, a distance of 400 km as the crow flies.

River transport is of great importance in the Llanos. During the rainy season several rivers are used for carrying livestock and agricultural products to ports connected by road to the interior of the country. In addition, people living on or near these rivers purvey goods not produced in the region, but shipped from outside.

Vessels engaged in river transport have a maximum displacement of 200 tons, with 2 or 3 feet draught, and are owned by private or semi-Governmental undertakings. They operate on average for 7½ months, from the end of April or beginning of May to the middle of December, when the river level falls.

The most important rivers in this connection are as follows:

Arauca: Navigable from Arauca to where it joins the Orinoco (450 km). In high-water periods vessels can get up to Arauquita (540 km).

Casanare: Navigable up to Rondón (150 km) in high-water periods, but normally only from Cravo Norte to where it joins the Meta (50 km).

Pauto: Navigable from San Luis de Palenque to where it joins the Meta (100 km).

Cusiana: Navigable from Maní to where it joins the Meta (60 km).

Meta: The main river artery of the region. Navigable from Puerto López to where it joins the Orinoco (720 km).

Menacacías: Navigable from where it joins the Meta for some 200 km upstream.

II. CLIMATE

A typical characteristic of tropical climates is uniform temperature throughout the year. At the three meteorological stations of the Llanos with over 7 years' records (Mejía, 1959), namely Arauca, Orocué and Villavicencio, mean monthly temperatures fluctuate by 1.1 to 2.3 °C from one month to another. Orocué, the most central station, records higher averages than Arauca or Villavicencio, but the difference is only 2°C.

There is more difference between daily maximum and minimum temperatures. Mean annual maximum temperatures for the above three stations fluctuate between 31.2 and 33.4°C, while mean annual minimum temperatures vary between 20.9 and 22.8°C. Maximum temperatures are recorded in March or April when the sun is high, but when the cloud cover has not yet developed very extensively. Minimum temperatures are recorded at the end of the rainy season when actual evaporation is high, owing to the start of the trades and the high level of soil moisture after the rains.

The trade winds blowing toward the Tropical Convergence are a typical phenomenon of the dry season in the Llanos. This dry season is known locally as summer ("verano") although it actually coincides with the period of low sun, or winter in the astronomical sense. The only data available on wind direction and speed in the Colombian Llanos come from Villavicencio (4 years' records) and vary greatly. Data from the Venezuelan Llanos give the prevailing direction as ENE and average speed as 4 meters per second. Fire trails visible in aerial photographs of the Colombian Llanos show this as the general direction of fire travel, indicating that during the dry season at least the trades reach the southernmost part of the Colombian Llanos.

Rainfall statistics (see Fig. I-3) are more plentiful; at least nine stations in the Colombian Llanos have over 5 years' records (Mejía, 1959, and Instituto Geográfico), although the longest records are not continuous. By combining data from Colombia and Venezuela (Sánchez Carrillo, 1960), a rainfall map of the Llanos was prepared (see Fig. I-4), showing isohyets at 200 mm intervals. This map shows that precipitations in the Soil Survey Program Area vary from under 1800 mm to 5000 mm per annum.

Mean minimum precipitation in the whole Llanos region has been recorded at Ciudad Bolivar in East Venezuela as 997 mm over 35 years. It increases to the west and south - 1455 mm in Barinas in West Venezuela (10 years' records) and 1733 mm in Orocué on the River Meta (7 years' records). Near the Cordillera Oriental rainfall increases rapidly, - 2000 mm on average in West Venezuela, 4000 mm in Villavicencio and up to 5000 mm in Acacías.

The rainy season coincides with the advance of the Tropical Convergence from the south, beginning in February in the southern Colombian Llanos and moving up in April to Arauca on the border of Colombia and Venezuela and in May to West Venezuela. About 90 to 95 percent of annual precipitation falls during this well-defined rainy season.

The end of the rainy season is more uniform throughout the Llanos and varies from the second half of November to December. The dry season thus lasts from one to five months in the Llanos region, increasing as one moves from south to north (See Fig. I-4).

Relative humidity is high throughout the Llanos; during the rainy season mean relative humidity is about 80 percent and during the dry season between 50 and 60 percent. Potential and actual evaporation can be calculated according to Budyko's method (1956) for the stations of Villavicencio and Arauca, the only ones for which sufficient data are available. The results are shown in Tables I-1 and I-2.

During the rainy season actual and potential evaporation are low, due to lower temperatures and high relative humidity. Under the influence of the trades potential evaporation increases in the dry season, but actual evaporation, after rising at the start of the dry season, decreases owing to the shortage of water. This decline in actual evaporation is not so apparent at Villavicencio where there is ample water throughout the year. In both stations potential evaporation is less than annual rainfall; only in North Venezuela, where rainfall is lower, does potential evaporation exceed annual rainfall (Blydenstein, 1962).

To sum up, the Llanos have a tropical climate with well-defined rainy and dry seasons. According to the Koeppen-Geiger classification (1954) it is an Aw climate or savanna climate. Koeppe (1958) classifies it as tropical humid and dry; and Papadakis (1961) as equatorial semi-warm, monsoon humid-dry (Eq,Mo) for Arauca and equatorial humid semi-warm (Eq, Hu) for the Villavicencio area.

TABLE I-1

CALCULATIONS (BUDYKO METHOD, 1956) OF ACTUAL AND POTENTIAL EVAPORATION AND WATER DEFICIT OR SURPLUS AT VILLAVICENCIO (META) 1/

Month	E_o	$\frac{E_o}{W_m} + 1$	r_n	w_{n-1}	$r_n + w_{n-1}$	w_n	E_n	(-) d (+) s	HR
1	88.8	1.296	77.4	300.0	377.4	291.2	86.2	- 2.6	75
2	109.6	1.365	110.4	291.2	401.6	294.2	107.4	- 2.2	71
3	102.8	1.343	129.0	294.2	423.2	315.1	102.8	+ 20.4	72
4	64.8	1.216	463.9	300.0	763.9	628.2	64.8	+ 399.1	81
5	59.5	1.198	591.2	300.0	891.2	743.9	59.5	+ 531.7	82
6	28.0	1.090	549.8	300.0	849.8	779.6	28.0	+ 521.8	83
7	70.8	1.236	574.7	300.0	874.7	707.7	70.8	+ 503.9	80
8	78.4	1.261	396.4	300.0	696.4	552.3	78.4	+ 318.0	79
9	86.8	1.289	366.2	300.0	666.2	516.8	86.8	+ 279.4	80
10	66.4	1.221	426.9	300.0	726.9	595.3	66.4	+ 360.5	81
11	68.5	1.228	381.6	300.0	681.6	555.0	68.5	+ 313.1	80
12	81.6	1.272	129.4	300.0	429.4	337.6	81.6	+ 47.8	78
Totals	906.0		4359.8				901.2	- 4.8 +3295.7	

1/ See Table I-3 for the meaning of the symbols.

TABLE I-2

CALCULATIONS (BUDYKO METHOD, 1956) OF ACTUAL AND POTENTIAL EVAPORATION AND WATER DEFICIT OR SURPLUS AT ARAUCA, INT. DE ARAUCA 1/

Month	E_o	$\frac{E_o}{W_m} + 1$	r_n	$\hat{w}_{n-1}$	$r_n + w_{n-1}$	w_n	E_n	(-) d (+) s	HR
1	136.6	1.455	13.9	249.8	263.7	181.2	82.5	- 54.1	65
2	161.3	1.538	7.4	181.2	188.6	122.6	66.0	- 95.3	61
3	166.4	1.555	26.9	122.6	149.5	96.1	53.4	- 113.0	60
4	120.5	1.402	193.0	96.1	289.1	206.2	82.9	- 37.6	72
5	70.7	1.236	230.7	206.2	436.9	353.4	70.7	+ 66.2	81
6	58.7	1.196	291.7	300.0	591.7	494.7	58.7	+ 233.0	82
7	58.2	1.194	261.1	300.0	561.1	468.9	58.2	+ 202.9	82
8	71.4	1.238	213.6	300.0	513.6	414.8	71.4	+ 142.2	80
9	73.1	1.244	227.4	300.0	527.4	423.9	73.1	+ 154.3	79
10	85.4	1.285	201.4	300.0	501.4	390.1	85.4	+ 116.0	78
11	74.5	1.248	87.9	300.0	387.9	310.8	74.5	+ 13.4	80
12	100.7	1.336	33.8	300.0	333.8	249.8	84.0	+ 16.7	73
Totals	1177.5		1792.6				860.8	- 316.7 + 948.0	

1/ See Table I-3 for the meaning of the symbols.

TABLE I-3

SYMBOLS AND FORMULAE FOR TABLES I-1 AND I-2

E_o	:	Potential evaporation in mm.
W_m	:	Soil water retention capacity in mm (estimated at 300 mm).
r_n	:	Monthly rainfall in mm.
w_n	:	Soil water in present month in mm.
w_{n-1}	:	Soil water in previous month in mm.
E_n	:	Actual evaporation in mm.
d	:	Water deficit for the month in mm.
s	:	Water surplus for the month in mm.
HR	:	Relative humidity as a percentage.
E_o	:	at; t = actual vapour pressure less saturation vapor pressure a = 14 (fixed factor for tropical climate).

$$w_n = \frac{(r_n + w_{n-1})}{\frac{E_o}{W_m} + 1}$$

$$E_n = (r_n + w_{n-1}) - w_n \text{ ; if } w_n \text{ is less than } W_m$$

$$E_n = E_o, \text{ if } w_n \text{ is greater than } W_m$$

$$\text{Deficit} = E_o - E_n$$

$$\text{Surplus} = (r_n + w_{n-1}) - (W_m + E_n)$$

III. VEGETATION

The vegetation survey area covered approximately 12 million hectares, or the same area as the soil survey, excluding the southern part of the Ariari and Güejar rivers. About 85 percent of the survey area, i.e. 10 million hectares, is under savanna and the remaining 15 percent under forest.

The vegetation map (Vol. III) distinguishes 27 units occupied by various combinations of the 10 types of savanna and 6 types of forest surveyed.

Apart from the forests on the river vegas and the gallery forests along the streams and "esteros", forests are mainly restricted to three areas (see Fig. I-5): the Arauca forest in the north, the piedmont hill and terrace forest along the Cordillera Oriental, and the high plain forest in the south. There are also some remnants of forest on some of the dunes of the aeolian plain.

Of these, the vega forests are the most valuable. Near the water courses there are sizeable trees of high value as timber. Further away from the rivers the trees become smaller and belong to different species. The gallery forests along the streams are not good for timber, except those on the piedmont which develop in heavier rainfall.

On the wet esteros there are groves of moriche palm, whose main value lies in the protection they afford to drainage channels. If there were no trees, the streams might become muddy, thus obstructing the natural drainage of the area and losing their value as a source of clear water for cattle.

The Arauca forest, which is semi-deciduous, occupies the habitat of the levees and depressions of the alluvial overflow plain, although on coarser soils than most of this region. One-story and two-story forests are to be found here. The two-story forest has a lower story similar to the one-story forest, plus the taller trees of the upper story. Although these forests are not commercially exploitable under present conditions, they have sufficient timber value (especially the two-story forest) to make it advisable to establish forest reserves in this area to protect them for future use.

The piedmont hill forest is deciduous and is of great value in protecting the catchment basins and controlling the levels of the Llanos rivers, along which most agricultural activity takes place and where the main settlements are located. It should be maintained as forest and some basins where the forest has been destroyed should be replanted. The piedmont terrace forests, on flatter ground, have almost all been felled and replaced by crops. The low terrace forest on the River Guaviare - an evergreen forest - has been preserved, mainly because it is a long way from the population centers.

The high plain forest, which is semi-deciduous, is found mainly on the hills of the dissected undulating high plain, especially south of the main rivers, which give some protection against fire advancing from the northeastern savannas. South of the Guaviare the forest is still in good condition. It is a low forest of little timber value and protects the slopes against soil erosion.

Savannas with remnants of forest are found on the piedmont hills and terraces, on the dissected high plain, and on the dunes of the aeolian plain, viz. Melinis minutiflora, Paspalum carinatum and Trachypogon ligularis-Paspalum carinatum respectively. They have in common the fact that they have replaced a forest on its habitat, but otherwise there is little affinity between them.

The remnants of forest, characteristically extended in the direction of the prevailing winds owing to the effects of fire, are easily recognizable as such and are common on these types of savanna. In the M. minutiflora savanna there is constant pressure for the return of the forest; in the P. carinatum savanna, however, soil erosion due to the disappearance of the forest prevents the restoration of the original vegetation. The T. ligularis-P. carinatum savanna of the dunes was probably created through the continual action of fire advancing from the surrounding savannas and destroying the original forest.

The Andropogon and Mesosetum savannas are subject to flooding and lie mainly on the low land between the piedmont and the River Meta. The Andropogon savanna on the heavy soils of the alluvial overflow plain develops a low layer of good fodder value in the dry season, while the Mesosetum savanna develops one of lush pasture only in the rainy season. A less floodable phase of the Andropogon savanna is found on the "esteros" of higher regions.

Wet savannas are intermediate between flood savannas and dry savannas. In a flood savanna habitat they occupy the high ground, while on a dry savanna habitat they are found in depressions and other moist areas. This group includes Leptocoryphium lanatum and Trachypogon ligularis savannas. These two types have a good deal of affinity with each other and there are many intergradations between them and also between each of them and other wetter or drier types.

There are various dry savannas, including Trachypogon vestitus-Azonopus purpusii, Paspalum pectinatum and Trachypogon vestitus, the last-named being the driest. The P. pectinatum savanna is apparently connected with erosion and the presence of plinthite or stones and is bound on the slopes of the water-courses and the hills of the badly drained high plain or on the high terrace with an indurated plinthite layer. The T. vestitus-A. purpusii savanna is the best of the three dry types as it contains many species of good fodder value.

IV. HYDROLOGY

The area surveyed in the Llanos Orientales comprises several river basins, the Meta being the most important. Its drainage basin covers practically the whole area between the Cordillera Oriental and its own channel, as well as a large tract on the south-west drained by the Manacacías. The Meta flows into the Orinoco, which in turn flows into the Atlantic Ocean.

Other river basins of less importance and similar characteristics are those of the Arauca and Ariari in the north and south of the survey area, tributaries of the Guayabero and the Orinoco respectively. Apart from the Manacacías, all these rivers rise in the Cordillera, which means that they have a special climatic and hydrological regime.

The other rivers rise in the Llanos, viz. the Manacacías, the Vichada and the Tomo, and cross the high plains, the first joining the Meta and the other two the Orinoco.

The characteristics of the river systems originating in the Cordillera Oriental depend on the sudden changes in rainfall from one season to another, the existence of heavily eroded steep slopes in the Cordillera, and the limited capacity of the River Meta to carry off the water.

River flow fluctuates sharply according to the season, as may be seen from the measurements obtained in some surveys: the flow of the River Guayuriba varied from a minimum of 41.6 cu.m. per second in March to a maximum of 1500 in the 1963 rainy season; the River Guatiquía from 14.5 to 700 cu.m. per sec. and the River Meta at Orocué from 395 to 8600 cu.m. per sec. during the same period. These flow variations caused differences in level of 2.85 and 2.20 m in the Guayuriba and the Guatiquía respectively at their exit from the Cordillera; while the figures for the Meta at Orocué show that its capacity is inadequate to cope with extreme seasonal differences in level of 4 to 5 m.

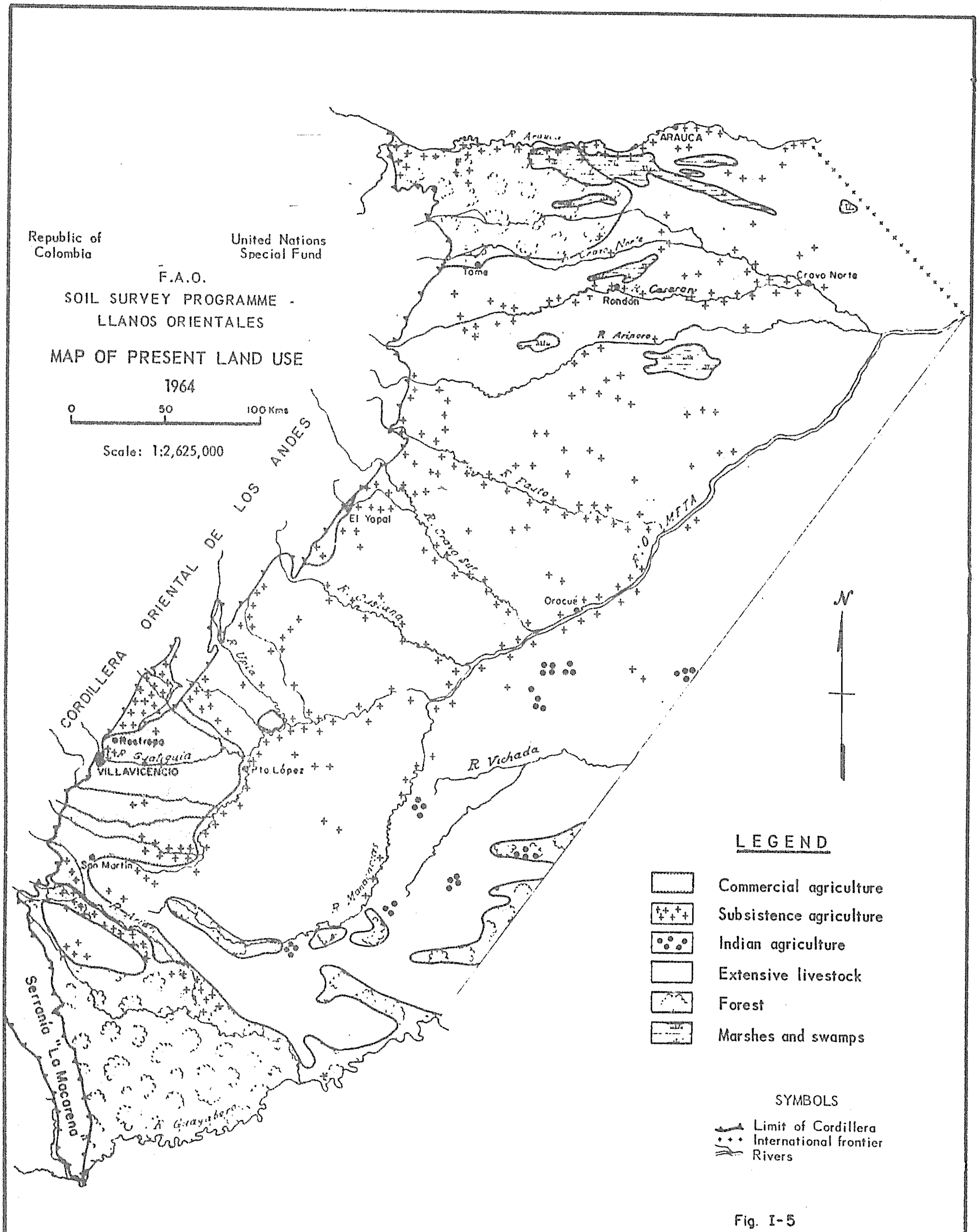

Republic of Colombia
United Nations Special Fund
F.A.O.
SOIL SURVEY PROGRAMME - LLANOS ORIENTALES
MAP OF PRESENT LAND USE
1964
0
50
100 Kms
Scale: 1:2,625,000
CORDILLERA ORIENTAL DE LOS ANDES
Serranía "La Macarena"
ARAUCA
R. Arauca
Tame
Rondón
Cravo Norte
R. Arinoco
El Yopal
Orocué
R. Meta
R. Vichada
Restrepo
VILLAVICENCIO
Pto López
San Martín
R. Guayabero
N
LEGEND
Commercial agriculture
Subsistence agriculture
Indian agriculture
Extensive livestock
Forest
Marshes and swamps
SYMBOLS
Limit of Cordillera
International frontier
Rivers

Fig. I-5

Rainfall variations in the Cordillera are not the only cause of overflowing; on leaving the Cordillera the rivers carry enormous quantities of solid matter, especially during the rainy season. This load slows down the Llanos rivers and fills up their channels. For instance, the bed of the Guatiquía is said to have risen some 5 to 7 m in the last 20 years. For this reason there is an increasing tendency for rivers to change course completely and to flood large parts of their vegas more frequently.

Lastly, the characteristics of the main water collector, the River Meta, are such, especially below its junction with the River Upía, that it cannot evacuate all the runoff efficiently. The gradient is very slight and the channel gets silted up.

These three main factors determine the hydrologioal characteristics of the rivers lying between the Cordillera and the Meta, almost all of which flood part of their vegas and change course frequently. This applies to the Cravo Norte, the Casanara, the Ariporo, the Pauto, the Cravo Sur, the Cusiana, the Upía and many others.

The same factors are probably responsible for the regular flooding of the low areas of the alluvial overflow plain, sometimes combined with the effect of the subsidence in the Casanare and Arauca regions (see section on Geology); in the aeolian plain it is more probably a question of waterlogging due to the rise of the water table as a result of increased rainfall on very flat lands with no adequate drainage.

In the survey area there is no doubt that ground water forms an important deposit on much of the land between the Cordillera and the Meta-Metica rivers, with the exception of the piedmont mesas and some high terraces near the cliffs. Such water forms a truly inexhaustible reserve, and as it is at no great depth, there is no difficulty in pumping it up, either by motor pumps or windmills. A large number of wells can thus be made available to supply water for domestic use or for watering animals.

There is no real shortage of water for irrigation. The probable extreme minimum specific runoff along the Cordillera has been determined as 0.6 x 15.7 cu.m. per ha per day, which would make it possible to irrigate some 88,000 ha of rice during the dry season in the Meta Department alone. At present not one tenth of that figure is cultivated, so there is a very wide margin for future development. With the exception of the Salinas water, all Cordillera runoff is suitable for irrigation.

The most serious hydrological problem of the Cordillera rivers is certainly flooding, generally on the more fertile areas best suited for agriculture. For this reason it is urgently necessary to protect the Cordillera basins against erosion, before planning large-scale engineering works. Possibilities of flood protection will be very limited if no effort is made to reduce the load of solid matter carried by the rivers.

The areas south of the Meta and Metica rivers have different characteristics. River flow depends above all on ground water supply, which collects and efficiently obviates sudden rises. The water table in the dry season lies at a depth of about 12 meters in the level high plain (Aa) near the Manacacías and gets gradually nearer the surface toward the north where the As soil association is found. (See Vol. II, Section One).

There is little flooding in Aa, Ao and Ac units, although the steeper slopes in the rolling, dissected high plains may cause waterlogging on lower levels.

For this reason the protection of steep slopes in these areas is also recommended.

A more detailed study of water problems in the Llanos appears in Vol. IV.

V. GEOLOGY, GEOMORPHOLOGY, LANDSCAPE MAP

The Llanos Orientales consist of geological formations of the Quaternary Period, which is subdivided into the Pleistocene, roughly from - 1,000,000 to - 10,000 years, and the Holocene, from about - 10,000 years upwards.

To understand the characteristics of the sediments forming the basis of the Llanos landscape and to explain some regional differences, it is necessary to give a brief geological history of the Cordillera Oriental. All surface sediments in the Llanos Orientales come from the Cordillera.

1. Geology of the Cordillera

The mountain mass of the Cordillera Oriental consists mainly of the Cretaceous formation, locally eroded, with outcrops of older formations of the Mesozoic and Palaeozoic. Between the Duda and Upía rivers intrusive granitic rocks appear. The flanks of the Cordillera on both sides present large stretches of strata from the Tertiary. The approximate composition of the various formations is given below.

Upper Middle Tertiary	sandstones and conglomerates
Lower Tertiary (Guaduas formation)	sandstones and argillaceous schists
Upper Cretaceous (Guadalupe formation)	sandstones
Middle Cretaceous (Villeta formation)	shales with limestone beds
Lower Cretaceous (Cáqueza formation)	shales
Palaeozoic: Carboniferous	argillaceous schists alternating with limestones
Intrusive rocks of Cundinamarca	granodiorites

The Cordillera has been uplifted several times in the course of its geological history. From the geogenetic standpoint of the Llanos, the last upheavals of the Tertiary and the Quaternary are the most important.

At the beginning of the Tertiary, when the Cordillera Oriental had not yet reached its present height, the Cretaceous formations were covered with new deposits. Sedimentation continued under terrestrial conditions by means of a river system descending from the Cordillera Central, which at that time was much higher than the Cordillera Oriental.

In the middle of the Tertiary the Cordillera Oriental began to lift, accompanied by intense folding and parallel and transverse faults, and reached a height of at least 2,000 meters. Later came the Upper Tertiary formations, still to be found on the flanks of the Cordillera.

In the Quaternary a great upheaval took place. According to Schuchert (1935), toward the end of the Pleistocene the Cordillera was uplifted to over 3,000 m. Hubach (1954) deduces from existing outcrops the following altitudes reached for the Guaduas formation (Lower Tertiary): over 6000 m. between Bogotá and Villavicencio, about 4,000 m in the Upía region, over 7,000 m in the Nevada del Cocuy, and between 2,000 and 3,000 m in the Alto Arauca depression, which clearly indicates undulations in the direction of the Cordillera.

The previous process of differential uplift is very important for an understanding of the Llanos sediments. Where the Cordillera was higher, erosion was greater and lower strata were uncovered and exposed to erosion. Thus in different parts of the Cordillera outcrops of different strata appear, which affect the composition of the materials deposited in the Llanos. In general we may say that the Tertiary strata were entirely removed, except on the lower flanks of the Cordillera.

The next stratum, the Upper Cretaceous (Guadalupe formation) was removed almost entirely in the south, but seems still to prevail in the north (possibly with the exception of Cocuy). This is probably the cause of the very sandy sediments of Arauca and part of Casanare, as the Guadalupe formation is chiefly sandstone.

South of the Upía most of the Llanos sediments contain more clay, which is quite natural since the corresponding section of the Cordillera exhibits more surface shale of the Middle and Lower Cretaceous. However, there is no lack of sand, since this part of the Cordillera also has outcrops of Pre-Mesozoic conglomerates and intrusive granodiorites.

During the soil survey it was observed that in the Medina depression and northwest of Villavicencio soils were redder than is usual in the Llanos. These soils seem rather more fertile than others of comparable age. The geology of this region is not known in sufficient detail to provide a satisfactory explanation for this phenomenon, but some studies indicate the direction in which the explanation may lie. Wokittel (1953) mentions that in the Cordillera west of Medina "strong red pans" of arenaceous clay are found, which may belong to the Permian or Upper Carboniferous; he also refers to Upper Carboniferous limestone. Huback (1955) refers to the so-called Gachalá Group of the Carboniferous, an outcrop to the west of Medina consisting of argillaceous schists alternating with limestone, and which in his opinion may produce productive soils as it contains plant nutrients.

2. Geology of the Llanos Orientales

This section relates solely to the Quaternary Period.

At the beginning of the Pleistocene a broad layer of alluvial sediment was deposited in the Llanos Orientales.

Before the last glaciation there was a very active period of mountain-building in the Cordillera, which affected the Early Pleistocene formation, especially at its apex on the Cordillera piedmont.

A large number of faults occurred parallel to the Cordillera; the apex of the Early Pleistocene was uplifted and sank some kilometers to the east. The subsidence affected the Arauca and Casanare region and continued to a lesser degree in Meta. The latter area presents a large number of parallel and transverse faults, each representing a movement of the Early Pleistocene on both sides of the fault, without producing complete subsidence as in Arauca and Casanare. For this reason the terracing east and south of Villavicencio is rather complex; some parts belong to the Early Pleistocene while others represent later sediments, and any attempt at dating by means of the different levels is extremely difficult.

The eastern limit of the subsidence is the valley of the River Meta. From its junction with the Manacacías to near the Venezuelan frontier, the Meta flows practically in a straight line; the cliffs on the right bank are higher than on the left, from which we may deduce the existence of a fault along the line of the Meta itself.

There are signs that the Pleistocene subsidence in Arauca and Casanare continues to a slight extent to this day.

For about 15 years the River Arauca has divided into two at El Bayonero. The southeast branch floods large areas known locally as "raudales" and at some points even draws near to the Casanare. Obviously there is a depression in the center of the Intendencia de Arauca below the level of the Arauca. It may simply be that sedimentation along the banks and on the bed of the Arauca have lifted it above the adjoining land and the El Bayonero diversion is the natural consequence of this difference in level, but it is more logical to suppose the continuation of tectonic sinking, since the present depression in Arauca coincides with the center of the Pleistocene subsidence.

The great unheaval in the Cordillera Oriental toward the end of the Pleistocene triggered off a new cycle of erosion in the Cordillera and sedimentation in the Llanos. The Llanos sedimentation occurred mainly in the Arauca-Casanare depression and partially in Meta where the alluvial terraces are now found. The Early Pleistocene zones on high ground near the Cordillera and east of the Meta were not covered by the new sediments and were subject to intense erosion, dissection producing very rugged topography.

Sedimentation in the depression took the form of an alluvial overflow plain whose main characteristics are the alternation of natural levees and depressions, called "bajos". This sedimentation may be related to the Cordillera glaciations, which covered all peaks over 3,200 m in various phases. As in the Magdalena Valley (Goosen, 1961), the three most important phases of the last glaciation may each be represented by a sedimentation phase in the Llanos. There is no evidence of this on the surface of the alluvial overflow plain, but the alluvial terraces might provide some.

The period in question, ie. from the end of the Pleistocene to the transition to the Holocene, is marked by intense erosion in the Cordillera and by several climatic changes. During the dry periods windborne sand and loess were deposited on the eastern part of the alluvial overflow plain, thus forming an aeolian plain characterized by dunes and loess flats.

In the transition to the Holocene, the end of glaciation in the Cordillera led to a decline in river flow and altered the river system in the Llanos Orientales. The rivers decreased in number as well as in volume, and this change is still visible on the surface. Various abandoned channels may be observed; in some valleys the meanders of the existing stream are very small in comparison with the size of the valley, and the abandoned meanders of the old river are up to 10 times larger than the present ones.

Flow reduction combined with less sedimentation lowered the river level at the beginning of the Holocene below the surface, leaving the alluvial overflow plain as a terrace. Near the Meta this difference of level may be up to 10 m but it is generally less. In the valleys cut by the rivers new sediments from the Cordillera were deposited and these form the broad strips of recent alluvium found along all the main Llanos rivers, but representing a very small percentage of the total area.

The existing rivers occupied roughly the same sites throughout the Holocene, during which they suffered various changes in level, as may be seen for instance from the "vegones", originally low terraces but subsequently invaded by recent river sediments. No further details of these variations are known.

The formations referred to above will be discussed in more detail in the following section on the various landscapes.

3. Geomorphology and landscape map

The geomorphological units of the Llanos Orientales form the basis of the soil and vegetation survey and are represented on the landscape map prepared. The units of this map have geomorphological significance and their subdivisions coincide with soil associations.

(a) Legend

The map legend (see Fig. I-6) indicates the following physiographic regions.

	Age of materials	Symbol
Piedmont		
Old alluvial fans	Early Pleistocene and Tertiary	M
Sub-recent alluvial fans	Middle and Late Pleistocene some Holocene	P
Terraces		
Alluvial terraces at various levels	Middle and Late Pleistocene Holocene	T
Alluvial overflow plain		
Alluvial overflow plain	Middle and Late Pleistocene Holocene	D
Aeolian plain		
Dunes	Late Pleistocene	E1
Aeolian plain with "esoarceos"	Late Pleistocene and Early Holocene	E2
Alluvium		
Recent alluvium	Holocene	V
High plains		
Level high plains	Early to late Pleistocene	A1
Level high plains with poor drainage	Early to Late Pleistocene	A2
Dissected high plains	Early Pleistocene	A3

The above dating must be considered tentative. To establish exact chronology more accurate data would be required.

(b) Description of units

The old alluvial fans (M) belong mainly to the Early Pleistocene and are found on high ground. The level, rolling phases in the Llanos are often known as "mesas," an appropriate name as the landscape is a tract of flat ground bounded by cliffs. Locally these formations have slopes of up to 10 percent, generally in an eastward direction. The cliffs on the eastern side almost always correspond to fault lines. Mesa material is sandy and in Casanare and Arauca boulders of up to 2 m in diameter are often found on the surface. High position and coarse texture lead to excessive drainage, so that the mesas are very dry in the dry season.

Another effect of high position is erosion. Steep cliffs may be regarded as very unstable slopes and are therefore easily eroded. Erosion continued for a fairly long time and as a result much of the Early Pleistocene does not appear as mesas but as low hills. Tertiary strata are often exposed and the boundary between the low hills and the Cordillera is therefore gradual. At various points the Early Pleistocene underwent gentle folding.

Toward the south the texture of the mesas is heavier. South of the Ariari and east of San Martín there are other Early Pleistocene formations, which bear some similarity to the high plain east of the Meta and Vichada and have therefore been included with it.

The sub-recent alluvial fans (P) of the piedmont must be regarded as the apex of the alluvial overflow plain; their slope, position and relatively light texture create better hydrological conditions than are found in the overflow plain itself. They are divided into three units. The first is the upper fan, consisting of the strip adjoining the Cordillera or the mesa cliffs and representing the apex of the sub-recent fans. It was originally a light sediment, but was frequently covered with heavy material as a result of slow sheet erosion from the lower Cordillera. The unit has a gradient of 1-5 percent; locally steeper slopes are found where the streams have cut down below the mean surface.

The lower fan is the eastward continuation of the upper fan and has gentler slopes. In the method of deposition it is possible to observe the beginnings of differential sedimentation, which is so apparent further down. This process is governed mainly by changes in slope and flood-water velocity and may be explained as follows.

Where there is a sudden change in slope, as happens at the exit from the Cordillera, coarse material in suspension or rolling along the bottom of the river is deposited. Intense accumulation of material at these points causes frequent changes of channel; in the end the apex of an alluvial fan shows such an intricate pattern of old channels that it is difficult to detect individual courses. Lower down the valley widens, giving more room for changes of channel, which can then be distinguished more easily. The rivers overflow in high-water periods and a sheet of water flows over the adjoining country. Once it has left the river bed, the water rapidly loses its velocity; the coarse material in suspension is soon dropped, while the finer particles are carried on and deposited on low ground. Differential sedimentation may be observed on various parts of the lower fan. Some sandy-textured strips cross the fan, representing places where a former river has deposited its coarse material to form natural levees. The surface of the lower fan underwent slight modifications after its formation. Sheet erosion seems to have smoothed out the sharp detritus of alluvial sedimentation. Some streams were formed, and at some points were subsequently filled with fine products of sheet erosion, while at others poor drainage led to greater accumulation of organic matter. By relating texture differences to the nature of geological formations in the Cordillera, the lower fan can be divided into three phases of light, medium and heavy texture respectively.

The third subdivision of sub recent alluvial fans is the stony fan, which may have been formed in a high-water period and often represents a later phase of sedimentation than the lower fan. The flood waters seem to have removed part of the lower fan and left their own sediments in its place. These are characterized by a larger quantity of gravel and stones near the surface, distributed in intersecting strips, which still reflect very well the crisscrossing flood channels of the "parents" of the unit.

The alluvial terraces at various levels (T) comprise the region between the Cordillera and the Upía, Metica and Ariari rivers and extend along the Ariari to the Guaviare. These terraces contain perhaps the greatest concentration of faults, representing the end-zone of the great Casanare-Arauca subsidence. At first sight the direction of the faults appears arbitrary, but if the pattern is analysed carefully, two main directions may be detected: SSW-NNE and WNW-ESE. The cross pattern is slightly in evidence in the rectangular shape of some terraces, e.g. the Alto de Chichimene east of Acacías, but it is mostly hidden, since the west-east faults are mainly occupied by tributaries of the Metica. This phenomenon makes it difficult to distinguish between faults and ordinary terrace cliffs.

The effect of the faults was a differential earth movement at various points, during which - and even after - the alluvial sedimentation of the Cordillera rivers continued. Sedimentation varied in intensity in the course of geological history and this is probably connected with the various phases of glaciation and with tectonic processes and consequent erosion in the Cordillera.

Summing up the geomorphological processes underlying the formation of alluvial terraces, we may say: (1) The crossed faults in the area led to the establishment of many different levels in the Early Pleistocene formation. (2) Alluvial sedimentation of varying intensity covered the lower levels of this formation.

This does not in any way claim to be the last word on this extremely complex landscape. For instance, faults can be observed in recent alluvial sediments, which indicates that their formation continued in recent times.

As may be seen from the foregoing, it is at present impossible to establish even a very relative chronology of the various terraces. Generally speaking, the highest are the oldest and the lowest the youngest, but this is not always the case. We shall therefore confine ourselves to a physical description of the terraces.

In the first place, the character of the terraces gradually changes from west to east. Near the Cordillera slopes are steeper, which entirely tallies with what is generally observed with alluvial sedimentation. The terrace base (subsoil) generally consists of an accumulation of gravel and stones, lying at greater depth toward the east and gradually changing to a sand and gravel layer. Although rainfall is heavier near the Cordillera, terrace drainage is better, for reasons of texture and relief. The percentage of badly drained soils that become waterlogged increases toward the east. In the region nearest the Cordillera textures are more uniform, while eastward the phenomena of differential sedimentation are more frequent.

In addition to differences in the same terrace, different levels between terraces affect land and soil quality. In general terms, and for purposes of comparison, terraces may be divided into three groups - high, middle, and low, although the number of levels is greater than three.

<u>High terraces</u> have good drainage; the percentage of badly drained soils is not more than 25 percent. The streams crossing these terraces are rather intermittent; they do not rise in the Cordillera, but on the terraces themselves, and dry up very easily in the dry season.

On <u>low terraces</u> drainage is usually poorer, although there are some well-drained soils. On this level water collects in the "bajos" or depressions, especially in the east, and may cause "zurales" (gully erosion).

In between these two lie the <u>middle terraces</u>. While most terraces show no traces of old channels, the middle terraces present a few natural levees, like corrugations on the surface, which bear witness to their alluvial origin.

The <u>alluvial overflow plain</u> (D) was so called by analogy with similar formations in the Argentine Pampas (Frenguelli, 1925), where it is known as the <u>overflow Llano</u>.

On the fan a deltaic pattern of channel distribution can be detected, spreading out from the point where the rivers leave the Cordillera; but the pattern of sedimentation on the alluvial overflow plain runs parallel to the various channels. There is no sharp boundary, for the overflow plain is the downstream continuation of the alluvial sedimentation beginning with fans.

We have said that the pattern of differential sedimentation can be distinguished on the lower fan. On the overflow plain it is even more apparent. The natural levees are further apart and are separated by depressions where the flood waters accumulate and deposit practically all the fine matter in suspension. In the Llanos these areas are appropriately known as "bajos". With a little practice it is not difficult to distinguish the two main landscape features, levees and depressions.

Further downstream the rivers deposited their load in a calm environment. There were fewer sudden changes of channel and rivers stayed longer in their beds. For this reason the individual levees are larger and the distance between them greater.

The levees are known as "bancos" in the Llanos. Heavy river loads and high flow during the sedimentation period raised the levees above the level of the general countryside. Sudden floods breached the levees and the waters flowed into the depressions, depositing their load along these breaches, or "salidas de madre". The small levees thus formed are called "banquetas" in the Llanos. The sedimentation pattern is very similar to a deltaic pattern. The old channels occupying the center of the levees are known as "cañadas"; in summer they are dry, but in winter they fill and drain off the rainwater. The depressions are completely flooded in winter; as they occupy over 50 percent of the alluvial overflow plain, travel becomes very difficult, and the inhabitants are forced to use the tops of the levees as paths.

A typical phenomenon throughout the overflow plain is the presence of "zurales". A "zural" is an area full of "zuros" - small mounds separated by gullies, the mounds representing the original level of the country and the gullies erosion channels. The gully network is very complex and irregular, varying between 0.20 and 1.50 m in depth and 0.30 and 2 m in width. Depth is determined by the local base level of erosion, which may be the bottom of a depression or the level of a neighboring stream. Gullies may form on almost level ground where the rainwater is drained by numerous rills seeking the path of least resistance i.e. between grass tufts or individual trees. Under forests the gullies may be further apart and deeper if the base level of erosion permits.

The soil contains kaolinite-type minerals and its cohesion and resistance to erosion are low, so that it is easily carried away by water. Each winter the gullies deepen, and when saturation is high the vertical walls may collapse and partially block them. The land then takes on a "pockmarked" appearance.

Zurales are mainly found on the upper stretches of the alluvial overflow plain near the Cordillera where slopes are steeper than in the east.

The presence of zurales creates an obvious problem for agriculture and for livestock; mechanization becomes very difficult and cattle falling into deep gullies often cannot get out and die of hunger or overwatering.

The aeolian plain (E1 and E2) runs eastwards into the interior of Casanare and Arauca and is bounded on the east by the River Meta. A few low terraces east of the Meta also have aeolian deposits and are therefore included in this unit.

The first subdivision consists of the dunes (E1). These are longitudinal formations of wind-borne sand from the beaches of the rivers which used to cross the alluvial overflow plain. They are thought to have originated in a period of dry climate in the Llanos when there was still intense erosion in the Cordillera and the rivers carried a large load. Such conditions may be assumed to have existed during the transition from the Pleistocene to the Holocene. This would tally with evidence from various other parts of the world, where dunes and loess layers were deposited at the same time.

The dunes run NW-SW and are found on the southwest side of former and existing rivers. Direction and location are governed by the summer trade winds, which blow mainly from NE to SW. The dunes are therefore on the leeward side of the rivers. They are undulating and have a maximum height of about 50 m. The depressions between the dunes are called "bolsas de dunas" (pockets) and may be deep enough to contain a lagoon.

The dunes are covered by forest or grass, which indicates that they are being stabilized. From their shape it may be deduced that the sand deposits were substantial but that they declined toward the end of the formation. Various dunes show some degradation and have a parabolic shape. The dunes were subsequently cut by watercourses, as the levee of an old river can be traced across a series of dunes.

The second and larger section is the aeolian plain with escarceous (E2). The base of this plain is the same as the alluvial overflow plain, levees and depressions being found in the subsoil; but that formation was buried under a loam-silt to loam-clay-silt deposit like a loess, which covers the ground to varying depths. At some points the layer is very thin and only the depressions were filled, the ridges of the levees still being visible.

As the topography is flat, drainage is poor and waterlogging occurs in winter.

The aeolian plain exhibits a phenomenon called "escarceos". These are raised strips, not very high (up to 50 cm) and between 5 and 10 m broad, although a few are broader. They are curved and run more or less parallel; occasionally they may be connected to each other but they never cross. They lie roughly parallel to the contours. So far the best explanation of their formation is as follows: the soil particles are fairly uniform in size and there are very few points of contact between them, resulting in minimum cohesion. In rainy seasons when the soil is completely saturated, cohesion decreases further and the surface layer creeps like a sheet of mud, even in places where there is practically no slope. The subsoil is slightly more compact and accordingly the movement of the surface layer, like any relative movement between two layers of different density, produces undulation in the form of escarceos. This movement may be compared with the formation of small hill terraces called "cattle tracks", which are also the result of a slow downward creep of the surface layer. After their initial formation escarceos may be built up by wind deposits, for the vegetation is well-developed herbage which can easily capture wind-borne particles near the ground. Large escàrceos are called "banqueticas" in the Llanos.

As a rule escarceos have an asymmetrical cross-section, with greater inclination on the lower side, but this is difficult to observe in the field since they are degraded by surface erosion and, secondly, because ants and termites like to build on them, thus modifying their shape.

Recent alluvium (V), known as "vegas", is found along the main rivers. After leaving the Cordillera the river system broadens out into a wide bed, with many intersecting branches and frequently shifting sand and gravel banks. Often a whole bed is displaced; high flow in winter causes irregular flooding of short duration, and alluvial sedimentation is the result of all these factors combined. At some distance from the Cordillera the rivers start to meander; the channels are better defined, but still liable to sudden changes. The vegas are enclosed between the cliffs of older sediments and cannot therefore spread over an unlimited area; there are no levees and depressions, but rather a complex sedimentation built up from frequent channel-changing and flooding, with appreciable differences over a short distance.

Gradual changes in the meandering channel are due to erosion at the concave bends and sedimentation at the convex ones. In this way "orillares", or banks, are formed in long narrow ridges, each representing the sedimentation of an individual high-water season (Raasveldt, 1958). The landscape thus formed, with parallel banks and an undulating microrelief in cross-section, should be regarded as the beginning of a natural levee; as time goes on, sedimentation continues on top of the banks and flattens out the undulating relief. In some cases, however, the banks are not buried under fresh sediments.

Bordering the vegas lie strips known in the Llanos as "vegones". A "vegón" is a complex of recent and sub-recent alluvium. Its level is that of the lowest terrace, which was partly invaded when the river levels were raised.

The high plains (A1, A2 and A3) form part of the alluvial deposits of the Early Pleistocene. As explained above, in Casanare and Arauca this formation sank and was covered by later sediments, but south and east of the Meta it is still found on the surface. In some parts the formation is heavily dissected and forms a hill landscape, called "La Serranía". Erosion was perhaps facilitated by the occurrence of slight folds and faults. It was not a continuous process, but was interrupted several times, as can be seen from the number of terraces in the Serranía below the high plain level. At one point east of the River Manacacías there are seven levels.

The river valleys crossing the dissected high plains show fairly pronounced asymmetry. The hills north and west of the valleys always have a more gentle slope than those on the south and east sides. If the valley contains any traces of a low terrace, they are mostly north and west of the river, i.e. on the left bank.

Although the high plain is an alluvial sediment, there is not much evidence of this on the surface. There are no old channels, natural levees or depressions. The surface is very smooth, as though all irregularities had been covered and flattened out. This is probably due to wind action during dry seasons. The surface material bears a strong resemblance granulometrically to loess and at one point a "dreikanter" was found, a small three-edged pebble very common in desert landscapes where the wind-blown sand polishes pebbles into a triangular shape.

The high plains are drained by broad streams with gentle slopes, whose soil contains a high percentage of organic matter as a result of adequate moisture throughout the year. These characteristic features are called "esteros", a term connected etymologically with "estuario", used on the Pacific Coast to denote places where the sea penetrates the marshes and tidal effects are felt. In some parts of the Llanos the term is used to indicate certain low lands which are often flooded, but not to denote the "bajos" of the alluvial overflow plain where rainwater collects in lagoons. It is therefore doubtful whether the term ought to be applied to the streams of the high plain, but it has been used for want of anything better and in order to distinguish these characteristic streams from others.

Near the esteros on gentle slopes the runoff is sandier than on the peaks. On the slopes drainage rills are found where there is slightly more organic matter. It is difficult to detect these rills as they are very shallow and the edges very smooth. They run roughly parallel and are separated by smooth convex ridges 20 to 50 m wide. The whole system is called a "rizamiento" (rippling), as it gives the impression of gentle undulation.

In Vichada there are large badly drained stretches lying slightly below the mean level of the high plain. It is possible that these may represent subsidence resulting from faults parallel to the Meta. The country is similar to the aeolian plain, but there are no dunes. Escarceos are found, and their characteristic asymmetry is more in evidence.

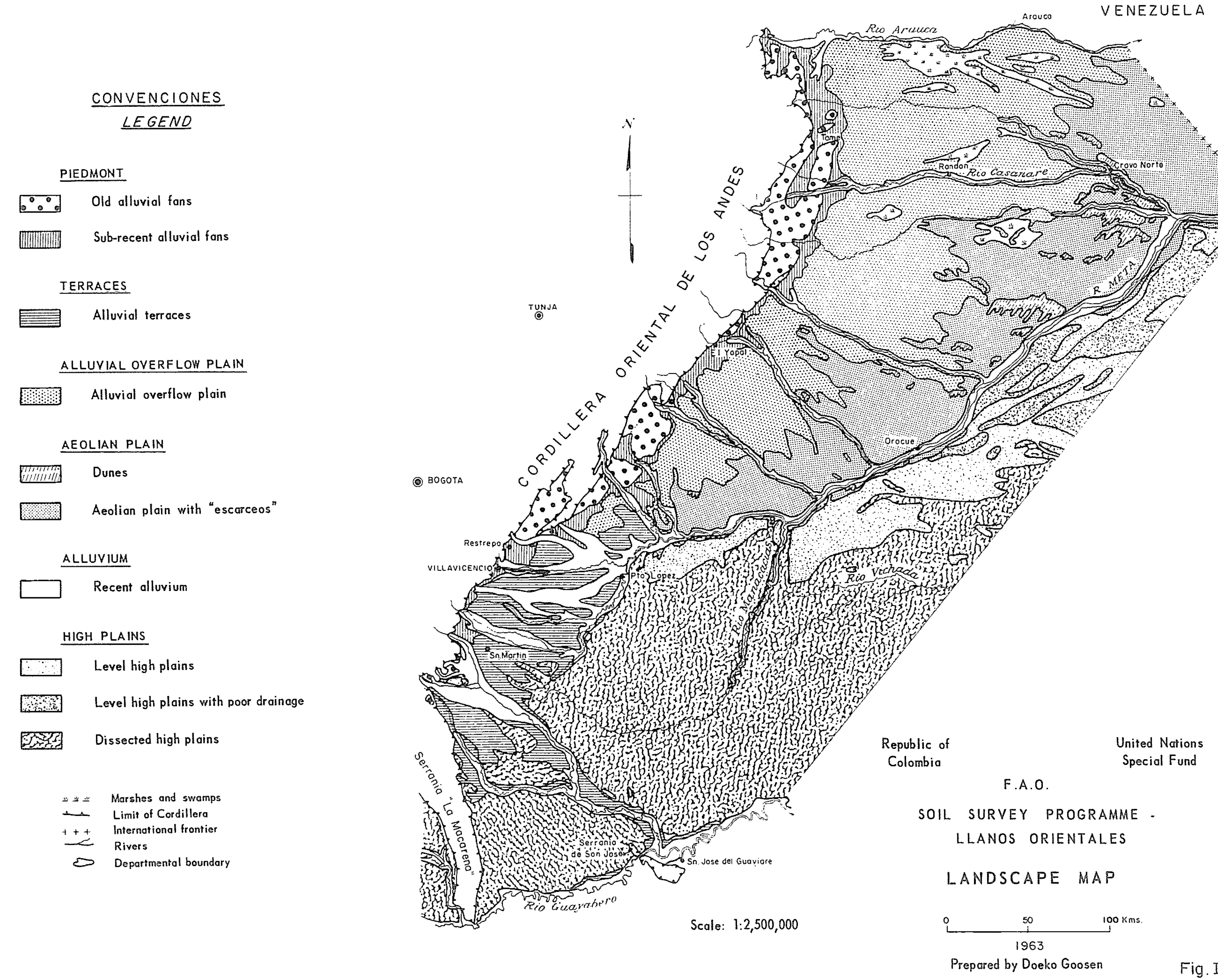

CONVENCIONES
LEGEND
PIEDMONT
Old alluvial fans
Sub-recent alluvial fans
TERRACES
Alluvial terraces
ALLUVIAL OVERFLOW PLAIN
Alluvial overflow plain
AEOLIAN PLAIN
Dunes
Aeolian plain with "escarceos"
ALLUVIUM
Recent alluvium
HIGH PLAINS
Level high plains
Level high plains with poor drainage
Dissected high plains
Marshes and swamps
Limit of Cordillera
International frontier
Rivers
Departmental boundary
N
VENEZUELA
Arauca
Rio Arauca
Tame
Rondon
Rio Casanare
Cravo Norte
R. META
CORDILLERA ORIENTAL DE LOS ANDES
TUNJA
BOGOTA
El Yopal
Orocue
Restrepo
VILLAVICENCIO
Pto. Lopez
Rio Manacacias
Rio Vichada
Sn. Martin
Serrania "La Macarena"
Serrania de San Jose
Sn. Jose del Guaviare
Rio Guayabero
Scale: 1:2,500,000
Republic of Colombia
United Nations Special Fund
F.A.O.
SOIL SURVEY PROGRAMME - LLANOS ORIENTALES
LANDSCAPE MAP
0
50
100 Kms.
1963
Prepared by Doeko Goosen

Fig. I-6

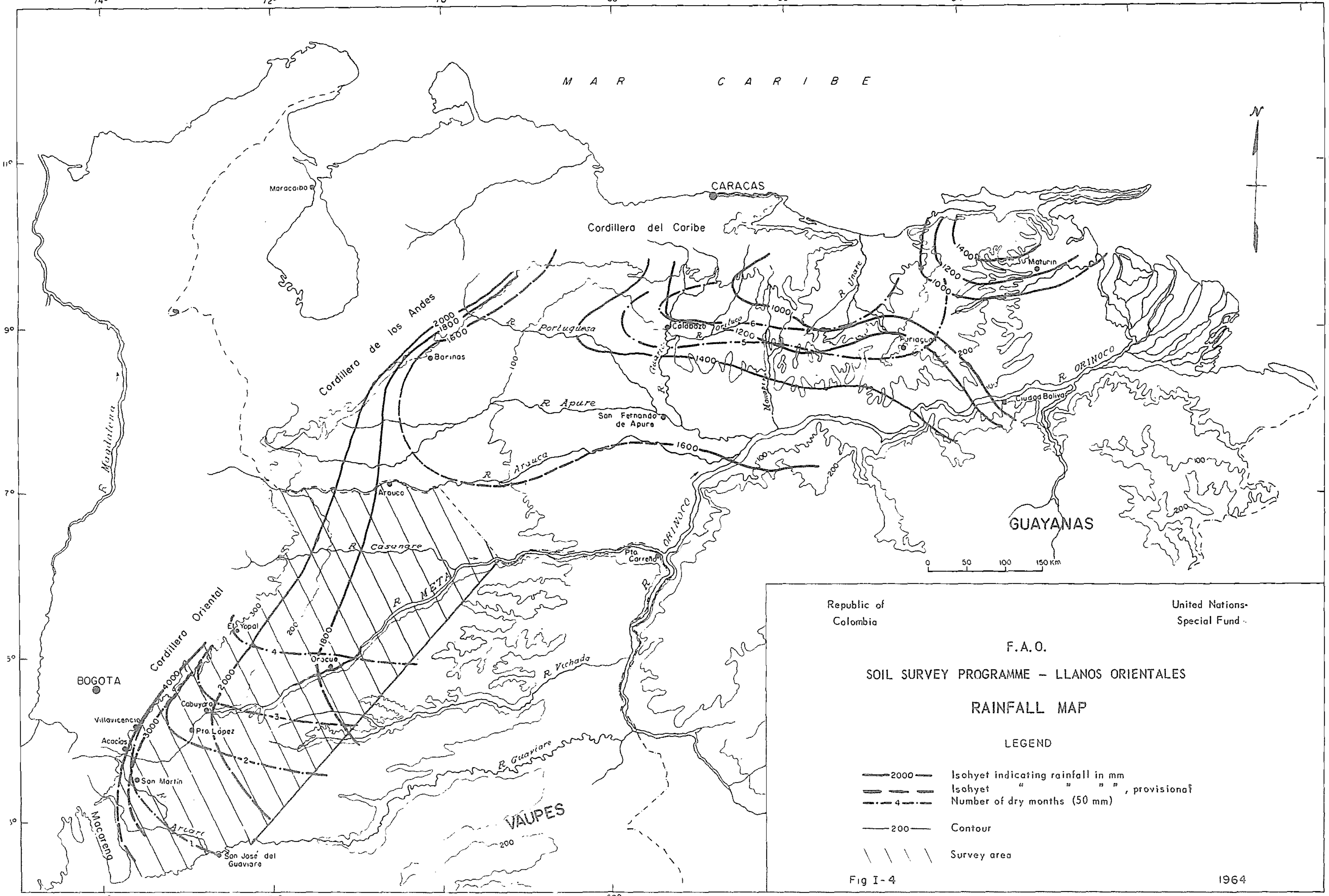

MAR CARIBE
CARACAS
Cordillera del Caribe
Cordillera de los Andes
Cordillera Oriental
Maracaibo
Barinas
Calabozo
Pariaguan
Maturin
Ciudad Bolivar
San Fernando de Apure
Arauca
Pto. Carreño
El Yopal
Orocue
Cabuyaro
Pto. López
Villavicencio
Acacias
San Martin
San José del Guaviare
BOGOTA
GUAYANAS
VAUPES
Macarena
R. Magdalena
R. Portuguesa
R. Apure
R. Arauca
R. Casanare
R. Meta
R. Vichada
R. Guaviare
R. Orinoco
R. Unare
R. Guarico
R. Orituco
R. Manapire
Ariari
0 50 100 150 Km
Republic of Colombia
United Nations-Special Fund
F.A.O.
SOIL SURVEY PROGRAMME - LLANOS ORIENTALES
RAINFALL MAP
LEGEND
2000 Isohyet indicating rainfall in mm
Isohyet " " " ", provisional
4 Number of dry months (50 mm)
200 Contour
Survey area
1964

Fig I-4

TABLE I-4

LANDSCAPE AREA

		Hectares	Percent
Piedmont			
Old alluvial fans		353,125	2.8
Sub-recent alluvial fans		300,650	2.3
Terraces		666,861	5.2
Alluvial overflow plain		2,950,625	23.0
Aeolian plain		2,076,875	16.1
Recent alluvium		1,286,875	10.0
High plain		4,985,625	39.0
Marshes, swamps		210,625	1.6
	Total	12,831,261	

VI. AGRICULTURE AND LIVESTOCK

This chapter gives a brief description of methods in these industries, on which the economy of the area and the livelihood of its inhabitants are based.

The map in Fig. I-5 shows the distribution of the various types of agriculture and animal husbandry in question. Only a small part of the area is devoted to commercial agriculture, which includes cultivated pasture for grazing and cutting. The rest is under savanna and forest.

Almost all farms, including those mainly devoted to commercial crops, carry a few head of livestock to provide milk for domestic consumption.

The crops generally grown in the survey area are rice, maize, cotton, plantain (Musa paradisiaca), banana (Musa sapientum), "topocho" (Musa balbisiana), yuca (Manihot Sp.), sugarcane, "chonque" (Xanthosoma violaceum), coffee, cacao, pineapple (Ananas sativus), haricot bean (Phaseolus Sp.), African oil palm (Elaeis guineensis L.) (now in development), and fruit trees, citrus and mango being the largest crops.

A. Present Types and Methods of Farming

1. Livestock

The main economic activity in the Llanos Orientales is cattle-breeding. Large stretches of natural savanna have been used for many years as cattle ranges. Most of the area is used by ranchers who have no title to the land, but merely own the cattle and a few improved pastures. In these conditions management methods are extensive and fairly primitive.

A typical ranch in these areas consists of a few rustic buildings, surrounded by not more than 2 hectares of land cultivated with plantain, yuca, and some fruit-trees and other plants providing food for domestic consumption. The cattle graze the adjoining land, bounded only by the rivers and streams, as there are no fences. Naturally all cattle from neighboring ranches graze together, and are distinguished only by their brands, which are officially registered by each rancher.

The size of a ranch is measured not by its area but by the number of cattle bearing the brand of the owner who has acquired a traditional right to graze his stock over an indeterminate area. With such rudimentary methods the economic profits obtained per unit area or per head of cattle are bound to be very small, so that a livestock enterprise must consist of a very large number of animals if it is to succeed. A typical ranch may have about 2,000 head, but some have over 20,000.

The biggest ranch-owners do not usually live on their ranches, but prefer to stay in Villavicencio or in the towns of the interior, especially Bogotá or Sogamoso. They visit the ranch once or twice a year, at rodeo time. Other ranchers, especially those in less accessible areas, live there all the time, but their management methods are no better than those of absentee owners.

As a result of the Llanos climate - 7 or 8 months of heavy rain, often accompanied by flooding, and 4 or 5 of intense drought - each ranch must have access to high ground above the flood level for winter grazing (rainy season) and to low ground which retains moisture and provides green pasture for summer grazing (dry season). This factor, combined with the natural poverty of the soil and inefficient management, means that a very large area (4-10 ha) is required per head of cattle.

The native breed of livestock predominates in the region - sturdy animals well adapted to the environment, but of low production and slow development. A high percentage of native stock has now been crossed with zebu bulls and various degrees of crossing are found. Both breeders and fatteners affirm without hesitation that the zebu strain has given the Llano breed greater weight and resistance to climatic conditions affecting pasture.

Earnings are derived from the sale of 2-3 year-old steers at each rodeo. Rodeos are held at the beginning of the dry season (November-December) and the rainy season (May). All stock are rounded up, calves born since the previous rodeo are branded, steers for sale are separated and on some ranches a few calves are castrated. These two rodeos (each lasting 2 to 4 weeks) are the only times when the owners, managers and cowboys really work in the Llano.

Store animals separated at rodeo time are taken to fattening grounds near Villavicencio or other regions, like Cúcuta, with better soil fertility, improved pastures, better management and better transport facilities. Fatstock are then sold for consumption on internal markets, especially Bogotá.

2. <u>Subsistence agriculture</u>

This type of farming is normally on a small scale as most of the output is used for home consumption; sometimes a small amount is marketed in the neighboring towns and farms. Methods are generally rather primitive; no soil and water conservation practices, no fertilizer treatment, no pest and disease control. The farmer merely fells part of the original forest, burns the ground, sows unselected seed (mostly produced on the same farm or on neighboring ones) and weeds the crop once or twice with hoe, machete or by hand, as the case may be. In order to grow rice or maize again on the same strip, for instance, the land is allowed to grow wild for two or three years, or even longer, the brush is then burned and the land resown. This gets rid of the innumerable weeds which infest land continually under quick-growing crops. No machinery is used for preparing the ground, which means high weeding costs and low crop production, as the crops have to compete with weeds.

Subsistence agriculture also includes the kitchen gardens or "topocheras" near ranch-houses or corrals, where natural manure is used to grow plantain, yuca, maize, citrus, mango, cashew, etc. for home consumption.

A subsidiary form of subsistence agriculture is that practised by the Indian population, which is essentially nomadic. The Indians clear small circular areas of varying size, according to their needs, and cultivate them for one or two years solely to provide food for the tribe. The main crops are plantain and yuca.

3. Commercial agriculture

Commercial agriculture deals with larger areas than subsistence agriculture and in most cases involves various degrees of mechanization, use of fertilizers or amendments, pest and disease control, and rice irrigation on some farms. Production is intended for national markets or for export.

Types of farming in the region are determined partly by farmland availability, but mainly by the existence of adequate communications ensuring that transport at reasonable cost is available for conveying produce from the farms to consumption centers and machinery, fertilizers, improved seeds, insecticides, etc. from the towns to the farms. A particular crop may therefore be grown in some areas for subsistence and in others as a commercial crop, the exception being cotton, which is always a commercial crop.

The map on present land use (Fig. I-5) shows the various parts of the survey area where each type of farming is practised. Subsistence agriculture, which includes plantain, yuca, banana, pineapple, maize, haricot bean, "topocho", sugar cane, citrus and mango, is distributed irregularly over a large part of the survey area near the Cordillera Oriental and nearly all the river vegas. Commercial agriculture, including cotton, African oil palm, rice, maize, and to a lesser degree, plantain, cacao, coffee, and yuca, is almost entirely located on the alluvial terraces, vegas and vegones around Villavicencio, Acacías, Guamal, San Martín, Granada, Puerto López, etc. in the Meta Department, where its development is due to the quality of the soil and the existence of some communications.

There is, however, widespread interest among farmers in the Meta Department in fertilizers, pest and disease control, and especially mechanization for soil preparation (ploughing and harrowing), which means that commercial agriculture is tending to expand in this area and will certainly do so once communications have been improved. The completion of the Ariari bridge, for instance, will promote development of this type of agriculture in a vast expanse of fertile land on the right bank of the Ariari.

4. Main crops

(a) Rice

Rice is one of the commercial crops grown on various types of soil from the low vegas to the low terraces, and by different methods, ranging from the most primitive to the most advanced, including full mechanization, fertilizer treatment and irrigation. The usual varieties are Fortuna, Blue Bonnet, Japan and Mono Olaya.

On mechanized farms using fertilizers and irrigation, average production varies from about 30 bultos (1,875 kgs) to 45 bultos (2,813 kgs) of paddy per hectare.

However, most rice-growers in the survey area do not use fertilizers, machinery or irrigation. The crop is produced by means of the natural fertility of the soil, the implements used are the machete, the axe and the hoe, and water is provided by rainfall. The usual practice is to clear the trees or brush, burn the ground and sow lavishly.

In these conditions rice is generally grown on the best soils, with a low average yield of 20 to 30 bultos (1,250 - 1,875 kgs) per hectare.

(b) Cotton

A purely commercial crop grown on the vegas in the Meta Department. Some is also grown on the vegones, but the plants are underdeveloped and average production per hectare is low. The variety is Delta Pine.

On the vegas production per hectare may be 2-2.5 tons of cottonseed, depending on weather conditions and the attention given to the plantation.

The use of machinery for soil preparation is fairly general among cotton-growers, although in areas like Ariari, for instance, where access is difficult, the only preparation is clearing and burning.

Frequent infestations occur, sometimes causing substantial losses. The main pests are aphids, Alabama, Proemia, Laphygma, Heliothis, etc.

(c) African oil palm

A commercial crop, but not yet in production. Plantations were started about three years ago and development is normal. The first trees are expected to produce fruit for oil extraction next year (1965). The Instituto de Fomento Algodonero (IFA) is to provide an oilpress specially for small and medium-sized growers; large growers intend to set up their own presses.

There are about 2,000 hectares under African oil palm, mostly on the well-drained soils of the high terraces, vegones and vegas.

The intense drought from December to March does not seem to affect the African oil palm particularly; however, it would be advisable to provide irrigation at that time when it becomes technically and economically feasible.

Fertilizers and basic slag are applied on all African oil palm plantations. IFA instructions are as follows: Apply 1 lb slag to each plant on planting and 0.5 lb complete fertilizer in the first year; in the second year, 1 lb. slag and 1 lb complete fertilizer per tree, and in the third and fourth years, 1 kg complete fertilizer.

(d) Maize

Grown on almost all farms, both for subsistence and as a commercial crop. Generally interspersed with rice, yuca, chonque, or with plantain, African oil palm and cacao trees in their first stages of development. Average production: 1,087 kg per hectare.

(e) Plantain and Banana

Grown for subsistence in some areas and commercially in others, according to transport facilities and costs; also grown to provide shade for cacao and coffee plantations in the first stages of development.

Plantain is mostly cultivated in the Meta Department on the vegas and high terraces. The crop supplies the villages of that Department and a large proportion of the demand from Bogotá.

Average production: 1,875 bunches per hectare.

(f) Cacao

Grown mainly in the Meta Department and in Tame (Arauca) on high vegas (best results), low vegas and high terraces. On these last two plant development is slower, due to inadequate drainage on the low vegas and low soil fertility on the high terraces.

Cacao is commercial crop, but most plantations are just coming into production or are still in the development stage.

The varieties grown are Calabacillo, Angoleta and recently, hybrids resistant to "witches' broom" disease.

(g) Coffee

Coffee is grown on the same soil units as cacao and also on recent alluvial fans.

It is often interspersed with cacao, both crops reacting in the same way to soil characteristics, especially drainage and fertility.

Average production in the Meta Department is 4 cargas of 125 kg, which might increase considerably with the use of fertilizers.

(h) Yuca

Grown on practically all soils of the Llanos Orientales. Production per hectare varies from 7.5 tons on low terraces to 12.0 tons on vegas and vegones.

In some parts of the Meta Department where yuca is grown commercially on vegas and vegones, yields of up to 17 tons per hectare have been obtained merely with tractor ploughing and occasional weeding. It is grown for direct consumption on the farm, for marketing and for starch production.

(i) Fruit-trees

Various species, e.g. avocado, soursop (Annona Sp.), cherimoya (Annona Sp.), and citrus, are cultivated on well-drained soils; citrus fruits are the most important, both in quantity and quality.

In addition, mango and cashew (Anacardium occidentale) do well on practically all relatively fertile or fertilized well-drained soils. They are not affected by the long drought from December to March.

On poor soils fruit-trees are always grown near ranch-houses and corrals, where the application of organic or artificial manure corrects any nutrient deficiencies.

5. Technical assistance

It is no great exaggeration to say that technical assistance for farmers in the Llanos Orientales is non-existent, except for some specific crops in the Meta Department, such as African oil palm, cotton and cacao. Even then it is most inadequate, except in the case of African oil palm, where it is relatively easy for the agronomist responsible for the program to give growers technical assistance, as there are still only a few plantations concentrated near Acacías and Villavicencio.

Cotton is a new crop in the Llanos and is grown on scattered plantations long distances from each other. There are only two technical advisers, one in the Puerto López area and the other in the San Martín area, so that many cotton-growers are not even visited once in the whole crop development cycle. The result for many growers is low output per unit area due to sowing at the wrong time, unsuitable cultural practices and frequent infestation. Technical assistance for African oil palm and cotton is provided by the Instituto de Fomento Algodonero (IFA).

Technical assistance for cacao is given by technical experts in the areas of Puerto López, Guamal, Granada, and San Juan de Arama respectively, under the control of a Ministry of Agriculture Zonal Agronomist in Villavicencio. The latter is also responsible for the improved pasture development program, and is thus too busy to organize either campaign efficiently.

As there is no effective technical guidance, farming methods vary greatly according to the educational level of the farmer. For instance, some use aircraft for sowing rice and spraying fertilizers and insecticides, while others do nothing but pray at infested crops, ostensibly to kill the pests, thus risking heavy losses in maize and rice plantations sometimes covering over 100 hectares.

SOILS AND THEIR USE

1. General

In an area as large as the Llanos Orientales, with such wide variations in soil formation factors, it is difficult to give a general comprehensive description of soil composition without using regional subdivisions. For this reason, in the chapters and volumes dealing with soil studies, the region is divided first into landscapes and then into soil associations, with a detailed description of their component series.

Considered generally, the Llanos Orientales of Colombia constitute a characteristic natural region differing greatly from other equatorial regions and possessing highly individual soil properties as a result of genetic factors. In the first place the Llanos belong to the intermediate zones between the continental shields and the upliftings of the Cordillera de los Andes, which were filled with important products of erosion.

The parent materials of all soils in the Llanos are of alluvial and aeolian origin. Sedimentation periods date back to the Early Pleistocene. The characteristics of the sediments depend not only on the properties of the parent rock but also on the method of transport and deposition. Generally speaking, in the piedmont soil texture gradually changes from argillaceous in the south to arenaceous in the north. This change is connected with the composition of outcrops in the Cordillera Oriental. Another sequence, from west to east up to the Meta, is due to the velocity of the watercourse depositing coarse material near the Cordillera; soils are generally heavier in the east, provided the wind did not act as a new factor of redistribution as it did in the aeolian plain, where loam predominates alternating with dune sand.

Whatever the method of deposition, all these materials are highly deficient in nutrients, partly as a result of the nature of the geological formations from which they derive. The parent rock imposes on the Llanos soils one of its most uniform characteristics, i.e. its deficiency or low potential in weatherable minerals and exchangeable cations, which form the basis of plant nutrition. As nutrient availability is of great importance in tropical soils, especially in regions whose development must be based on natural resources, it is necessary to describe briefly the nutritional behaviour of the Llanos soils. Other factors involved are climate, topography and hydrology, which determine drainage and consequently provoke leaching of soluble nutrients.

Starting with the recent deposits on low and high vegas, which have the highest cation saturation percentage and therefore offer acceptable chemical conditions for crops, it was observed that, when the soils were drained, saturation rapidly decreased to such an extent that acidity acting on aluminium silicates released large quantities of aluminium. As most Llanos soils situated on high ground above the river level are well drained, they contain more exchangeable aluminium than total bases, which indicates their cation deficiency. This aluminium, together with iron oxides, acts as one of the phosphorus-fixing agents, whose shortage constitutes one of the main factors limiting agriculture and livestock production in the Llanos.

In this progressive leaching various stages may be distinguished, culminating in the formation of soils with practically no other nutrients than those in the plant-humus organic cycle; the minerals in this last degree of development are completely weathered and consist mainly of unalterable particles, kaolinite and sesquioxide. This stage corresponds to the Latosols or Oxysols of the level high plains south of the Meta, where they are associated with indurated "plinthite" or "laterite" layers at varying depths in the soil profiles.

Between these two extremes, the soils of the recent vegas and the high plains belong to the sequence established as drainage improves, i.e. soil groups like the Acid Tropical Brown Forest Soils or "sols bruns acides" (Inceptisols) and the Red Yellow Podzolics (Ultisols), which are regarded as of intermediate potential and generally improve in quality nearer the Cordillera. Inceptisols predominate on the piedmont, while Ultisols occupy a larger area on the low alluvial terraces.

The sequence described above refers mainly to the chemical aspects, but has some positive factors, such as the structural improvement generally achieved as the soils reach their last stage of development. In certain economic conditions, particularly when markets are far from production areas, it may be more feasible to correct chemical defects than physical ones. In any case, the possibility of improving the nutritional level of soils with good physical characteristics should be explored more thoroughly, for should this be achieved, vast regions would be opened up to agriculture and livestock production.

The phenomena described in previous paragraphs occur in climatic conditions of high rainfall and high temperature, when soil drainage is unimpeded. In the Llanos, however, there are many plains with inadequate drainage, either because the land has no slopes or drainage ways, or because the rivers overflow and cause flooding. Some plains also become waterlogged when the rainfall increases in the wet season and the water table rises. Soil horizons formed in these conditions are bound to be different. Here we should mention the somewhat incipient constitution of a gray, gleyed horizon, heavily mottled with iron oxides, which periodically dries out and hardens. This "plinthite" or "ground-water laterite" forms with gley a continuous layer below the surface in the soil profiles of the low terraces, the alluvial overflow plain and the aeolian plain with escarceos. It begins to appear in the depressions of the sub-recent fans. This horizon is usually found at a depth of 1 to 2 meters and the upper horizons may vary considerably, the majority being gleyed. In the depressions they are argillaceous and may have medium cation saturation; on the aeolian plain they are mainly well leached acid loam; on the low terraces drainage is better and soils offer greater possibilities than in the two previous associations. Where drainage is poor, as in the two plains referred to, soils are waterlogged throughout the rainy season and only the levees and the dunes rise above the water. Their soils are of different quality, being generally light-textured and very undeveloped. They are used as a refuge for cattle during the floods, as sites for houses, and as embankments carrying cart-tracks. Soil drainage and the ratio of flooded to non-flooded areas are the main points to be taken into account when considering how to secure more efficient management of the livestock ranches which will remain the basis of the agricultural industry for a long time to come.

Another genetic aspect of great importance refers to the organic constituents of the soil in relation to types of vegetation and variations in climate and drainage. Despite the fact that the biology of these problems is outside the terms of reference of this soil survey, the following points must be mentioned: there is a greater accumulation of organic matter in areas which remain moist practically all year round, such as esteros and old river channels. In these conditions of poor to very poor drainage, organic matter is also very poor and offers no great advantages which might have a lasting effect when the soils are drained.

Other instances of organic accumulation, this time on well-drained soils with thicker surface horizons, are found on some high alluvial terraces with no genetic explanation for the phenomenon. Generally the increase in organic matter is accompanied by a simultaneous fall in cation saturation, especially when the land is under savanna vegetation.

Many forests in the north and south of the survey area, excluding vega forests, are found on light soils of the alluvial overflow plain or on one of the high plains. It was not possible to determine systematically whether soils under forest were richer than soils under savanna. It is assumed that, especially with Oxysols, most of the nutrients are found in the plant-organic matter mobilization cycle. Consequently the agricultural potential of these soils is very transitory in the climatic conditions of the Llanos.

It is also known to be more difficult to conserve fertility in sandy soils than in clay soils, particularly with great temperature increases. This is one of the reasons why no recommendation has been made to clear the forest in the soil conditions described, for savanna soils are not managed any more efficiently. Forest can, however, certainly be replaced by crops conserving much the same ecological conditions by using proper soil conservation methods. In such cases prospects will always be best on soils with high saturation and good drainage.

Another aspect connected with organic matter, but of rather more academic importance, relates to the problem of savanna and forest distribution. In this survey no exclusively edaphic reason could be found for the presence of these two types of vegetation. Practically all the soil series could be observed under forest and under savanna.

Detailed soil studies are contained in Vol. II of this Report. The land capability classes are described below.

2. Land capability classes and map

Soil associations have been classified into land capability classes for the Llanos Orientales (see Table I-5) on the basis of the permanent properties of the constituent soils, e.g. relief, drainage, texture, and fertility, together with field observations of present agricultural and livestock development.

To ensure that these classes are correctly interpreted in practice, some general characteristics should first be explained.

In the first place, the classification is relative, in that it does not give absolute values for economic yields; soil characteristics are compared and Class I contains the associations with the fewest adverse properties. The other classes are established as the adverse factors increase in gravity or combine with each other to produce a cumulative effect.

Secondly, the units classified do not correspond to individual soils, but to associations, which may show quite considerable variations in the characteristics of constituent series. Accordingly, the inclusion of a certain association in a particular class does not imply that all soils in this association belong exclusively to that class; many of them may include series showing a combination of more favorable factors than in the association as a whole, or vice versa.

The land classification was not designed to define suitability of units for a single type of crop, but to classify the possibilities of agricultural development. Different associations which can all be integrated into a certain type of agriculture and livestock farming have been grouped together. The properties mentioned in the first paragraph play a very important part in establishing land capability, because they determine the chemical or physical limitations of the soils.

A soil in Class I may, for instance, be suitable for various crops which are all economic. Soils in a lower class will normally not be so suitable for cropping, but might give a good yield for a particular crop or pasture. Consequently a soil highly suitable for rice but not for other crops will remain in a low class. If there were a capability classification for rice only, that soil would naturally go into Class I.

Because irrigated rice-growing has very special characteristics, a special capability map for irrigated land in the Villavicencio, Puerto López, and San Martín area was prepared and included in the section dealing with water problems in part of the Llanos (see Vol. IV).

The land capability classification is chiefly useful for regional agricultural planning. Planning on an individual farm, i.e. where to grow a particular crop or pasture, should be based on series differences within a class. Such differences are described in Vol. II, "Soil Associations", where a detailed description is given of the characteristics of each series in an association.

Detailed soil studies are necessary in order to know and locate the exact extent of each series. Such studies are recommended for soils in Class I and Class II. When economic and geographical factors are favorable to agricultural development, they should also be made for soils in Class III.

Thirdly, the land capability classification presented in this Report is based on soil properties which may be modified by agricultural technology. Soils are classified with reference to the traditional system of agriculture and livestock management, as practised to-day and as it will probably be practised in the immediate future. In this system, as the use of fertilizers is very limited, natural fertility is an important criterion for soil assessment. The natural fertility factor was decisive in determining the capability class of many Llanos soils, for the majority of associations have very low nutrient contents and their perennial amendment is still considered uneconomic in most areas or is subject to testing.

If, however, fertilizer use became common economic practice in the area, natural fertility would be of less importance and other factors would become the main classification criteria. As the region develops, the land capability classification will have to be modified to take account of changes in technological, economic and social conditions in the survey area.

The classification presented here, taking account of present limitations groups the Llanos soils into six capability classes, which are described below. These classes are shown on the land capability map at the end of this volume.

TABLE I-5

CLASSIFICATION OF SOIL ASSOCIATIONS INTO SIX CAPABILITY CLASSES

Landscapes		Capability Classes				
		I	II	III	IV	V
Piedmont	Old alluvial fans		Mf		Mg	
	Sub-recent alluvial fans	Pf	Pa Pm	Pl	Pg Pp	
Alluvial Terraces			Ta Tb Ti	Te Tp Tm Tw	Tv	
Alluvial Overflow Plain				Da Dd Dr	Db	
Aeolian Plain				Ea Er	Em Es Ee	
Recent Alluvium		Va	Vb Vn			
High Plains				Aa A c Av	As Ac Ae	
						marshes swamps La Macarena

Class F: This is a special class for forest reserves. It includes some units in Class IV and some of the high plain with forest in Class III.

Class I. Land suitable for cultivation

The soils in this Class are good for most crops adapted to the climate of the region. Physical conditions are very favorable for intensive use. Relief is flat to slightly sloping, drainage is generally adequate, and soils are mostly deep. Texture is medium, with large quantities of silt, which ensures good moisture retention in the dry season. Soils resting on sand and gravel can easily be irrigated. The microrelief is not pronounced and except where zurales occur, there are no obstacles to mechanization and there is no danger of erosion.

These lands are situated on the high parts of the main river vegas and on sub recent alluvial fans of fine texture in the piedmont near Medina. Associations Va and Pf on the soil map (see Vol. II) come into this Class.

As the parent material on the vegas is of recent date and the rocks near Medina are fairly rich in nutrients, this Class has a relatively high mineral reserve.

The natural vegetation is wet high forest, which has been replaced in many parts by pasture and various crops. High and low forests on the vegas represent between 38.3 and 145.8 cu.m. of commercial timber per hectare. The piedmont forests have a total volume of 132 cu.m. per hectare. This forest has mostly disappeared and where the ground has not been cultivated, Melinis minutiflora savanna has become established.

There are no hydrological problems for agriculture. Flooding practically never occurs and it is not difficult to provide artificial drainage as the average slope is 1 percent. The water table never falls too low and for most crops in deep soil there is no great need of irrigation.

The following observations may be made with regard to soil management. The mineral reserve is relatively high in soils in this Class, but to maintain crops at a high level and conserve soil fertility, fertilizers must be applied. Crops should be sown in appropriate soils, taking account of the fact that drainage is sometimes inadequate and that in some places stony or very sandy layers impede good root development, especially of shrubs.

Cacao might be grown on the vegas and African oil palm on the piedmont, as long as the water table is at a depth of over 1 meter. Some areas suffer from occasional waterlogging, in slight depressions which can easily be drained as necessary, if shrubs are to be grown. It is, however, advisable to concentrate such industrial crops on low well-drained soils.

On the rest of the area annual crops may be grown, e.g. cotton, peanut, maize, rice, etc., the worse drained parts being reserved for pasture. In the occasionally flooded depressions pará and janeiro grass are recommended for grazing and sorghum and guatemala for cutting. Rotations of these forage crops with annuals are also recommended. On the piedmont gordura or guinea and the above cutting forage might be grown.

Very wet areas in this Class still under forest should be left as forest reserves.

Class II. Land suitable for cultivation and livestock farming on cultivated pastures

This Class contains soils of medium capability for crops and cultivated pasture. Productivity may be as high as in Class I, but it is achieved only with greater outlay on soil management to correct adverse factors.

Soils in this Class have one or more of the following adverse factors: high water table, flood danger (vegas), very low fertility (terraces, vegones and fans), moderate erosion danger (mesas). However, with the exception of low fertility, these are not too limiting factors if the soils are used for cultivated pasture.

In general, relief is flat with no great obstacles to agricultural mechanization; but in a few parts there are zurales or stony layers to hamper the use of machines.

In some soils of an association the adverse factors may not be very serious, in which case the soils belong to Class I and may be used as such. On the other hand, when there is an accumulation of adverse factors, the soils should go into Class III.

Soil associations Mf, Pa, Pm, Ta, Tb, Ti, Vb, and Vn belong to this Class.

According to the nature of the adverse factors, three sub-classes may be distinguished. The first comprises low vega soils (Vb) subject to frequent uncontrollable flooding during the rainy season. In areas remote from the Cordillera the low vegas are regularly flooded from May till the end of September. Near the piedmont flooding is less regular. For reasons of topography it is difficult to establish artificial drainage on the low vegas.

Most soils are poor and badly drained. Their chemical properties are similar to high vega soils (Va, Class I). Annual crops may be grown in the areas with the best flood protection.

Some banks and levees cross the vegas and are generally better drained. On silty textures, plantain gives good yields. Shrubs are not recommended as commercial crops, as there is danger of occasional flooding. More efficient use of low vega forest is recommended.

The second sub-class comprises soils of alluvial terraces, vegones and fans which generally have excellent physical properties for all crops, but offer only low to very low fertility. On the depressions and esteros crossed by these units, various soils are suitable for rice-growing, but some of them present zurales hampering the use of agricultural machinery.

The use of fertilizers is essential on most soils in this sub-class in order to obtain good yields. Some fertility trials carried out by the National Chemical Laboratory (1963) showed the need for phosphoric fertilizers to correct the phosphorus deficiency, which is the primary limiting factor. Any system of intensive agriculture should normally be based on complete fertilizers.

Drainage possibilities are good for units in this sub-class located on high ground, namely Pa, Pm, Ti and Vn. Normally the units in the lowest position on the terraces and fans offer better fertility and more favorable characteristics for irrigation and drainage. Vegones are specially recommended for intensive use.

Stony layers likely to impede root development of shrubs were observed on some soils in this sub-class; there are also sandy layers in the vegones which increase the need for summer irrigation. Farm planning should take account of this varying effective depth.

As regards the establishment of improved pastures, puntero, gordura, pangola and guinea are recommended on well-drained soils of Pm, Ti, Vn and Mf units and, south of the River Upía, on Pa soils. On poorly drained soils of the same units, except Pa, pará and janeiro are recommended. Fertilizers should be applied to obtain good forage production.

Soils of low fertility, medium texture and good drainage are found on unit Mf. Stony layers occur frequently, often cropping out on the surface. Rainfall is high owing to the proximity of the Cordillera, which makes the unit suitable for improved pastures.

To sum up, soils for crops must be selected with special care in the light of adverse factors and those for which artificial drainage is not very feasible should be allotted to cultivated pasture or forest reserves. The physical characteristics of various soils make them specially suitable for arboriculture and the best drained should be used for this purpose. Units Tm, Ta, Tb, Vb and Vn contain various soils suitable for irrigated rice-growing. Lastly, fertilizers are required on most soils to ensure good yields. Trials should be carried out to determine the most economic formulae and quantities.

Class III. Land suitable for grazing on natural savannas in combination with improved pastures and subsistence agriculture

This Class comprises soils not capable of commercial crops, chiefly because the outlay required for a good management system is so high as to be unjustifiable economically. Soils may be suitable for cultivated pasture and limited areas of subsistence agriculture, combined with the use of natural vegetation.

The most limiting adverse factor is low to very low fertility, often combined with poor drainage or some other unsatisfactory physical condition, such as potential waterlogging or surface stones. Some soils would be liable to wind erosion if ploughed.

Cultivated pasture can give good production, but requires greater outlay than on Class II soils.

On most soils savanna vegetation is established, while near the Cordillera forest predominates.

As stated above, natural drainage on various soils is inadequate to poor but on the better drained soils it would be relatively easy to establish artificial drainage. In some locations, especially on the high terraces, artificial irrigation would involve heavy capital expenditure. Some of these associations have only intermittent streams and no surface water is available in the dry season.

This Class mainly comprises the dominant soils of units Pl, Te, Tp, Tm, Tw, Da, Dd, Dr, Ea, Er, Aa, Ao and Av.

Some areas of the high plain units in this Class which are at present under forest have been included in Class F in order to be maintained as forest reserves.

Some of these soils have more favorable characteristics for certain crops, especially rice, while others combine several adverse factors and should be treated as Class IV.

Some ranchers with Class III farms have obtained good results with certain forage varieties, but if they do not follow up with other good practices like fertilizer use and proper pasture management, the results are not very assured. Various soils in this Class are subject to erosion by wind or water after ploughing. The presence of zurales in various units makes any kind of agricultural mechanization very difficult.

Units Dd, Dr and Er are mainly suitable for house and road building.

Class IV. Land suitable for grazing on natural savannas in combination with forestry

Soils in this Class generally have very poor physical and chemical characteristics for most crops. These disadvantages are generally combined with other equally adverse factors, such as potential waterlogging, and standing water. Some units have very steep slopes or escarpments and the surface soil is liable to erosion. On other units the water table is very near the surface and artificial drainage is not easy. All soils in this Class have very low fertility.

Soils are suitable only for extensive livestock farming based on natural pasture, with appropriate management adapted to existing conditions.

Vegetation consists of natural savanna with scattered remnants of forest or woodland.

Most soils are on low, level ground with slopes of under 1 percent; artificial drainage is therefore difficult or at least very expensive. Class IV comprises the dominant soils of units Mg, Pg, Tv, Db, Em, Es, Ee, Ac, As and Ae.

The only management recommendation concerns the efficient use of natural vegetation; overgrazing should be avoided and the vegetation maintained in the best possible condition under normal grazing.

Where the natural vegetation is forest, it may be better to maintain it for lumbering and as watershed protection. As it is considered more advisable to maintain these areas as forest reserves, they have been included in Class F.

Subsistence crops may be grown on some soils, but they should rotate with fallow or pasture.

It would be technically possible to improve the soils by means of fertilizers, drainage and erosion control, but the necessary capital expenditure would not be justified in present conditions of development.

Unit Em is suitable for building houses and airstrips, the latter being extremely useful during the rainy season.

Class V. Land suitable neither for agriculture nor for livestock and recommended for reforestation or maintenance of natural vegetation

Soils in Class V are very poor for both agriculture and livestock, as their low fertility is combined with other serious disadvantages e.g. stones, steep slopes, flooding, etc. Consequently there is grave danger of erosion on the slopes or of flooding on low-lying areas like swamps, etc.

This Class comprises Mc soils, the marshes and swamps shown on the map, and the Serranía La Macarena; all might be grouped under the heading "Miscellaneous".

These lands are of some value when the vegetation cover provides adequate watershed protection; it is therefore recommended that existing forest should be maintained and that areas where it has been destroyed should be replanted.

Class F. Forest reserves

Class F comprises units in Class IV and some units of high plain with forest in Class III. The aim is to conserve them as forest reserves with a rational lumbering program, as it does not seem justifiable to increase the area under savanna when existing savannas are not properly managed.

NEED FOR RESEARCH

In view of the soil characteristics and farming methods described in this Report, it is clear that some of the present conditions of land use in this vast area must be altered in order to derive greater benefit for the country's economy.

Some of the factors affecting economic production in the Llanos are social, economic and technical and in some aspects are closely inter-related. On the basis of the survey and classification of natural resources, a series of investigations should be planned and carried out in order to help to solve technical and practical problems and provide a basis for any necessary changes in the social and economic structure of the region.

Research should relate to the main soil associations in land capability classes I, II and III and must necessarily deal not only with the soils themselves, but also with the plants and animals which they are intended to support.

1. Research plan

Research services should be the responsibility of a permanent body, to ensure the long-term continuity needed to achieve positive results. A broad-based agency like the Instituto Colombiano Agropecuario (ICA) seems most suitable for this purpose.

Research must be eminently practical, with regional trials and demonstrations on individual farms, so that the important connection between research and extension services may be established.

Technical personnel responsible for these services will not be confined to experimental stations, as much of their work will consist of checking research results by regional trials on individual farms and demonstrating to farmers and ranchers the excellence of the methods and practices recommended.

A series of experimental stations and sub-stations must be set up in areas accessible throughout the year, representing different landscapes and the main soil associations. Naturally complete coverage cannot be achieved immediately, but it would be desirable to start with experimental farms on representative areas of the piedmont, the high plain, the alluvial overflow plain and the aeolian plain. The first of these would be devoted mainly to commercial crops and intensive livestock farming, while the others would be extensive cattle ranches organized on rational lines.

A. Intensive farm (piedmont and terraces)

La Libertad Experimental Station near Villavicencio has an ideal situation. It could be the center for basic research on the various aspects to be studied and the administrative and technical headquarters of the program.

As this is the area with the highest proportion of relatively rich soils, it might be devoted to research on commercial crops, pasture and forage, and dairy and beef cattle, using present methods on more intensive lines. It will be necessary to use large areas for crop trials and to increase technical staff, labor and agricultural equipment.

The Station has land on high terraces (Te), low terraces (Tb) and vegas (Vb) which would be available for trials on these associations. For some perennials, however, e.g. African oil palm, it would be advisable to seek the co-operation of IFA and private growers for trials in commercial plantations, with special reference to fertilizer use, weed and pest control, irrigation, etc.

Since this zone contains commercial crops of rice, cotton, maize, yuca, cacao, and African oil palm, research might be carried out on these crops with reference to the following points:

(1) Fertilizer use

Research might be in three stages, viz.:

Stage 1. Response to the various fertilizer elements and amendments. Trials with a control (no fertilizer), complete treatment containing N, P, K, Mg, S and a mixture of trace elements, and treatments from which each fertilizer element is omitted in turn. The proportions or amounts of the various fertilizers should be sufficient to meet the requirements of the respective crops. If there is a response to trace element mixtures, subsequent trials should be broken down in order to isolate the critical element or elements. Similar trials should be held to determine response to lime, not only as an acidity corrective but as a source of calcium.

Stage 2. Once the deficiencies in each fertilizer element are known, other trials will be planned to determine the most suitable proportions and the form or chemical combination permitting most efficient use in the light of greater economic yield.

Stage 3. The last stage will be to determine the most appropriate form of application to obtain efficient utilization of each element, having regard to individual soil conditions, e.g. reaction, granulometric composition, organic content, iron and aluminium content, etc., and to crop characteristics. Comparisons should be made of different depths of application, distance from root zone, and periods of application.

These studies of fertilizer use and soil productivity should be accompanied by analysis of soil samples in order to establish correlation norms for fertility diagnosis.

(2) Variety

Comparative trials of various varieties and hybrids adaptable to the climatic conditions of the area. These should begin at the same time as Stage I of the fertilizer trials, so that the last stages can be carried out with the varieties showing the best results as regards productivity, early maturity, quality, resistance to pests and diseases, etc.

(3) Cultural methods

Once the best varieties and fertilizers for each crop have been determined, studies should be made of various aspects of agricultural practice, the most important being the following:

(a) Sowing time

To determine, with reference to the vegetative period and the date of the beginning and end of the rainy season, what times are most appropriate for sowing and harvesting various crops in order to obtain the best economic results. The need for supplementary irrigation at certain seasons and perennial irrigation for rice-growing should also be considered.

(b) Sowing density

Distance between furrows and plants etc., with reference not only to unit yields, but also to incidence of pests, diseases and weeds.

(c) Crop rotation and soil conservation methods

Use of green manure and other organic fertilizers to improve physical conditions, especially soil granulation. Trials of long-term rotation between annual crops and perennial pasture or cutting forage should be considered.

(d) Control of weeds, pests and diseases

Trials of various commercial products.

(e) Introduction of new commercial crops

To give an economic return and form part of a rational rotation. Introduction of legumes such as haricot bean, soya, peanut, etc. would be highly desirable.

(4) Pasture and forage

This most important research field covers three main subjects: (a) Introduction and selection of species and varieties; (b) Cultural methods; (c) Nutritional value and economic yield of various pasture and forage crops.

(a) The experimental ranch should contain as complete a collection as possible of native and imported grasses and legumes in order to observe their behaviour and resistance to excessive moisture and drought, and to carry out bromatological analyses and yield tests. With these preliminary data it will soon be possible to discard species which are obviously unlikely to prove satisfactory as feedingstuffs.

In view of the general data available on the main soil deficiencies, it would seem advisable to apply a fertilizer containing at least phosphorus and calcium (possibly basic slag) in order to maintain this collection adequately. This recommendation will not introduce any factors of error into the preliminary observations, since this treatment at least is essential if it is desired to improve the quantity, and possibly also the quality, of forage produced per unit area.

As a second stage, the collection may serve as the basis for genetic work; by means of crossing, new varieties of pasture and cutting forage and hybrids better adapted to Llanos conditions may be produced.

(b) Species which have given good preliminary results as forage should be subjected to trials to determine the best methods of establishing range pasture or crops to be cut for green forage, silage or hay. Such trials should include: (i) propagation methods - generative or vegetative; (ii) sowing methods and seasons; (iii) fertilizer use - similar trials to those for commercial crops; (iv) control of weeds, pests and diseases; (v) yield of green matter per hectare; (vi) cutting and grazing frequency; (vii) resistance to trampling; (viii) economic life of pastures and cutting crops; (ix) grass and legume mixtures for pasture formation.

(c) As intense drought for four months with the consequent decline in green pasture is one of the major problems facing Llanos ranchers, silage trials are strongly recommended, in order to determine the most suitable forage species and the best methods to be used for this purpose in the light of environmental conditions (especially poor drainage). A study of haymaking would also be very useful; cutting and drying could be done in the first weeks of the dry season, and the hay could be used at the end of the season when the feed shortage is most acute.

Forage research should be supplemented by studies of digestibility. For this purpose the in vitro method described in the "Journal of the British Grassland Society", Vol.12, No.2, 1963, is recommended; it has the advantage of making a large number of determinations in a short time and obtaining digestibility data on the various parts of the plant at different ages.

Final verification of forage efficiency and of the best economic methods can only be established with animals as indicators. Comparative trials should be held to determine differences in meat and milk yield obtained with current methods and with the new practices regarded as technically most appropriate.

B. Extensive cattle ranches

In regions where extensive cattle-breeding has been practised i.e. the high plains, the alluvial overflow plain and the aeolian plain, it is not possible in present conditions to change over to the intensive methods proposed for the piedmont area, for the following reasons: (i) poor soils; (ii) poor drainage and periodic flooding, and prolonged drought; (iii) lack of communications.

However, it is possible to improve present methods and with the introduction of relatively simple practices total production and yield per unit area can certainly be increased very substantially.

It is proposed to set up three experimental stations on fairly accessible sites representative of the various landscapes. They might be located as follows:

High plain area, east of the River Meta. As far as possible the ranch should include parts of the level, rolling and dissected high plain. It would also be expedient to take in part of the vegas on the right bank of the Meta. The best place would be between the Meta and the Manacacías. For greater operational convenience, there should be access to the Puerto López - El Porvenir highway.

Aeolian plain area. The ranch might be located near the town of Orocué on the left bank of the Meta. If possible, it should cover soil associations on the dunes, edges of streams, and escarceos in order to permit a study of drainage conditions. It should be connected with Orocué by road and also by launch if it is sited on the banks of the Meta.

Alluvial overflow plain area. The ranch may be located near Arauca, with permanent access to it by road. Both "bajos" and levees should be covered, as these are the two main landscape features and are of vital importance in the dry and rainy seasons respectively.

As these are very isolated regions where normal living conditions are very hard, it is essential to ensure that the staff assigned there have at least a minimum of comfort, e.g. housing, drinking water, electricity, social center, school, medical service, etc., as otherwise it would be almost impossible to recruit qualified staff.

The main purpose of these experimental ranches is to develop methods of improving and managing natural pastures and to establish more advanced extensive practices permitting more efficient use of these natural resources.

In view of the type of research to be done on these ranches, where the economy of the undertaking must necessarily be a basic aspect, an area of adequate size, e.g. 2000-3000 hectares, and a corresponding number of cattle must be available. Similarly, equipment and working material must be provided in sufficient quantity for the proper operation of a large-scale undertaking.

Improvement of natural pastures. On the basis of the natural vegetation survey given in this Report (Vol.III), which describes the various constituent grasses of the savannas and the environment in which they develop, the first step should be to establish a duly differentiated collection of the main species in order to study growth habits, reproduction methods, green forage yield, fertilizer response, nutritive value, palatability, change in nutritive value with fertilizer treatment, age, cutting and grazing frequency, reaction to mixture with other native or introduced species, etc.

Each ranch should include land on which the natural vegetation is conserved in order to carry out studies on the following points:

(1) Effects of fire

(a) Soil and air temperatures provoked by burning.
(b) Changes in soil microflora and microfauna.
(c) Changes in soil moisture content.
(d) Effects of burning at different times of year.
(e) Growth curves of main grasses after burning.
(f) Development of vegetation when protected from burning.
(g) Comparison of burning with mechanical cutting of lignified pasture.

(2) Resistence to grazing

(a) Pasture utilization at different periods of development.
(b) Utilization at different heights and intervals.
(c) Resistance with different grazing loads.
(d) Observations on increase or decrease of each forage species as a result of grazing.
(e) Observations on weed infestation with different grazing methods.
(f) Pasture rotation and most appropriate pasture area.

(3) Fertilizer application

(a) Effects of the various nutrients, including trace elements, on pasture yield.
(b) Use of organic fertilizers.
(c) Effects of fertilizers on nutritive value and digestibility of pasture.
(d) Large-scale trials on economic effect of fertilizers, comparing weight gain in animals grazing fertilized and unfertilized pastures.

(4) Introduction of new pasture

Each ranch should plant a collection of grasses and legumes in order to observe adaptability and investigate possibilities of establishing pastures or cutting silage and hay crops with the most promising.

(5) Water supply

(a) Methods of constructing wells and watering points for drinking troughs.
(b) Optimum distance between troughs to obtain optimum utilization of pastures.

LIST OF COLLABORATORS

The survey of soils, vegetation and other agricultural resources of the Llanos Orientales of Colombia was carried out jointly by the Government of Colombia and the Food and Agriculture Organization of the United Nations (FAO) under a project sponsored by the United Nations Special Fund.

The following teams of technicians took part in the work:

I. SOILS

A. Soil survey, Photo-interpretation

Doeko Goosen	Expert in photo-interpretation (FAO)
Elvers Martín A.	Agricultural engineer
Jaime Villegas A.	Agricultural engineer
Marco F. Cano L.	Agricultural engineer
Ricardo Bernal P.	Agricultural engineer

B. Soil classification

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Jaime Villegas A.	Agricultural engineer
Humberto Toquica	Agricultural engineer

C. Chemical analysis

Josué S. Quintero Q.	Chemical engineer
Eduardo Palacio G.	Chemical engineer

II. VEGETATION

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Germán Clavijo N.	Forestry engineer
Jaime Rivera C.	Botanist

III. LIVESTOCK

J.K. Makhijani	Livestock expert (FAO)
Luis Vélez K.	Zootechnician

IV. AGRICULTURAL ECONOMY

Aurelio Gómez P.	Agricultural engineer, agricultural economist
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J.P. De Groot	Agricultural economist (FAO)

V. HYDROLOGY

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ENGLISH SUMMARY

I. Introduction

Thirteen million hectares of land in the Llanos Orientales of Colombia, an area comprising approximately 11% of that country, were surveyed under a United Nations Special Fund project, executed by the Food and Agriculture Organization in collaboration with several Colombian Government Institutions.

The study area is located at the foot of the eastern Cordillera of the Andes and covers parts of the departments of Meta, Boyaca and Cundinamarca, the intendencia of Arauca and the comisaria of Vichada. The land is mainly flat and covered by an open savanna vegetation; only 1.8 million hectares of forests, 15% of the study area, were found.

The survey included investigations on soils, vegetation, and livestock management.

More detailed studies on the hydrology as well as a quick economic survey to investigate the various factors which influence agricultural production, were carried out in the department of Meta.

1. Background

The request of the Government of Colombia to the Special Fund for the soil survey of the Llanos Orientales, was made on the 13th March 1959. The Plan of Operation was signed in September 1960, and the first international expert assigned to the project took up his duties on 2nd January 1961. The purpose of the project was formulated as follows: "to carry out a soil survey and establish land use capability classes of an area of approximately 16.8 million hectares of the Northern part of the Llanos Orientales with the help of aerial photography".

2. The project and its execution

The execution of the project began with the arrival of the first FAO expert on 2nd January 1961, and went through the following stages:

a) Aerial photography and mosaicing of 4.5 million hectares in the Llanos, in order to complete the aerial coverage of the study area;

b) preliminary photo-interpretation of the whole region in order to delineate the major physiographic regions;

c) semi-detailed soil survey of 20 key-areas, the location of which was determined on the basis of phisiography, up to a total area of 381.550 hectares. These surveys included soil profile descriptions, correlation between soil boundaries and photo interpretation data, and the physical and chemical analyses of soil samples;

d) use of the basic data collected in the key-areas in order to achieve the following:

   i) Soil Association map of the complete study area at 1:250.000 scale;

   ii) Establishment of a soil taxonomic classification based on the properties of the soils;

   iii) Land suitability classification and map at 1:500.000 scale covering the whole area.

e) Vegetation surveys began when soil studies reached their completion. Grassland and forest types were described and mapped, and management problems were discussed. A vegetation map at 1:500.000 scale was prepared.

f) A survey of livestock in the Llanos was conducted at the end of the project, which describes the general management conditions prevailing in the study area.

g) Finally, hydrological and economic surveys in the Meta department completed the investigations.

3. Training of personnel

Close cooperation between international staff and their Colombian counterparts during field operations secured adequate training in all the practical aspects of natural resources surveys. Modern methods of photo-interpretation, soil survey, soil classification, vegetation survey, hydrological and livestock management investigations were introduced, and actually used by the Colombian personnel.

Besides this in-service training program, five of the most qualified technicians were sent abroad for theoretical and basic science training; in European and North American Universities.

4. Composition of the report

The complete report on the project comprises four volumes. The first volume, the General Report contains a summary of the main conclusions and recommendations, a general description of the area, the grouping of the soils occurring in the Llanos into land capability classes and includes a land capability map at a scale of 1:500.000.

Volume II, and its appendices, discusses the soils of the Llanos from the geographical and taxonomic viewpoints and provides detailed descriptions and analysis of the cartographic units which are shown in a soil map at the scale of 1:250.000.

Volume III reports the results of the vegetation and livestock surveys and comprises two sections. Section 1 describes the types of vegetation occurring in the project and includes a vegetation map at a scale of 1:500.000. Section 2 deals with the problems of livestock management and meat industry in the Llanos.

Volume IV contains the information on surveys carried out in the Meta department in the fields of agricultural economics and hydrology.

II. Summary of Main Conclusions and Recommendations

1. The survey has shown that the productivity of the land in the Llanos Orientales can be considerably increased by adequate management practices or by improving the existing production methods taking into account the suitability of the soils.

2. The classification of the soil associations occurring in the Llanos Orientales into land capability classes indicates that the possibilities offered by the soils occurring in the study area for the development of systems of agriculture are as follows:

Class I	Land suitable for cultivation - 106,250 hectares.
Class II	Land suitable for cultivation and livestock on improved pastures - 1,566,900 hectares.
Class III	Land suitable for grazing on natural savannas in combination with improved pastures and subsistence agriculture - 3,981,875 hectares.
Class IV	Land suitable for grazing on natural savanna in combination with forestry - 6,750,610 hectares.
Class V	Lands neither suitable for agriculture nor for livestock, recommended for forestation or conservation of forest - 215,000 hectares.
Class F	Forest reserve lands, which include soil units of Class IV and some of Class III.

The recommendations regarding the use and management of the soils of each land class and the map showing the geographical distribution of these land classes are included in this Volume.

3. The soils which show the highest potential, and on which the first agricultural development should take place are located in the recent alluvium. These soils, however, need protection against periodic flooding. Fundamentally, these inundations are caused by severe erosion which affects the upper valleys of the rivers in the eastern Cordillera. It is recommended that the Government take the action needed to protect these upper valleys. For this purpose the proper management of the vegetation and control of the cutting and fire are recommended. In order to achieve these objectives, the following steps are suggested:

a) Detailed studies of the possibilities of agricultural and forestry development in the watershed areas and delineation of the areas more appropriate for this purpose;

b) Soil and vegetation management studies in order to maintain an optimum productivity and to prevent the destruction of the natural resources;

c) Proper organization of forest exploitation and the establishment of a program of reforestation with native and imported tree species of fast growth and economic value;

d) Creation of a well established forestry service to be responsible for surveillance and technical assistance to secure the implementation of the above.

4. Many soils of the Llanos area have excellent physical conditions for plant growth but suffer from extreme nutrient deficiencies. It is considered that without adequate experimental work on the use of fertilizers, no recommendations can be made on the ways and means to correct the low nutrient status of the soils of the area. No experimental data are available on the real grazing potential or best use of the natural land and how this may be best implemented. For these reasons it is urgently recommended that the Government strengthen their Agricultural Experimental Stations in the Llanos and concentrate on the study of the use of fertilizers, grassland management and cattle production. A preliminary plan of the investigations to be carried out to achieve the above objectives is given at the end of this Volume.

5. It can be considered, even on a long term basis, that the development of the Llanos Region will depend on the growth of a limited number of foci which will, spontaneously or by previous planning, develop in places where good soils are dominant. In this respect, it may be pointed out that the improvement of the present living conditions in the Llanos will be greatly accelerated by the construction of an adequate road system. Considerable detail has been given to the soil map so as to enable correct planning of roads, according to soil characteristics and the location of markets. Action of the Government is therefore recommended to accelerate road building.

6. A large part of the area of the Llanos is only suited for extensive grazing. Livestock will, for a long time, constitute a major element in rural production. The most important problems connected with livestock production in the area are animal health and particularly foot-and-mouth disease and parasites, safe drinking water for animals and the organization of improved means for transporting, slaughtering and marketing livestock.

7. On the basis of the studies of the cattle and beef industry in the Llanos the following is recommended for immediate implementation: (i) the construction of a number of wells with windmills whenever necessary, to provide safe and sufficient drinking water for animals, in order to prevent parasitic infections and (ii) to organize an effective campaign to increase the production of foot-and-mouth vaccine. Other recommendations for early and long-term implementation include the initiation of experiment and demonstration centers in selected regions of the Llanos Orientales study area to carry out investigations or practical programs such as carrying capacity of pastures, spacing between watering and salting points, rotational grazing, effects of burning pastures, introduction of new grasses, and other problems peculiar to the region; study of practical methods of irrigation from the large number of rivers of the Llanos and investigations on the possibilities of drainage of flooded waters of the winter season; intensification of the assistance to the cattle owners for the construction and use of cattle dips and of insecticides in and outside the dips for human and cattle health.

8. Most important improvements in production methods involve changes in farm management, correct use of natural and cultivated pastures, including grazing, management and livestock husbandry. These measures, which imply a certain amount of capital investments, are usually not implemented before the type of land tenure is precisely defined. It is therefore recommended that the Government undertake a census of landownership in the Llanos.

9. It is believed that the actions recommended will be best achieved by an organization which would coordinate the activities of all the Government institutions operating in the Llanos and extend them to all the Department, Intendencias and Comisarias which constitute the administrative divisions of the Llanos. This Organization should improve technical assistance to farmers, cattle raisers and breaders, develop supervised credit, provide for adequate marketing systems and coordinate development schemes according to the most urgent needs of the region.

10. The vegetation study of the Llanos led to the preparation of a vegetation map. The map, as well as the recommendations for the proper management of the various types of vegetation for forestry and livestock raising are included in Volume III, Section 1 of this Report. To assure a sustained exploitation of forests, proper management may be achieved by means of a program of selected cutting, upon which minimum lengths should be imposed together with a planned reforestation to secure population of species of high economic value. Under present conditions, and in view of the state of development of the forests of the Llanos, a minimum cut of 35 cm. in diameter is recommended. The native and introduced species best suited for reforestation are: cachicamo, mahogany, caracolí, cedar, eucaliptus, pardillo and teak.

The proper management of savanna, which will continue in the future to be used as natural pastures, must take into account the pasturing time and include the control of the movement of animals and the establishment of improved pastures.

11. In view of the importance, in all aspects, that knowledge of water resources signifies in the future development of the region, we suggest that a hydrometric service be organized in the Llanos. This service will take charge of methodic measurements, with the aim of establishing adequate hydrological statistics. The work of this service will be carried out in accordance with a graded plan, which will take into account the situation and the real possibilities. These works should commence in those places which, due to the present development of the zone, are of greater interest and offer greater facilities. Future extension will be made as the economic importance of the area increases, and its rythm will also depend on the output of the hydrometric service which will increase proportionately as greater practical experience is acquired in the varied conditions to be found in the water resources of the area. To carry out the hydrometric works in the field, including systematic measurements and appraisals, establishment and control of fixed stations and general observation of the rivers, it will be necessary to establish a mobile group of hydrometric experts. A detailed account, including materials necessary and estimated budget required for this mobile group, as well as a graded plan of work of the hydrometric service, is to be found in Chapter IV of this report.

III. General Description of the Project Area

1. Geography and Location

The project area covers about 13 million hectares and comprises the Departments of Meta, Boyaca and Cundinamarca, most of the Intendencia of Arauca and part of the Comisaria del Vichada. Geographically the area is located between 2° and 7° latitude North, and 69° and 74° longitude West of Greenwich. The population is about 300,000 inhabitants, mostly concentrated in the Department of Meta. The largest city is Villavicencio, with about 35,000 inhabitants, which constitutes the major trading centre of the region, and to which come the majority of products on their way to the markets of the interior.

2. Climate

The climate of the Llanos is a tropical climate with well-defined rainy and dry seasons. According to the classification of Koeppen-Geiger (1954) it belongs to the Aw climate, savanna climate. Annual rainfall ranges from 1800 mm. to 5000 mm. in the Llanos. Temperatures are rather uniform throughout the year. Relative humidity is high; during the rainy season it averages 80 percent and varies between 50 and 60 percent in the dry season.

3. Vegetation

The vegetation survey of an area of about 12 million hectares has shown that the savannas cover about 85 percent of the Llanos, the remaining 15 percent being forest. Ten types of savannas and six types of forest were identified during the survey.

4. Hydrology

The main rivers of the Llanos regions are the Meta, Arauca, Casanare, Pauto, Cusiana and Manacacias. The Meta is the most important river of the Llanos and it is navigable from Puerto Lopez to the Orinoco River (720 km).

5. Geology, Geomorphology, Landscape map

A. Geology - The Cordillera Oriental is dominantly a Cretaceous formation locally eroded, on which occur the remainder of older formations, mainly from the Mesozoic and Paleozoic eras. The Cordillera suffered several upliftings during the geological times, and those which took place during the Tertiary and Quaternary periods are especially important in determining the nature of the sediments occurring in the Llanos. These latter sediments are Quaternary formations both from the Pleistocene and Holocene.

B. Geomorphology and Landscape Map - The geomorphological units occurring in the Llanos constituted the basis for the reconnaissance of the soils and vegetation, and are represented in a landscape map. The map units have a geomorphological meaning and their subdivisions coincide with the soil associations.

The following are the geomorphological units identified in the Project area:

Piedmont - This unit is subdivided into old alluvial fans and subrecent alluvial fans. The old alluvial fans consist of Pleistocene deposits, which have been subject to some uplifting, and are partly heavily dissected. The soils are mostly sandy but towards the south heavier textures occur. The subrecent alluvial fans lie at a lower level than the old fans, and form an almost continuous piedmont alluvial plain. The texture of the soils ranges from sandy with stones into the north, to clayey in the south, but otherwise follows the usual pattern of sedimentation in the Piedmont area. The old alluvial fans are occupied mostly by Regosols and Acid Tropical Brown Forest Soils, mostly depending on the texture. The sub-recent fans present an association of Red-Yellow Podzolic and Acid Tropical Brown Forest Soils.

Alluvial terraces - This landscape is found near the Cordillèra in the most western part of the area. The terraces are formed of alluvial deposits, left as terraces because of recurrent changes in the level of the rivers. Several levels can be distinguished, but correlation is difficult due to the occurrence of many faults. The soils range in texture from sandy loam to clay, and many have gravel in the subsoil.

Soils are dominated by Acid Tropical Brown Forests on the higher terraces, with Red-Yellow Podzolics increasing in importance on the lower heavier textured levels.

Alluvial overflow plain - The piedmont alluvial fans change gradually into the alluvial overflow plain. The principal characteristics of the latter is the alternation of natural levees and slackwater areas, together forming a deltaic pattern spreading out from the piedmont. The slackwater areas occupy more than half of the surface, and are flooded by rain water during the wet season. The texture of the soils is heavy clay, although nearer the Cordillera and in the north lighter textures occur.

Alluvial soils and Regosols constitute the high parts of the natural levees which are dominated by acid Tropical Brown Forest soils, often with lateritic concretions at the bottom of the profiles. The slackwater areas contain low Humic Clays, with minor extensions of Organic Soils and Grumusols.

Aeolian plain - The aeolian plain comprises an area where loess and longitudinal dunes have been deposited on top of the eastern part of the alluvial overflow plain. Except for the sand dunes, topography is level, and drainage is poor. The soil material itself, moderately fine textured, was probably at the time of deposition already heavily leached, and is therefore poor in nutrients.

The dunes are covered by Regosols, and the most typical profile on the flat plain corresponds to incipient Ground-Water-Laterites, mostly poorly drained.

Recent alluvium - Along the main rivers strips of recently deposited alluvium occur, which are gravelly near the Cordillera, and become gradually finer towards the east. The soils are not yet old enough to be highly leached and contain more nutrients than most of the other soils of the Llanos.

Alluvial Soils is the best correlative soil group which fits the high variability of profiles in this landscape.

High plains - The landscape identified as high plains is actually an old Pleistocene alluvial deposit, locally, especially in the northeast, covered by loess, and for the most part heavily dissected into hills. It is found at the south of the river Meta at a level up to 150 meters higher than the river. The level, very smoothly rounded tops have fairly heavy textured soils which are well drained. On the slopes towards the drainage ways lighter textures are found.

The dissected part of the landscape is very strongly rolling country with hardenes plinthite at the surface in many places.

Latosols occupy the non-dissected parts of the high plains. As soon as the relief becomes more rolling indurated lateritic crusts occur which alternate with Acid Tropical Brown Forests on the slopes. Drainage ways either present Humic Gleys of Poorly Drained Latosolic associates.

Overflow marshes and swamps - This miscellaneous land type occurs in the north within the alluvial overflow plain and the aeolian plain. Overflow marshes are created by riverwater which flows through a crevasse in the natural levees and spreads out over a large area, while swamps are defined as zones of stagnant water.

6. Agriculture and Livestock (animal husbandry)

The land use map enclosed in this Report (Fig. I-5) shows the distribution of the different types of agriculture and animal husbandry in the Llanos. The map shows that only a small area is being used for the commercial type of agriculture, the largest part being covered by savannas and forests. Most of the farmers in the Llanos, including those exclusively engaged in the commercial type of agriculture always have some herds of cattle. The main crops in the area are rice, maize, cotton, platano (musa paradisica), banana (musa sapientum), guineo "topocho" (musa balbisiana), yuca (manihot Sp.), sugar-cane, "chonque" (Xanthosonia violaceum), african palm (Elaeis guineensis L) and fruit trees, especially citrus and mangoes.

The main economic activity in the Llanos, however, is cattle raising.

THE SOILS AND THEIR UTILIZATION

Detailed studies about the soils occurring in the Llanos are given in Volume II of this Report. In this volume, however, a description is made of the system of land capability which has been established to assist in guiding agricultural development into areas of better soils. The grouping of the soil association into land capability classes (see Table I-5) was made on the basis of certain properties of the soils of each association, such as relief, drainage, texture and fertility, complemented by the results of field observations about local conditions of present agriculture and cattle raising. The following six land capability classes have been established.

Class I. Land suitable for cultivation

The soils of this class are good for the majority of the locally adapted crops. Their physical conditions are favourable for an intensive land use. They are located on the recent alluvium along the main rivers and on the fine textured sub-recent alluvian fans in the Piedmont, near Medina (See Land Capability map at the end of this volume). The soil associations Va and Pf (see Soil Map, Volume II) belong to this class.

Class II. Land suitable for cultivation and livestock on improved pastures

The soils of this class have medium suitability for cultivation and cultivated pastures. They have at least one of a combination of the following unfavourable characteristics: high groundwater level, danger of flooding, moderate erodibility and low fertility. Except for the low fertility the other characteristics are of less importance, when the land is used as cultivated pasture. The soils of the associations Mf, Pa, Pm, Ta, Tb, Ti, Vb, and Vn belong to this class.

Class III. Land suitable for grazing on natural savannas in combination with improved pastures and subsistence agriculture

The soils of this class can be used to a limited extent for cultivated pastures and subsistence agriculture, in combination with the use of the natural vegetation.

The most important limiting factor for agricultural production is the low to very low natural fertility which is frequently combined with poor drainage or other unfavourable physical conditions such as excess of water on stoniness. The soils of the associations Pl, Te, Tp, Tm, Tw, Da, Dd, Dr, Ea, Er, Aa, Ao, and Av, belong to this class.

Class IV. Land suitable for grazing on natural savanna in combination with forestry

The soils of this class are physically and chemically poor. The majority of the soils of this class are found in low areas, with flat topography and slopes of less than 1%, which makes it difficult and expensive to establish a system of artificial drainage. The soil associations Mg, Pg, Tv, Db, Em, Es, Ee, Ac, As, and Ae, belong to this class. These soils can only be used for extensive cattle raising making use of the natural pastures.

Class V. Lands neither suitable for agriculture nor for livestock, recommended for forestation or conservation of forest

The soils of this class are extremely poor, both for agriculture and livestock because of the low fertility and other unfavourable conditions which may include stoniness, steep slopes, erodibility and flooding. The soils of the association Mc, belong to this class.

Class F. Forest reserve lands

This class includes soil units of Classes IV and some of Class III.

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APPENDIX I

PLAN OF OPERATION

SOIL SURVEY PROJECT

COLOMBIA (LLANOS ORIENTALES)

PLAN OF OPERATION

Special Fund - Soil Survey Project

Colombia (Llanos Orientales)

Special Fund Contribution:	US $370,500
Government Contribution:	US $317,800
Duration:	Three years
Executing Agency:	Food and Agriculture Organization of the United Nations
Co-operating Government Agency:	Planning and Technical Services Administrative Department, Government of Colombia

This Plan of Operation for the soil survey of the northern part of the Llanos Orientales, Colombia, to be undertaken by the Food and Agriculture Organization of the United Nations acting as the Executing Agency for the United Nations Special Fund, shall be the Plan of Operation referred to in Article I, paragraph 2, of the Agreement signed on 4 February 1960, by the Government of Colombia and the United Nations Special Fund.

I. Purpose and Description of the Project

A. The Purpose of the Project

1. To carry out a soil survey and establish land use capability classes on an area of approximately 16.8 million hectares of the northern part of the Llanos Orientales with the help of aerial photography.

B. The Project

2. The Government of Colombia urgently requires for its agricultural development program basic data on the soil resources of the country and information and advice on the use capabilities of these soils for agricultural production.

3. The Project will be carried out by using existing aerial photographs available in the form of contact prints at a scale of 1:40,000. These photographs of 10.3 million hectares are available in two lots, one of the northernmost part taken in 1946 and another in 1957. The Government of Colombia is at present undertaking aerial photography of 2 million hectares, which will be completed during the first half of 1960. The remaining 4.5 million hectares will be photographed during the early stages of the Project. The Special Fund will cover the cost of the latter.

4. The Project is conceived as a combined investigation and training program where specialists of the Executing Agency will work jointly with the Geographic Institute and other Government Departments and will train Colombian technicians.

5. The area to be surveyed is indicated on the attached map. However, a final determination of the area to be surveyed will be made by the Government

Interdepartmental Co-ordinating Committee and the Project Manager after a preliminary reconnaissance of the Project area has been carried out.

6. The findings of the soil survey, in the form of printed reports and soil and land classification maps, indicating the degree of suitability of areas for irrigation and other development purposes, will be presented to the Planning and Technical Services Administrative Department. This material will be prepared and printed in Spanish and English. Pending this final publication, preliminary maps and duplicated reports will be made available to the Interdepartmental Co-ordinating Committee.

7. All work under this Project as described above is scheduled to be completed in three years.

II. Work Plan

A. Participation of the Executing Agency

1. Experts:

(i)	Senior Soil Specialist and Project Manager	3 years
(ii)	Soil Surveyor specialized in Photo-interpretation ..	2 1/2 years
(iii)	Soil Surveyor	2 years
(iv)	Livestock Management Expert	1 year
(v)	Agronomist	1 year
(vi)	Consultants or short-term experts as required in such fields as Water Development, Settlement and Farm Forestry..	1 1/2 years

The Project Manager will be assigned to the Project for its whole duration, the Soil Surveyor specialized in Photo-interpretation for 2 1/2 years and the Soil Surveyor for the initial 2 years only. The Livestock Management Expert and the Agronomist are scheduled to take up their assignments during the second year and the Consultants and short-term experts will be required during the last year of the Project.

2. Fellows:

Six fellowships will be provided by the Executing Agency to the Colombian soil and land use technicians for training abroad. The duration of each fellowship will be one year. This training will probably take place during the second year of the Project when the most suitable candidates will be known. However, the final decision as to the timing of the training should rest with the Project Manager who, under the general guidance of the Executing Agency, will also recommend the foreign institutions where fellows will be sent.

The lines of specialization of these six fellows in disciplines of soil science will be determined by the Project Manager and the Government in consultation with the Executing Agency.

3. Equipment and materials:

(i) Soil laboratory equipment and supplies, such as pH meters, flame photometer, Kjeldahl apparatus, chemicals and glassware.

(ii) Photo-interpretation and cartographic equipment, such as pocket and mirror stereoscopes, photographic plotting instruments, tracing instruments, etc.

(iii) Field and camp equipment, such as soil augers, pH kits, tents, etc.

4. Printing of the map and report:

The printing of the map and report will be provided for by the Special Fund through the Executing Agency.

5. Sub-contract:

A contract will be awarded to a private aerial survey company for photographing approximately 4.5 million hectares of the project area. The contract will be drawn up in close co-operation with the Geographic Institute and will follow specifications, standards, scales, etc., of the contracts usually awarded for aerial photography work by this Institute.

B. Participation and Contribution of the Government

6. Government contribution other than local facilities:

(i) Counterpart personnel to be appointed at the request of the Project Manager within the following limits:

Co-Manager	3 man-years
Soil Technicians	12 man-years
Soil Chemist	3 man-years
Agronomist	2 man-years
Forester	1 man-year
Agricultural Economist	1 man-year
Draftsmen	5 man-years
Administrative Assistant	3 man-years
Bilingual shorthand-typist	3 man-years
Bilingual typist	3 man-years
Drivers..............................	24 man-years
Labor	24 man-years

(ii) The necessary vehicles, numbering not less than eight, including their operation and maintenance, and drivers for these vehicles.

(iii) Soil laboratory facilities required for carrying out soil and water analyses in connection with the Project.

(iv) Life and accident insurance for all personnel utilizing aircraft and helicopter services in reconnaissance flights.

(v) Offices for UN and Colombian personnel and storage space for equipment. Field accommodation and working facilities for Colombian staff, including camp equipment for draftsmen, drivers, laborers, etc.

(vi) Stationery, office supplies and postal expenses, telecommunications services.

(vii) The Government will issue Customs-free import licences for equipment supplied by the Special Fund to the Project or pay the necessary Customs charges upon arrival of the equipment and/or supplies.

(viii) Transportation, handling and storage of Project equipment within Colombian territory.

(ix) The equipment, materials and supplies provided by the Executing Agency will be consigned on loan to the Geographic Institute of the Government of Colombia, which will assume responsibility for safe keeping, operation and maintenance of the equipment in the interest of the Project from the date of arrival in Colombia until completion of the Project or re-assignment or transfer of title, as provided in Article II, paragraph 4, of the Agreement between the United Nations Special Fund and the Government of Colombia, concerning assistance from the Special Fund.

(x) The Government will provide copies of aerial photographs and also photomosaics at a scale of 1:40,000 (or base maps at a scale of 1:100,000) covering the project area for which such photographs exist in the number required by the field parties and for mapping purposes. They will also provide all available contour maps, notes, reports and publications connected with soils, irrigation, groundwater prospecting, range and forestry problems and other matters relating to soil and land use studies.

(xi) Government contributions against counterpart heading shall generally be made in kind. However, in cases where cash payment represents an advantage from the operational point of view, a change from payment in kind to cash can be made by agreement between the parties concerned.

7. <u>Government contribution to local facilities</u>:

(i) In accordance with Article V, paragraph 1, of the Agreement between the Special Fund and the Government of Colombia, the Government will contribute the equivalent of US $30,840 toward local facilities.

(ii) This amount represents 15 percent of the total cost to the Executing Agency of foreign personnel.

(iii) The amount mentioned above shall be deposited by the Government of Colombia in an account designated by the Secretary-General of the United Nations and shall be made available as follows:

Equivalent of US $2,814 on signature of the Plan of Operation
Equivalent of US $10,638 on or before 1 January 1961
Equivalent of US $12,295 on or before 1 January 1962
Equivalent of US $5,093 on or before 1 January 1963

8. <u>Organization</u>:

Under the general supervision of the Executing Agency, the Project Manager, assisted by the Co-Manager, will be responsible for the detailed planning, administration and execution of the Project, including the timing and budgeting of the various elements, the preparation of technical material and the organization and supervision of related training programs.

9. The Government will appoint an <u>Interdepartmental Co-ordinating Committee</u>, here designated as the <u>Co-ordinating Committee</u>, composed of a representative of the Economic Planning Board who will act as Chairman, a representative of the Minister of Agriculture, the Director of the Geographic Institute, the TAB Resident Representative and the Project Manager. The Co-ordinating Committee will act for the Government in the undertaking of the survey.

10. The team will be attached to the Co-ordinating Committee and will work in close co-operation with the "Instituto Geográfico AGUSTIN CODAZZI" and with the Ministry of Agriculture. The Co-ordinating Committee will appoint the Co-Manager who will represent the Government on the Project.

11. Selection of counterpart personnel will be made jointly by the Project Manager and Co-Manager, as well as selection of candidates for fellowships.

12. The Project Manager will be assisted in administrative matters by an administrative assistant and other office personnel supplied by the Government.

13. The Project headquarters will be in Bogotá in the building of the Instituto Geográfico "Agustin Codazzi". The laboratories and facilities of the Geographic Institute will be utilized for the analysis of aerial photographs, the analysis of soils, and the mapping tasks.

14. The Soil Surveyor specialized in stereoscopic interpretation of aerial photographs for soil survey, under the general supervision of the Project Manager, will be in charge of the cartographic work of the team. He will also be responsible for all photo-interpretation work in relation to soil survey, and for training Colombian technicians in the use of aerial photographs for soil survey.

15. The Soil Surveyor specialized in the field operations of soil survey, under the general supervision of the Project Manager, will work in close contact with the Soil Surveyor specialized in photo-interpretation and will be generally responsible for the ground soil survey operations. He will also be responsible for training Colombian technicians in field methods of soil survey and other related subjects.

16. The Livestock Management Expert will, under the general supervision of the Project Manager, assist and advise on the management of cattle on the rangelands, including feeding, breeding, cattle and range management, establishment of shelters, fencing, etc.

17. The Agronomist, with a general background of crop production and economics will assist the Project Manager in investigating the suitability of different soil areas for crop production, the selection of suitable crop varieties, cultivation methods, including response to fertilizers, having in mind the economic aspects of production.

18. During the last year of the Project expert advice will be required in the following fields:

(i) Water development with special reference to the investigation of the availability of water for rural settlements, for livestock and for supplementary irrigation.

(ii) Land settlement, to advise on the selection of suitable areas where successful settlement could be obtained at reasonable cost.

(iii) Forestry, with special reference to farm forestry problems.

C. <u>Sequence of Operations</u>

20. The Executing Agency shall commence execution of the Project upon receipt of written authorization to do so from the Managing Director of the Special Fund.

21. Before the arrival of the Project Manager, the Government will make available:

(i) One set of glossy contact prints of aerial photographs of about 10.5 million hectares (which have been photographed on 1:40,000 scale) on single weight paper, covering most of the northern parts of the Llanos Orientales.

(ii) One set of photomosaics on double weight paper and on a scale of 1:40,000 for the same area as the above, or base maps at the scale of 1:100,000 prepared with radial triangulation.

22. Further requests for contact prints and mosaics or base maps of the remaining area of 6.5 million hectares will be made in later stages according to the needs of the work.

23. The Government will provide a map of the 4.5 million hectares suitable for planning the aerial photography to be provided by the Executing Agency in contract with an aerial photography company. The company will make available two sets of contact prints. The negatives will be delivered to the Government through the Geographic Institute. The Government will be responsible for obtaining further copies of contact prints whenever necessary.

24. As soon as the Plan of Operation has been signed by the Government, the Executing Agency and the Special Fund, the Government contribution for local facilities paid and the authorization of the Managing Director received, the Executing Agency shall proceed with:

(i) Recruitment of the Project Manager.
(ii) Purchase of equipment, details of which have been discussed and agreed upon by the Executing Agency and the Co-operating Government Agency.
(iii) Initiating arrangements for about 4.5 million hectares to be flown.

25. Counterpart personnel, both technical and administrative, will be recruited by the Co-ordinating Committee on the proposals of the Project Manager.

26. Work will start with photo-interpretation, combined with ground operation, for the general reconnaissance survey. The data thus obtained about major soil resources will be transferred to the base maps. More detailed surveys of soil and agricultural potentialities will be made essentially following the same techniques. Training in soil survey methods and aerial photo-interpretation will start as soon as field parties can be formed.

27. The target area to be surveyed during the first twelve months of the program is about 8 million hectares. The targets for the second and third years are tentatively fixed at 7 million and 2 million hectares respectively.

28. The first year of the Project will be devoted mainly to general reconnaissance surveys of the area. The second year a larger proportion of time will be spent in preparing maps and obtaining data concerning soil and other characteristics in relation to suitabilities and capabilities for production. Therefore a somewhat smaller area will be surveyed during this year. During the third year, the work of compilation of data, correlation of soils and preparation of maps and reports will take up the major proportion of the work of the team.

29. During the period of the Project, and especially during the third year, the Project Manager will assist the Government in the selection of specific areas where settlement could be successfully started and where the Government could plan pilot settlement schemes.

III. Budget

In accordance with Article I, paragraph 3, of the Agreement between the United Nations Special Fund and the Government of Colombia, the total sum to be made available by the Special Fund through the Executing Agency to assist in the execution of this Project is US $334,000 as detailed in the attached Appendix I.

In addition to the above, the United Nations Special Fund shall make available an amount of US $36,500 to the Executing Agency to defray the Agency's costs.

Unless otherwise agreed at any time by the three parties, this sum will be disbursed under the main objects of expenditure in amounts and at times as scheduled in the Project budget attached as Appendix I.

The total cost of the Project to be borne by the Government is estimated at the equivalent of US $317,800, as shown in the Project budget (Appendix 2).

IV. Reports to the Special Fund

1. Progress Reports: The Executing Agency will submit to the Managing Director the following reports on the Project:

(i) An inception report to be supplied two months after field operations have started.

(ii) An annual report to reach the Managing Director not later than 1 February each year covering the previous calendar year.

(iii) A mid-year report to reach the Managing Director by 1 August each year covering work up to 30 June of that year.

2. Financial Reports

Financial reports will be submitted by the Executing Agency to the Managing Director of the Special Fund in a manner and at times to be agreed upon by the Managing Director and the Executing Agency.

3. Audit Reports:

The Executing Agency shall submit to the Managing Director audited annual statements of accounts. Accounts for the completed Project will be submitted within .... months after the completion of the Project, together with the External Auditors' Report.

4. Final Report:

The Executing Agency will submit a final report to the Managing Director after the conclusion of the Project.

V. Conclusions

The results of this study will be co-ordinated with climatological and hydrological data, and with data on crops, fertilizers and livestock, which are being collected at present. Their co-ordination will provide the necessary basis for the Government to establish successful settlement, better utilization of the land, production of crops, livestock and forestry on a sustained basis.

2. At the conclusion of the Project, the Government, the Executing Agency and the Special Fund will consult with a view to transferring the title of the equipment from the Special Fund, in whose name it has been held by the Executing Agency, to the Government or an Agency nominated by the Government.

Agreed, on behalf of the Parties, by the undersigned:

Date: 1 September 1960

For the Government of Colombia:

Julio César Turbay A.

(Minister of External Relations)

Date: 1 September 1960

For the United Nations Special Fund:

Luis Pérez Artera

(United Nations Technical Assistance Board Resident Representative, United Nations Special Fund Programs Director)

Date: 1 September 1960

For the Food and Agriculture Organization of the United Nations:

C. Clyde Mitchell

(FAO Representative in Colombia)

APPENDIX 1

UNITED NATIONS SPECIAL FUND - COLOMBIA (LLANOS ORIENTALES) - SOIL SURVEY PROJECT

PLAN OF OPERATION

Budget and Plan of Expenditure

	Period Man-Months	Total Project Costs $	1960 Oblig. $	1960 Cash Disb. $	1961 Oblig. $	1961 Cash Disb. $	1962 Oblig. $	1962 Cash Disb. $	1963 Oblig. $	1963 Cash Disb. $
United Nations Special Fund Contribution										
1. Personal Services: 1 Project Manager; 1 Soil Surveyor specialized in Photo-interpretation; 1 Soil Surveyor; 1 Livestock Management Expert; 1 Agronomist; Consultants or short-term experts as required in Water Development, Settlement and Farm Forestry	132	205,600	74,458	18,758	75,694	70,924	34,750	81,965	20,698	33,953
		205,600	74,458	18,758	75,694	70,924	34,750	81,965	20,698	33,953
2. Fellowships: 2 groups of 3 fellowships, 12 months each		27,000	-	-	27,000	27,000	-	-	-	-
3. Equipment and Supplies (Incl. preparation of reports and maps)										
Field equipment		16,000	14,000	14,000	2,000	2,000	-	-	-	-
Aerial photography		92,840	92,840	80,000	-	12,840	-	-	-	-
Printing of reports and maps		15,000	1,000	1,000	2,000	2,000	2,000	2,000	10,000	10,000
		123,840	107,840	95,000	4,000	16,840	2,000	2,000	10,000	10,000
4. Miscellaneous										
Secretarial assistance		4,400	600	600	1,400	1,400	1,400	1,400	1,000	1,000
Travel within the country		2,000	300	300	700	700	600	600	400	400
Cable and postal charges		2,000	350	350	650	650	650	650	350	350
		8,400	1,250	1,250	2,750	2,750	2,650	2,650	1,750	1,750
Total Project Costs		364,850	183,548	115,008	109,144	117,514	39,400	86,615	32,448	45,703
Deducts Contribution for local facilities		30,840		2,814		10,638		12,295		5,093
Total		334,000		112,194		106,876		74,320		40,610
Agency overheads (pro rata)		36,500		15,000		10,000		8,000		3,500
Total United Nations Special Fund Contribution		370,500		127,194		116,876		82,320		44,110

APPENDIX 2

UNITED NATIONS SPECIAL FUND - COLOMBIA (LLANOS ORIENTALES) - SOIL SURVEY PROJECT

PLAN OF OPERATION

Budget and Plan of Expenditure

	Period Man-Months	Total Project Costs	1960 Oblig. $	1960 Cash Disb. $	1961 Oblig. $	1961 Cash Disb. $	1962 Oblig. $	1962 Cash Disb. $	1963 Oblig. $	1963 Cash Disb. $
Government Contribution										
1. Personal Services										
(Technical Staff):										
Co-Manager	36									
Soil Technicians	144									
Soil Chemist	36									
Agronomist	36									
Forester	12									
Agricultural Economist	12									
(Other Staff):		109,000	18,000	18,000	36,000	36,000	36,000	36,000	19,000	19,000
Draftsmen	60									
Administrative Assistant ..	36									
Bilingual Shorthand-Typist.	36									
Typist (bilingual)	36									
8 Drivers	288									
Labor										
		109,000	18,000	18,000	36,000	36,000	36,000	36,000	19,000	19,000
2. Equipment and Supplies										
8 vehicles and spare parts		40,000	35,000	35,000	1,000	1,000	3,000	3,000	1,000	1,000
Camp equipment		8,000	8,000	8,000	-	-	-	-	-	-
Office, Drafting and Photo-interpretation equipment		15,000	2,500	2,500	5,000	5,000	5,000	5,000	2,500	2,500
Fuel and lubricants		15,000	2,000	2,000	5,000	5,000	5,000	5,000	3,000	3,000
Laboratory equipment		25,000	25,000	25,000	-	-	-	-	-	-
Field equipment		5,000	1,000	1,000	1,500	1,500	1,500	1,500	1,000	1,000
		108,000	73,500	73,500	12,500	12,500	14,500	14,500	7,500	7,500
3. Services										
Soil and Water Analyses		15,000	2,000	2,000	5,000	5,000	5,000	5,000	3,000	3,000
Maintenance and vehicles		8,000	1,000	1,000	2,000	2,000	3,000	3,000	2,000	2,000
Land and air transport		5,000	800	800	1,600	1,600	1,600	1,600	1,000	1,000
Reconnaissance flights		30,000	10,000	10,000	10,000	10,000	8,000	8,000	2,000	2,000
Rent of premises		10,000	2,000	2,000	3,000	3,000	3,000	3,000	2,000	2,000
Post and telecommunication		1,960	300	300	700	700	600	600	360	360
		69,960	16,100	16,100	22,300	22,300	21,200	21,200	10,360	10,360
		286,960	107,600	107,600	70,800	70,800	71,700	71,700	36,860	36,860
Add: Contribution for local facilities		30,840		2,814		10,638		12,295		5,093
TOTAL GOVERNMENT CONTRIBUTION		317,800		110,414		81,438		83,995		41,953

APPENDIX 3

AMENDMENT 1 OF THE PLAN OF OPERATION

UNITED NATIONS SPECIAL FUND PROJECT IN COLOMBIA

SOIL SURVEY PROJECT (LLANOS ORIENTALES)

The Plan of Operation signed by the Government of Colombia, by the United Nations Special Fund and by the Food and Agriculture Organization of the United Nations on 1 September 1960, has been amended as per the attached.

Agreed on behalf of the Parties by the undersigned:

For the Government of Colombia:	For the United Nations Special Fund:	For the Food and Agriculture Organization of the United Nations:
Luis Eduardo Samper	Anthony E. Balinski	P. Terver
Director of the Project Co-ordinating Committee	Resident Representative, Special Fund Programs Director in Colombia	Assistant Director-General
Date: 18 November 1963	Date: 18 November 1963	Date: 18 November 1963

EXPLANATORY NOTE TO AMENDMENT NO. 1

PLAN OF OPERATION

UNITED NATIONS SPECIAL FUND PROJECT IN COLOMBIA

SOIL SURVEY PROJECT (LLANOS ORIENTALES)

The purpose of the Project is to carry out a soil survey and establish land use capability classes of an area of approximately 16.8 million hectares of the northern part of the Llanos Orientales with the help of aerial photography. The progress on this Project has been satisfactory; however, due to delayed implementation, the Project is behind schedule. With a view to completing the work foreseen in the Plan of Operation, FAO has recommended an extension of this Project from 31 December 1963, to 30 September 1964, involving fifteen additional man-months.

In order to meet the cost involved in the proposed nine-month extension of the Project, it has been agreed to apply the existing savings under Personal Services, including the unused allocation for consultant services and some of the unused earmarking for fellowships, and to allocate an additional amount of US $12,000 to cover the deficit. The Special Fund has accepted FAO proposals subject to the inclusion in the 1964 Government Budget of an amount of 1,000,000 pesos to cover the increased Government counterpart obligation due to the proposed extension of the Project.

The extension in the duration of the Project necessitates modifications in the Plan of Operation and in the Plans of Expenditure for both the UNSF and Government contributions. The Plans of Expenditure appended to the Plan of Operation are modified to reflect these changes.

ooOoo

AMENDMENT NO. 1

PLAN OF OPERATION

UNITED NATIONS SPECIAL FUND PROJECT IN COLOMBIA

SOIL SURVEY PROJECT (LLANOS ORIENTALES)

In pursuance of the Plan of Operation signed on 1 September 1960 by the Government of Colombia, the United Nations Special Fund and the Food and Agriculture Organization of the United Nations;

And whereas it is necessary to extend the duration of the Project in order to complete the program of work laid down in the said Plan of Operation, the following modifications are made:

Page 2:

The heading is amended as follows:

Special Fund Allocation: consisting of:		US $415,940
Special Fund Contribution:	US $382,760	
Government Contribution toward local operating costs:	US $ 33,180	
Government Counterpart Contribution in kind:		US $361,889
Duration:		Three years and nine months.
Executing Agency:		Food and Agriculture Organization of the United Nations.
Co-operating Government Agency:		Planning and Technical Services Administrative Department, Government of Colombia

* * *

Page 3:

7. All work under this Project, as described above, is scheduled to be completed in three years and nine months.

* * *

Page 2:

II. WORK PLAN

A. Participation of the Executing Agency

1. Experts:

(i)	Senior Soil Specialist and Project Manager	36 man-months
(ii)	Soil Surveyor specialized in Photo-interpretation	42 man-months
(iii)	Soil Surveyor	31 man-months
(iv)	Livestock Management Expert	12 man-months
(v)	Agronomist	14 1/2 man-months
(vi)	Consultant (Water Development)	5 1/2 man-months

The Project Manager will be assigned to the Project for its whole duration, the Soil Surveyor specialized in Photo-interpretation for 42 months and the Soil Surveyor for the initial 31 months. The Agronomist and the Livestock Management Expert are scheduled to take up their assignments during the second and third year of Project operations.

2. Fellows:

1st line is amended as follows:

Five fellowships will be provided by the Executing Agency to the ......

* * *

Page 3:

1st line of 1st paragraph is amended as follows:

The lines of specialization of these five fellows in disciplines of ....

* * *

Pages 3 and 4:

B. Participation and Contribution of the Government:

6. Government contribution other than local facilities:

(i) Counterpart personnel to be appointed at the request of the Project Manager within the following limits:

Co-Manager	40 man-months
Soil Technicians	172 man-months
Soil Chemist	47 man-months
Agronomist	38 man-months
Forester	15 man-months

Agricultural Economist	12 man-months
Draftsmen	94 man-months
Administrative Assistant	39 man-months
Bilingual shorthand-typist	36 man-months
Typist (bilingual)	39 man-months
Drivers, Labor	as required

(ii) The necessary vehicles, numbering not less than seven, including their operation and maintenance, and drivers for these vehicles.

* * *

Page 5:

7. Government Contribution to Local Facilities

(i) In accordance with Article V, paragraph 1, of the Agreement between the Special Fund and the Government, the Government will contribute the equivalent of US $33,180 toward local operating costs.

(ii) This amount represents 15 percent of the total cost to the Executing Agency of foreign personnel.

(iii) The amount mentioned above shall be deposited by the Government into an account designated by the Secretary-General of the United Nations Special Fund and will be made available as follows:

Equivalent of US $	2,814	on signature of the Plan of Operation
Equivalent of US $	10,638	on or before 1 January 1961
Equivalent of US $	12,295	on or before 1 January 1962
Equivalent of US $	5,093	on or before 1 January 1963
Equivalent of US $	2,340	on or before 1 January 1964

* * *

Page 6:

18. During the last year of the Project expert advice will be required in the field of water development with special reference to the investigation of the availability of water for rural settlements, for livestock and for supplementary irrigation.

* * *

Page 8:

28. The first year of the Project will be devoted mainly to general reconnaissance surveys of the area. The second year a larger proportion of time will be spent in preparing maps and obtaining data concerning soil and other characteristics in relation to suitabilities and capabilities for production. Therefore, a somewhat smaller area will be surveyed during this year. During the third and fourth years, the work of compilation of data, correlation of soils and preparation of maps and reports will take up the major proportion of the work of the team.

29. During the period of the Project, and especially during the third and fourth years, the Project Manager will assist the Government in the selection of specific areas where settlement could be successfully started and where the Government could plan pilot settlement schemes.

III. BUDGET

In accordance with Article I, paragraph 3, of the Agreement between the United Nations Special Fund and the Government of Colombia, the total sum to be made available by the Special Fund through the Executing Agency to assist in the execution of this Project is US $376,840, as detailed in the attached Appendix II.

In addition to the above, the United Nations Special Fund shall make available an amount of US $39,100 to the Executing Agency to defray the Agency's costs.

Unless otherwise agreed at any time by the three Parties, this sum will be disbursed under the main objects of expenditure in amounts and at times as scheduled in the Project budget attached as Appendix II.

The total cost of the Project to be borne by the Government is estimated at the equivalent of US $361,889 as shown in the Project budget, attached as Appendix 3.

APPENDIX II

UNITED NATIONS SPECIAL FUND PROJECT: COLOMBIA - SOIL SURVEY (LLANOS ORIENTALES)

Revised Plan of Expenditure

United Nations Special Fund Allocation

	Total Man-months	Total Project Costs $	Estimated Cash Disbursements 1961 $	1962 $	1963 $	1964 $
1. Experts						
(a) Soil Surveyor and Project Manager	36	70,750	9,635	16,700	22,500	21,915
(b) Soil Surveyor Photo-interpretation Expert	42	70,000	17,238	15,742	20,000	17,020
(c) Soil Surveyor	31	33,850	8,851	12,086	12,913	-
(d) Livestock Management Expert	12	18,000	-	-	5,100	12,900
(e) Agronomist	14½	20,300	-	-	15,500	4,800
(f) Consultant (Water Development)	5½	8,300	-	-	8,300	-
	141	221,200	35,724	44,528	84,313	56,635
2. Fellowships						
(a) Use of aerial photography in soil science	12	3,400	-	-	2,000	1,400
(b) Soil classification and survey	12	5,300	-	1,522	3,778	-
(c) Geomorphology, soil morphology and soil mineralogy	12	5,400	-	1,523	3,877	-
(d) Soil chemistry	12	5,400	-	-	2,000	3,400
(e) Field of study to be determined	12	5,400	-	-	1,500	3,900
	60	24,900	-	3,045	13,155	8,700
3. Equipment and Supplies						
Field and camp equipment, soil laboratory equipment and supplies		16,340	3,053	4,785	5,000	3,502
Printing of reports and maps		15,000	-	-	1,000	14,000
		31,340	3,053	4,785	6,000	17,502

UNITED NATIONS SPECIAL FUND PROJECT - COLOMBIA - SOIL SURVEY (LLANOS ORIENTALES)

Revised Plan of Expenditure (cont'd)

	Total Man-months	Total Project Costs $	Estimated Cash Disbursements 1961 $	1962 $	1963 $	1964 $
4. Sub-contracts						
Aerial Photographic Survey		92,500	63,031	29,469	-	-
5. Miscellaneous						
Cable and postal charges		600	-	30	200	370
Secretarial and clerical assistance		3,000	-	20	600	2,380
Contingencies		3,300	104	203	300	2,693
		6,900	104	253	1,100	5,443
Total Gross Project Costs		376,840	101,912	82,080	104,568	88,280
6. Agency Overhead Costs		39,100	25,000	8,000	6,100	-
SPECIAL FUND ALLOCATION 1/		415,940	126,912	90,080	110,668	88,280

1/ The Special Fund Allocation includes the equivalent amount of US $33,180 to be paid by the Government toward local operating costs of the Project. The amount represents 15 percent of the cost of foreign personnel. This amount is payable by the Government in instalments as shown in Section II, paragraph 7(iii) of the signed Plan of Operation revised in this Amendment No. 1.

UNITED NATIONS SPECIAL FUND PROJECT: COLOMBIA - SOIL SURVEY (LLANOS ORIENTALES)

Plan of Expenditure

Government Counterpart Contribution in Kind and Estimated Cost
(Government financial year begins on .... and ends on ....)

	Total Man-months	Total Project Cost $	Estimated Cash Disbursements in U.S. Dollars 1961 $	1962 $	1963 $	1964 $
1. Personal Services						
(a) Professional Staff						
Co-Manager	40	22,822	2,943	7,637	6,992	5,250
Soil Technicians	172	64,590	5,250	17,300	25,738	16,302
Soil Chemist	47	15,375	-	4,650	3,575	7,150
Agronomist	38	16,590	2,050	4,990	5,450	4,100
Forester	15	6,200	-	-	4,650	1,550
Economist	12	4,500	-	-	3,000	1,500
	324	130,077	10,243	34,577	49,405	35,852
(b) Other Staff						
Draftsman	94)					
Administrative Assistant	39)	39,680	3,390	11,440	13,850	11,000
Bilingual Shorthand-Typist	36)					
Typist	39)					
Labor, maintenance, drivers		29,203	850	9,417	10,936	8,000
	208	68,883	4,240	20,857	24,786	19,000
	532	198,960	14,483	55,434	74,191	54,852
2. Equipment and Supplies						
7 vehicles		23,260	8,960	14,300	-	-
Office, field and camp equipment		14,450	7,550	3,500	1,400	2,000
Laboratory equipment		31,600	-	11,600	10,000	10,000
M/ce of Vehicles (incl. fuel, spare parts, etc.)		47,791	1,230	7,561	23,700	15,300
		117,101	17,740	36,961	35,100	27,300
3. Miscellaneous						
Transportation		7,350	310	2,040	2,000	3,000
Reconnaissance flights		21,068	1,180	1,040	11,500	7,348
Rent of premises		15,410	2,170	2,740	5,500	5,000
Post and telecommunication		2,000	100	200	1,000	700
		45,828	3,760	6,020	20,000	16,048
TOTAL COUNTERPART CONTRIBUTION IN KIND EXPRESSED IN U.S. DOLLARS		361,889	35,983	98,415	129,291	98,200

UNITED NATIONS SPECIAL FUND PROJECT: COLOMBIA - SOIL SURVEY (LLANOS ORIENTALES)

Total Government Contribution

	Total	Equivalent in U.S. Dollars			
		1961	1962	1963	1964
Counterpart contribution in kind 1/	363,889	35,983	98,415	129,291	98,200
Contribution toward local operating costs 2/	33,180	13,452	12,295	5,093	2,340
TOTAL GOVERNMENT CONTRIBUTION	395,069	49,435	110,710	134,384	100,540

1/ These amounts have been calculated at the prevailing United Nations operating rate of exchange of U.S. dollar = 10 pesos.

2/ These amounts are payable in local currency at the United Nations operating rate of exchange (based on the most favorable legal rate of exchange available to the Special Fund), which at the present time is 1 U.S. dollar = 10 pesos.

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