74-13,001

MALAGON-CASTRO, Dimas, 1938-
CHARACTERIZATION AND GENESIS OF SELECTED SOILS IN THE EASTERN PLAINS OF COLOMBIA.

The University of Nebraska - Lincoln,
Ph.D., 1973
Agriculture, soil science

University Microfilms, A XEROX Company, Ann Arbor, Michigan

CHARACTERIZATION AND GENESIS OF SELECTED SOILS IN THE EASTERN PLAINS OF COLOMBIA

by

Dimas Malagon-Castro

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor in Philosophy

Department of Agronomy

Under the Supervision of Dr. James V. Drew

Lincoln, Nebraska

August 1973

TITLE

CHARACTERIZATION AND GENESIS OF SELECTED

SOILS IN THE EASTERN PLAINS OF COLOMBIA

BY

Dimas Malagon-Castro.

APPROVED	DATE
James V. Drew	August 27, 1973
A. D. Flowerday	August 27, 1973
T. M. McCalla	August 27, 1973
R. A. Olson	August 27, 1973

SUPERVISORY COMMITTEE

GRADUATE COLLEGE UNIVERSITY OF NEBRASKA

GRAD 52002 300 5-66(T)

ACKNOWLEDGEMENTS

The author wishes to express special appreciation and gratitude to Dr. J. V. Drew for his counsel, guidance and assistance throughout the study and preparation of the manuscript.

Special note of gratitude is expressed to Drs. James Spain, Kenneth Frank, Javier Sparza and Ricardo Martinez for their permanent help and encouragement, making this investigation possible.

Appreciation is extended to Dr. W. Lynn for his counsel and assistance in the study of the clay minerals.

A special note of thanks is expressed to my colleagues and friends: Abdon Cortes, Jairo Jimenez, Jaime Rey and Victor Posso for their help and assistance in this investigation.

Appreciation is also extended to Dr. D. Lewis and Mr. J. James for their continuous help during this investigation.

Recognition is expressed to Drs. D. Flowerday, T. McCalla and R. A. Olson for their advice in the revision of the manuscript and to Mr. Paul Komarek for his help in the preparation of the manuscript.

The author is also grateful to the Universidad Nacional de Colombia and the International Agency for Development (AID) for making possible attendance at the University of Nebraska during this Graduate program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

INTRODUCTION

The purpose of this study was to investigate the genesis and classification of four soil profiles representative of soils in the High Plains and Aeolian Plains in the Eastern Plains of Colombia. Scientific knowledge of the soil is developed as soil characteristics are interpreted with respect to the factors of soil formation. Decisions involving the proper use and management of soils have a scientific basis when soil behavior is understood in relation to soil characteristics and the origin of these characteristics.

Studies of soil genesis constitute the traditional approach of pedologists to interpret the origin of physical, chemical and mineralogical properties of soils, characteristics which, in turn, govern the choice of management practices. Mineralogical studies of the sand, silt, and clay fractions, and micromorphological examination of soil thin sections are basic techniques necessary to understand the morphology of the soil in its natural environment.

Studies involving the characterization and classification of soils in the tropical areas of Colombia are only in the beginning phase. Nevertheless, these studies must be of the high priority when these tropical areas become colonized. Plans for the economic development of the Eastern

Plains must start with an accurate study of the natural resources present in the area. Agricultural soils are of predominant importance among the natural resources of the region.

The present study has as its most important objectives the interpretation of the genesis of selected soils formed under savanna vegetation within the Meta Department and the Boyaca Department of Colombia, and the relationships of physical, chemical, and mineralogical properties of these soils to soil behavior.

GENERAL DESCRIPTION OF THE STUDY AREA

Three of the soil profiles studied (Red Neblinas, Yellow Neblinas and Gaitan) represent soils of the High Plains, and the fourth profile (Orocue) represents soils of the lower lying Aeolian Plains of Colombia.

The Orocue profile was located near Orocue, Colombia, at latitude 04° 54' north and longitude 71° 22' west. The Red Neblinas and Yellow Neblinas profiles were located near Puerto Gaitan, Colombia, at latitude 04° 8' north and longitude 72° 03' west, and at latitude 04° 15' north and longitude 72° 04' west, respectively. The Gaitan soil profile was located at latitude 04° 21' north and longitude 72° 17' west near Puerto Gaitan, Colombia.

Eastern Plains is the name given to the gently sloping plains east of the eastern Andean Cordillera in Colombia. In general, the Eastern Plains have a slight downward slope in a northern and eastern direction. The eastern drainage system constitutes the so-called "Colombian Orinoquia".

The Colombian Eastern Plains occupy approximately 250,000 km^2 to 340,000 km^2 (Guerrero, 1965). Blydenstein (1967) indicates that the total savanna area in Colombia and Venezuela occupies 462,500 km^2. In Colombia, savannas represent 22 to 27 per cent of the total land area characterized as tropical dry forest. Discrepancies among estimates of

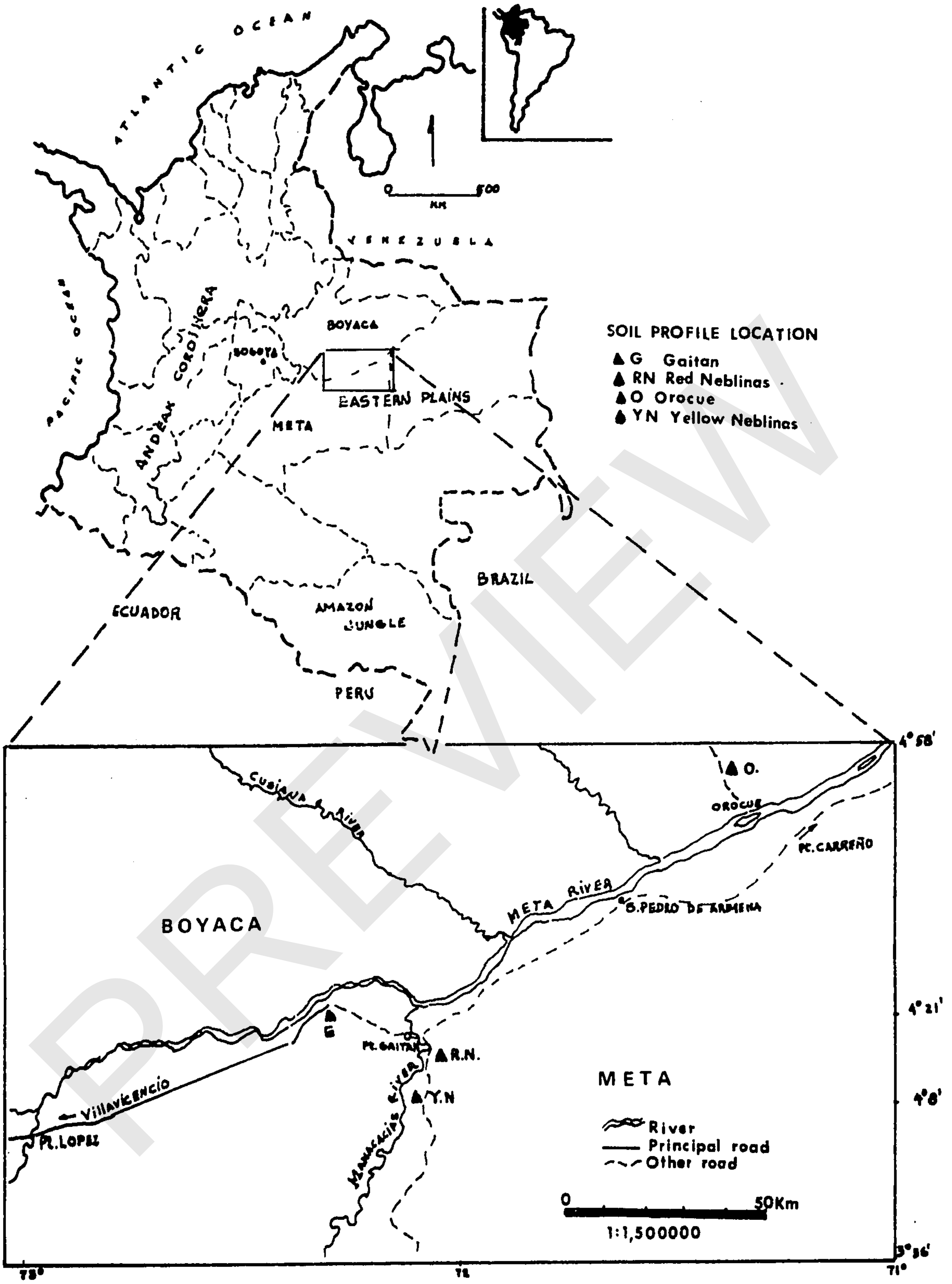

Figure 1. Location of the soil profiles in the study area.

the areal extent of savannas result from differences in criteria used to define the Eastern Plains (Llanos Orientales).

The altitude of the profiles on the High Plains is in the range of 180 to 300 meters above sea level. The profile near Orocue is about 180 meters above sea level.

Geology-Geomorphology.

The Eastern Plains in Colombia are composed of sediments deposited during the Cenozoic era. Hubach (1956) identified Pliocene and Pleistocene deposits covering the older sediments.

The Eastern Plains are related to the eastern Andean Cordillera with respect to the source area of sediments for the plains. The Eastern Plains of Colombia and Venezuela form a giant geosyncline between the Guiana shield and the Andean Mountains. A series of subsidences in the geosyncline and the accumulation of sediments from the erosion of the Eastern Cordillera formed the bulk of the Eastern Plains. Wind erosion and aeolian sediments modified the surface layers of the area (Hubach, 1954). The first sedimentation occurred in the Tertiary and deposited sandy sediments which were subsequently covered with clayey sediments. In still later stages sandy sediments were laid down once more (Hubach, 1956). Sediments were transported long distances and were weathered and increased in acidity during transport.

Sediments composing the Eastern Cordillera were derived from weathered materials from the Central Cordillera.

Uplift of the Eastern Cordillera during the Tertiary resulted in erosion and the production of sediments which were deposited in the Eastern Plains. The largest uplift occurred in the Miocene and Pliocene periods, and sediments eroded from the Cordillera were carried away by rivers and deposited in the Eastern Plains (Goosen, 1972). Tertiary rocks, the Cretaceous Guadalupe formation, and granodiorite from intrusive Cundinamarca rocks were sources of sediments. Clay is an abundant constituent of the Cretaceous shale formations present in the Cordillera. Gneisses and acidic igneous rocks compose the basement of the Eastern Plains (Hubach, 1956).

Materials present in the Andean Colombian Cordilleras were affected by glaciation. In the Colombian Equatorial Andes, glacial episodes correspond with pluvial intervals, and interglacial periods correspond with interpluvial intervals (Van der Hammen, 1961). Glaciation, tectonic movements, and climatic and vegetational changes affected both the rate of erosion and the rate of sedimentation. According to Goosen (1972), at the end of the Pleistocene erosion in the Cordillera and sedimentation in the Plains were much reduced. Thus, the surface sediments of the Plains are late Pleistocene to the early Holocene.

According to the soil survey of FAO (1965), a number

of physiographic units are present in the Eastern Plains of Colombia: piedmont (alluvial fans), terraces, alluvial overflow plains, aeolian plains, and high plains. Soils investigated in this study formed on the High Plains and the Aeolian Plains. The High Plains are characterized by Pleistocene terraces where alluvial sediments were deposited and eroded as the result of climatic changes (Tricart, 1965). Terrace formation, related to fluctuating Pleistocene climates, required at least two morphogenetic actions: an alluvial accumulation and the subsequent down-cutting of deposited materials. Loess dominated by silt later covered the Aeolian Plains as well as portions of the High Plains. After aeolian sediments up to several meters thick were deposited, they were distorted by faulting, tectonic uplift, and subsidence in the vicinity of the Meta River.

Climate

Precipitation decreases from the Cordillera to the Plains: Villavicencio has a mean annual precipitation of 4,196 mm, Puerto Lopez has 2,909 mm, and Orocue has 1,673 mm. Mean annual precipitation based on records obtained from 1963 through 1970 in the High Plains is 2,570 mm. Mean annual precipitation based on records obtained from 1932 through 1939 in the Aeolian Plains near Orocue is 1,678 mm. Monthly distribution of precipitation is shown in Figure 2

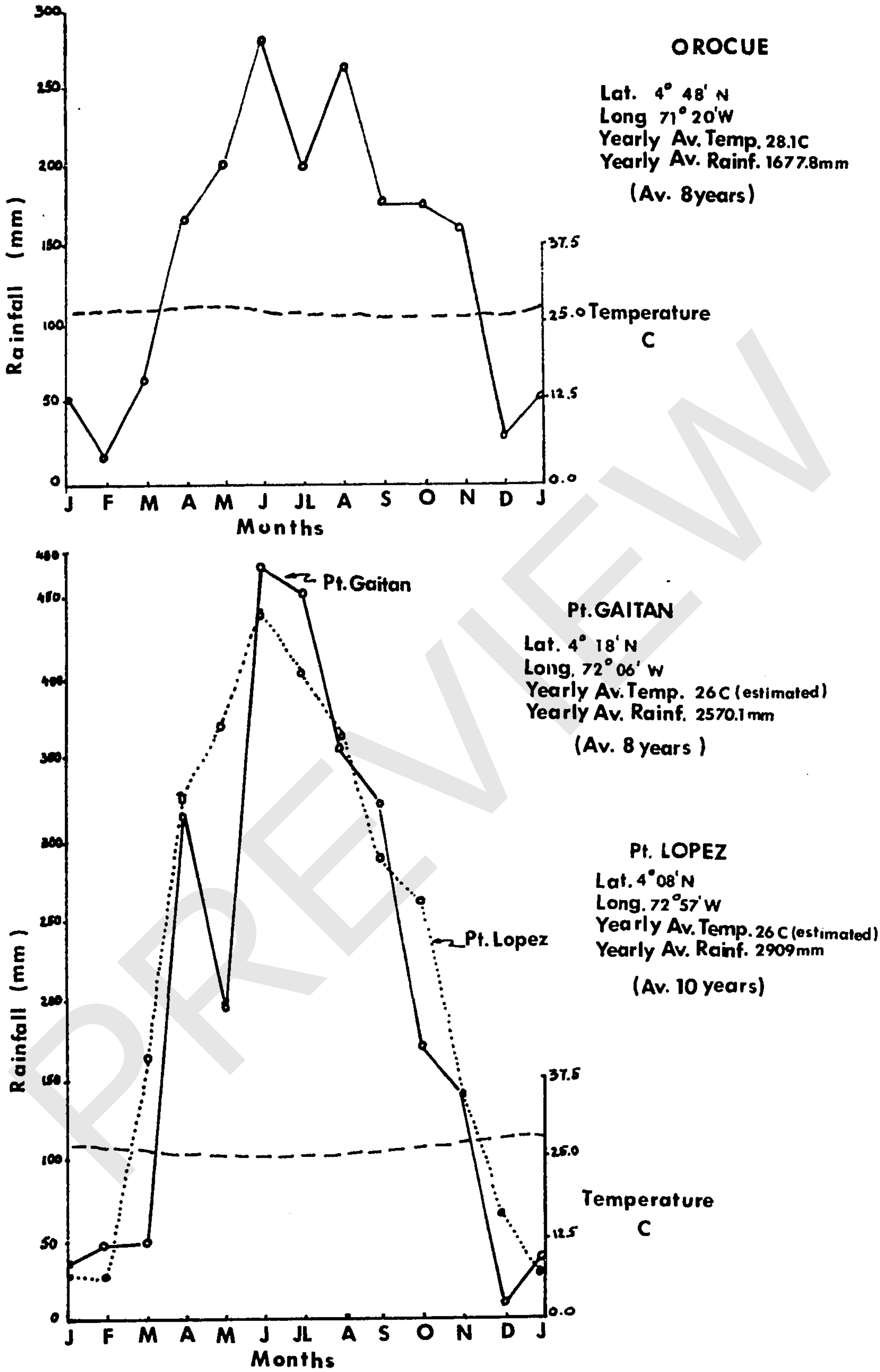

Figure 2. Average monthly distribution of rainfall and temperature in the area studied.

and show relationships between precipitation and temperature. Mohr (1944) defined a wet month in tropical conditions as one receiving more than 100 mm of precipitation. In the study area precipitation is abundant from April to October-November and infrequent the other months. Through the year, three dry months occur in the High Plains and nearly four dry months occur in the Orocue area (FAO, 1965). Average annual air temperature for Orocue is 28.1 C (FAO, 1965). In the Puerto Gaitan area reliable data are not available; nevertheless, average annual air temperature is estimated at 26 C. Fluctuation of temperature through the year is less than 5 C and is typical of tropical climates.

According to Tricart and Cailleaux (1965), in climates with a characteristic dry season, forest is replaced by savannas in response to soil moisture conditions. Winds blowing from north-east to south-west are especially strong in December through April in the study area (Goosen, 1972). Utilizing these data, climate and vegetal formations have been classified as follows:

(1) Montenegro and Espinal (1962), applying Koeppen's system, classified the zones studied as tropical dry forest (annual precipitation values range from 1,000 to 2,000 mm, and temperatures are higher than 24 C). Based on more recent data, this classification is interpreted as moist forest for the soil areas near Puerto Gaitan, and remains as dry forest near Orocue. Nevertheless, characteristics of

soil permeability and water retention in the zone near Orocue create soil conditions that are more moist than in the High Plains.

(2) Lang's factor of 59 characterized the soil profile near Orocue, and a factor of 99 was found for soil profiles near Puerto Gaitan. The first value (59) falls between semi-arid and semi-humid categories, and the second value (99) between semi-humid and humid categories.

(3) According to Tricart and Cailleux (1965), Birot's index (precipitation ÷ 4 x temperature) has been applied in the tropical areas being considered. An index lower than 2 characterizes dry months, whereas values lower than 0.5 characterize very dry months. Applying this index to the area studied, December through March must be considered very dry months (values lower than 0.5).

(4) Batista and Molano (1966) characterized the climate of the study area as Aw, or moist-dry savanna climate.

(5) Garcia (1964), working with Mexican savannas, found that the Aw classification was not always correct in these areas, and that the Af (tropical-wet type of climate) classification also occurred.

In the study area climate may be classified as Am, where A is associated with a tropical rain climate with an average annual temperature higher than 22 C and an average in the coldest month higher than 18 C. The m is related

to abundant precipitation in the wet season which compensates for the lack of rain in the dry season. Am is not considered by Koeppen (1954) as a fundamental type of climate, but according to Garcia (1964) it is important in areas south of the Tropic of Cancer. Therefore, following Garcia (1964), the climate of Orocue is Aw.

Vegetation

Native grasses cover the areas where the soil profiles were studied. In general, these areas are characteristically flanked by rivers, where gallery forest and other types of forests predominante. The low protection of the soil surface in areas sparsely covered by grass however, resulted in high soil temperatures which, in turn, affected the dynamics of organic matter and humus. Mesosetum savanna is dominant in the area where the Orocue soil profile was studied. In the High Plains Paspalum pectinatum, and Trachypogon vestitus savannas are dominant (Goosen, 1972).

Cuatrecasas (1956) and Blydenstein (1967) indicated that vegetation and edaphic factors are partly related to the permeability and the leaching conditions of the soils. Cuatrecasas (1956) emphasized the importance of human activity as a factor in savanna formation.

According to Goosen (1972), citing Wymstra and Van der Hammen (1966), based on pollen-analytical data, the High Plains was a "dry forest or a closed savanna wood land"