ABSTRACT

SOIL
IN THE PROCESS AND PATTERN
OF SETTLEMENT

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THE THESIS INVESTIGATES THE ROLE OF SOILS IN THE PROCESS AND PATTERN OF SETTLEMENT IN SELECTED AREAS OF BOTH THE MID-LATITUDES AND THE TROPICS, AS A MEANS OF TESTING A VARIETY OF HYPOTHESES USED TO EXPLAIN THE NATURE OF THE RELATIONS BETWEEN SOILS AND MEN. SPECIAL ATTENTION IS GIVEN TO THE SIGNIFICANCE OF A PEOPLE'S KNOWLEDGE, ATTITUDES TO AND PERCEPTION OF SOILS IN TRYING TO EXPLAIN RELATIONSHIPS WHICH VARY WITH THE PROCESSES OPERATIVE, PHYSICALLY AND CULTURALLY. IN THAT MIS-CONCEPTIONS ABOUT THE PHYSICAL NATURE OF TROPICAL SOILS HAVE PLAYED A MAJOR ROLE IN MID-LATITUDE MAN'S INTERPRETATION AND EXPLOITATION OF THE TROPICAL ENVIRONMENT, THE DEVELOPMENT OF THESE MISCONCEPTIONS IS DESCRIBED AND ANALYSED.

INCIDENTAL TO THE MAIN THEME, LAND DIVISION WHICH IS A MANIFESTATION OF BOTH PROCESS AND PATTERN, IS STUDIED AND A COMPARISON AND EVALUATION OF SYSTEMS EXTANT IN BOTH THE MID-LATITUDES AND THE TROPICS INDICATE THAT UNDER SOME CIRCUMSTANCES NON-GEOMETRIC SYSTEMS OF LAND DIVISION COULD BE USED IN SETTLING LANDS OF DEVELOPING COUNTRIES, FOR THE BETTER UTILISATION OF ALL RURAL RESOURCES AND FOR THE FULL BENEFIT OF ALL RURAL INHABITANTS.

SOILS

In the Process and Pattern of Settlement

by

Theo L. Hills

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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PREFACE

Anybody who places himself in the rather embarrassing position of submitting a doctoral dissertation after 15 years of university teaching, obviously owes a great deal to many people. The author owes a debt of gratitude to a generation of graduate students whom he introduced to the tropics, worked with in the field and from whom he learned a lot. In Guyana, particularly, association with E. Waddell, M. Eden, N. Sinha, D. Frost and R. Goodland, an especially enlightened and perceptive group of graduate students, was greatly appreciated. Chapter 13 owes much to their combined efforts in the field. (Bibliographical details of their theses are listed on p. 329.) The Guyana experience was also enriched by brief associations in the field with G. K. Rutherford, Queen's University, R. Salisbury and J. B. Bird, both of McGill University, J. Dummett, then of the Department of Agriculture, Government of Guyana, and R. Dagon, Conservation Consultant, New York.

For what the author knows and understands of man/land relations in the Caribbean, he is also indebted to a host of graduate students and colleagues with whom he worked in the field, more especially J. Anderson, I. Smith, J. Mbogua, J. Oyelese, J. Henshall, F. Innes, D. Watts, J. McEachern, R. Paquette, N. Walters and D. Brack.

For his concern with the landscape and with people's attitude to and perception of it, he owes a debt to his early New Zealand professors, Sir Charles Cotton, Donald McKenzie, George Jobberns and Kenneth Cumberland. At a later stage - Dan Stanislawski, Donald Brand, Erich Zimmermann and

Walter Webb, of the University of Texas, broadened his view of both man/land relationships and of the nature and appraisal of resources, and during the early 1950's he benefited from Kenneth Hare's concern with the meaning of landscape. However, it was only with the advent of the ethnoecologists, led by H. Conklin, and of 'perception geography' led by David Lowenthal, Yi Fu Tuan and others, that the author had the courage to display his own concern for this vital human aspect of the appraisal of resources.

On the local scene, both in Quebec and in the Tropics, the author has spoken with well over a thousand farmers and peasants - call them what you will - and for their indulgence he will be forever grateful.

For one who prefers research in the field, long tedious hours, days and months in archives in England, Ottawa and Quebec, were a hardship. The burden was considerably lightened by the assistance of my wife, who also spent many hours extracting census data from microfilms.

Along the way, and during the final throes, the assistance with translation, editing, illustrations, cartography and typing, of Martha Mount, Betty Wilson, Nancy Beaton, Joan Retallack, Maureen Card, John Toft and Don Prozetsky was vital and greatly appreciated.

In the use of air photographs on pages 76 and 77 and 86, the author is indebted to the Canadian Air Force and the National Air Photo Library, Ottawa; for the copy of an air photograph on p. 232, to Hunting Aerial Surveys, U. K. With the exception of the photographs on pp. 222, 266 and 269, which were taken by R. Dagon for the McGill University Savanna Research Project, the photographs in the thesis were taken by the author.

Finally, for the encouragement to submit this thesis the author is most grateful to T. Lloyd and S. B. Frost.

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P R O L O G U E

Part I provides the setting. It introduces the subject of soils and men. It explains the author's concern for soils and men as well as what others in both the physical and social sciences have had to say on the subject. It emphasises the importance of attitudes to and perception of soils by men in any study of the relations between the two. It states the thesis.

CHAPTER I

OF SOILS AND MEN

Of soil and man, or soils and men, much has been written. Writers in many fields have written in general terms of man's attachment to the soil, of his roots, and those of society, in the soil, of his inspiration from the soil, of soil as a source of well-being, of man's use and misuse of soil, and to a lesser extent, more recently and more specifically, of his increasing demands from the soil, but at the same time, of his rapidly increasing scientific knowledge and understanding of soils.

Soils and Men, Yearbook of Agriculture, 1938, of the United States Department of Agriculture, is one of the outstanding publications of the 20th century on the subject of soils and men. The concepts and sentiments expressed in this influential volume range from the most scientifically acceptable concepts regarding the nature of soils and soil classification to the expression of sentiments regarding man's debt to the soil and of its deterministic influence upon the development of his laws and culture.

In the Foreword, Henry A. Wallace, then Secretary of Agriculture, stated:

> "In this book the effort is made to discover man's debt and duty to the soil. The scientists examine the soil problem from every possible angle. This book must be reckoned with by all who would build a firm foundation for the future of the United States. The social lesson of soil waste is that no man has the right to destroy soil even if he does own it in fee simple. The soil requires the duty of man which we have been slow to recognise."[1]

A physical-environmental, deterministic interpretation of the development of man and his cultures is well illustrated in the following quotation from Soils and Men, in which soil is expressed as the source of man's well-being and as a determinant, or major influence, upon his action and living.

> "Society has its roots in the soil. Man receives inspiration as well as physical necessities from the soil he occupies. The folk-songs of the world are less expressive of the people than of the landscape from which they have originated. It is the songs of the mountain, of the desert, of the plains, of the forest, and of the jungles, that are distinctive. The powerful influence of the landscape is reflected in literature. Men and societies are thus products of the landscape. The strong races first approached to physical and social equilibrium with its own landscape. The great cultural systems, whose subsequent civilisations have made their mark on world history, had, for the most part, originated in a particular landscape and a particular group of soils -- the Egyptian, on the alluvial soils of the desert of the Nile valley; the Arabian, in the semi-desert; the classical (Greece and Rome), on the Red soils; and the Western on the leached forested soils of Northern Europe. People may move from one landscape to another, but a race is rooted to the soil that gave it birth. As soon as people move, serious conflicts develop socially and within the individual. Fundamentally the conflict is between the genetic heritage, carried from another soil, and the new landscape with its different possibilities and requirements. Such conflicts reach from the simple life of the individual to the highest grounds of government and politics."[2]

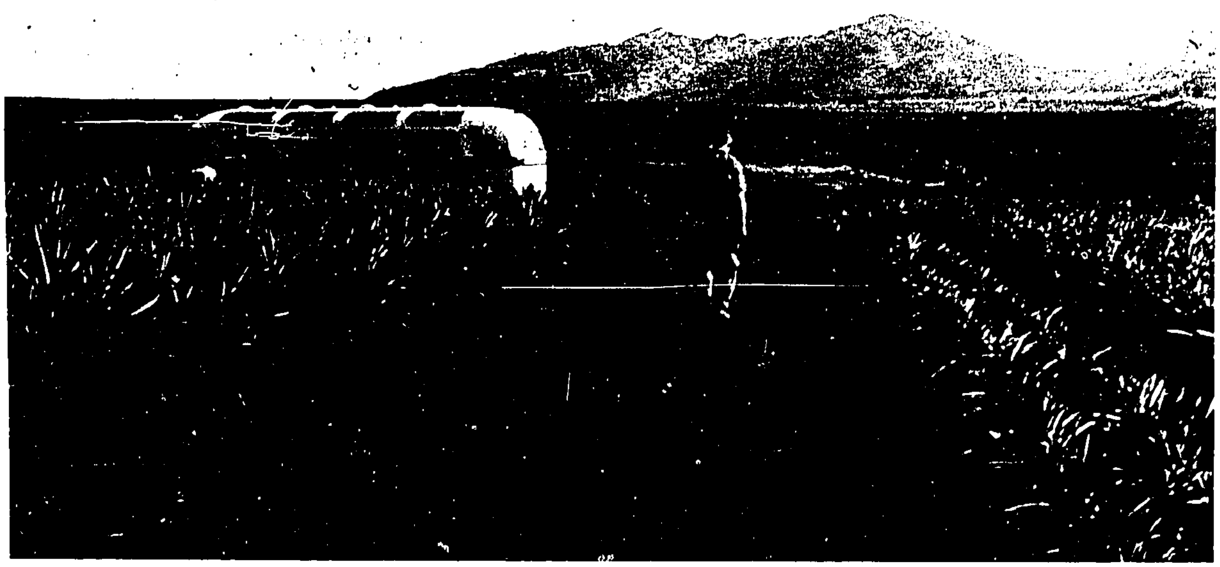
Similar sentiments are expressed in the words of Henri Prat, one-time Professor of Soils at the Université de Montréal, in L'Homme et le Sol, especially in the following statement:

> "L'histoire des civilisations est, dans une large mesure, celle des rapports de l'homme avec le sol. La distribution actuelle de nos peuples, leur structure sociale, leur degré de prospérité, sont les fruits de la longue évolution de ces rapports."[3]

In more emotive, though nevertheless perceptive prose, Alan Paton wrote of soils and men:

PHOTO 1

A 'Capitalist' Soil -- This designation was applied by a Russian pedologist in observing structural changes in soils on the island of Oahu, Hawaii Islands. He claimed that the soils had been exploited under a capitalistic monocultural agricultural system.



"There is a lovely road that runs from Ixopo into the hills. These hills are grass-covered and rolling, and they are lovely beyond any singing of it. The road climbs 7 miles into Carisbrooke; and from there: if there is no mist, look down on one of the fairest valleys of Africa. About there is grass and bracken and you may hear the forlorn cry of the titihoya, one of the birds of the veld. Below you is the valley of the Unzimku, on its journey from the Drakensberg to the sea; and beyond and behind them, the mountains of Ingeli and East Griqualand. The grass is rich and matted, you cannot see the soil, it holds the rain and the mist, they seep into the ground, feeding the streams at every kloof. It is whirl-tended, and not too many cattle feed upon it; not too many fires burn it, laying bare the soil. Stand un-shod upon it, for the ground is holy, being even as it comes from the Creator. Keep it, guard it, care for it, for it keeps man, guards man, cares for man. Destroy it and man is destroyed. Where you stand the grass is rich and matted, you cannot see the soil but the rich green hills, break down. They fall to the valley below, change their nature. For they grow red and bare; they cannot hold the rain and mist, and the streams are dry in the kloofs. Too many cattle feed upon the grass and too many fires have burned it. Stand shod upon it for it is coarse and sharp and the stones cut under the feet. It is not kept or guarded or cared for, it no longer keeps man, guards man, cares for man. The titihoya does not cry there any more. The great red hills stand desolate, the earth is torn away like flesh. The lightning flashes over them, the dead streams come to life, full of the red blood of the earth. Down in the valleys, women scratch the soil that is left, and the maize hardly reaches the height of a man. They are valleys of old men and old women, of mothers and children. The men are away, the young men and the girls are away. The soil cannot keep them any more."[4]

Sherlock Holmes once suggested that soil is something that everyone sees but that few observe. The following words of Karel Kapek, in The Gardener's Year, well illustrate this point of view:

"In fact one does not care what one is treading on; one rushes somewhere like mad, and at most one notices what beautiful clouds there are or what a beautiful horizon it is, or how beautifully blue the hills are; but one does not look under one's feet to note and praise the beautiful soil that is there. You must have a garden that would be no bigger than a pocket-handkerchief; you must have one bed at least to know what you are treading on, then my friend, you will see that not even clouds are so diverse, so beautiful, and terrible as the soil under your feet. You will know that the soil is sour, common, tough, clayey, cold, stony, and rotten; you will recognize the mould, puffy like pastry,

PHOTO 2

The 'Rape' of the Earth -- Soil erosion on Barbados.

> warm, light, and good like bread and you will say of this that it is beautiful, just as you say of women or of clouds. You will feel a strange and sensual pleasure if your stick runs a yard deep into the puffy and crumbling soil, or if you crush a clod in your fingers to taste its airy and tepid warmth."[5]

Acceleration of soil erosion in the 20th century has given rise to a plethora of literature on the subject. One example is The Rape of the Earth - A World Survey of Soil Erosion, a widely-read and most influential publication. The book commences:

> "To gain control over the soil is the greatest achievement of which mankind is capable. The organization of civilized societies is founded upon the measures taken to wrest control of the soil from wild Nature....As the result solely of human mismanagement, the soils upon which men have attempted to found new civilizations are disappearing...and when that thin cover -- the soil -- is gone, the fertile regions where it formerly lay will be uninhabitable deserts."[6]

Elsewhere in the same book, on a page titled 'Native Attitude to the Land', the following statement appears:

> "A witness before the Kenya Land Commission gave his opinion that 'the African people have never established a symbiotic relationship with the land. They are in a strict scientific sense parasites on the land, all of them.' This sweeping statement is, at first, somewhat difficult to reconcile with the fact that erosion is most widespread and severe in European colonies in Kenya and Southern Rhodesia. There is, however, a good deal of truth in it, in the sense that the African has no instinctive love for land, as such, at all comparable with that exhibited by Europeans." [7]

It is obvious that attitudes to land and soil vary, and that in evaluating these attitudes, one must be able to understand all the values involved.

There is such infinite variety in the ways of looking at the land and establishing values regarding soils. As Ely states:

> "Under English law, the ownership of the surface carries with it rights to soil within this space down to the center of the earth, and indefinitely upward. This concept has been modified considerably. Ownership of the surface of the earth may be entirely different from the ownership of the minerals below the surface. In China the landlord may own the space while the tenant owns the soil-body representing the man-made fertility."[8]

In considering the absolute limits in cultivability or physical productivity, E. W. Zimmermann, a resource economist, recognised four factors of which soils were mentioned last. He said of soils, they:

> "are much more amenable to human influence than is climate. To be sure it took man a very long time even to begin to understand land soils and during the stage of ignorance and inadequate understanding, frightful damage was wrought. But real progress has been made of late and it is continuing." 9

It is clear that <u>soil</u> is often one of several factors that have impact upon man's habits and values. Stanislawski states in regard to the 'durable' nations of Western Europe that:

> "The habits and values of such people have been established in relation to the land upon which they have lived, to the climate affecting it, and to the soils and vegetation that respond to a complex of factors belonging to that specific territory." 10

The statements quoted up to this stage, merely serve to introduce the reader to the complexity of the problem in attempting to sort out, unravel and analyse the great variety of statements about soils, and the relations between <u>soils</u> and <u>men</u>. There are scores of statements, in many works, which deal in many ways with the relations between man and his environment, that either imply or state that soil, as one of a number of elements of the physical environment, has had a significant influence upon man's occupation and use of the earth's land surface. Many authors have endowed man with a remarkable appreciation and understanding of this influence. In the long history of migration and settlement, how many men have had sufficient appreciation and perception of the significance of soil, to enable them to take soil into account in making a decision as to where to settle and cultivate? And, even if they have had this ability, what proportion have been given the opportunity to exercise it? There is no questioning of the ultimate significance of soil as a location factor in the pattern of man's distribution on the earth's surface. What is questioned is both the weight so often given to soil in analyses of the process of settlement, and the amount of knowledge and degree of perception of the role of soils with which the settler is so often imbued. You can see them now, the rugged pioneers, crossing the Urals, approaching the coast of Southeast Australia, reaching for the farthest corner of Polynesia, passing through the Cumberland Gap, or disembarking at Quebec or Kingston, all eager and able to seek out well-watered, fertile soils.

The author was once questioned and criticised by a senior Canadian geographer for neglecting soils in an explanation of the pattern of settlement in the Eastern Townships of Quebec in the year 1830. At that time, the chief determinants of the settlement pattern were the colonisation roads which tended to follow the high ridges, because little bridging was required and, here as well, were the hardwoods, the source of potash, a major cash crop of the period, and a rigid survey system within which large areas were held by speculators. It is obvious that soils must have had some locational significance, but in 1830, it was by good luck, if any number of settlers ended up on good soils. However, the criticism led the author to look more seriously and systematically at the role of soils in the process and pattern of settlement.

Some Preliminary Considerations.

The process of settlement is taken to be, not only the occupation of land for agricultural and other purposes, but the whole series of decisions and actions that must be taken at the time that an individual, a group or a state decides that a given area is to be settled or made available for settlement. In the case of the Eastern Townships of Quebec, the process of settlement began, for people of European origin, when American frontiersmen first crossed an indefinite international boundary to settle in the upper Connecticut River valley and on the Stanstead Plain. Subsequently, the governments of Lower Canada and Great Britain had to develop, modify and adapt policy to allow for the occupation and settlement of this region. A variety of institutions, both governmental and private, had to recognise the needs of the region, both in the form of the settlers and the techniques by which the settlers would actually be settled on the land. From this stage in the process of settlement to the stage where a fair portion of the forest cover had been cleared from the settled land, what was the significance of soil as an element of the physical environment? Of all concerned, particularly those who were in a position where they had to make decisions related to the selection of the region, an area of the region, a range or a lot, what was their knowledge, experience of, attitude to, and perception of the physical environment of the region, especially the soil?

What of the settler and where did he come from? Was he an agricultural man? Did he know anything of the land and of its soils? What was the state of soil science in his homeland? From the time that he decided to migrate, to the stage that he was settled on the land, what opportunity did he have for making any decision pertaining to the soil? Did he select his lot? What choice did he have? What assistance was he given in both selecting his lot and in making good use of his land?

To a very different locale, to the island of Barbados, where one finds both plantation and peasant. On this tropical island, as in many parts of the tropical world, a high proportion of those settled on the land, namely the peasant or smallholders, have had virtually no opportunity for making decisions related to soil. The majority of those who have freehold tenure have purchased whatever land was available, there very rarely being any choice.

In the Amazon, one encounters shifting cultivators practising a system that has traditionally been explained in terms of the rapid depletion of soil fertility. The author suggests that the rationale of the system be looked at through the eyes of the Amerindian cultivators. How do they perceive of soil? Are they aware of the nature and significance of soil fertility? How many of them have ever tried to grow a second crop, only to discover that the soils were exhausted?

Pattern of settlement is taken to be the distribution of man upon the earth's surface, and obviously the distribution varies in an infinite number of ways. How significant have soils been in the development of the pattern of distribution of the world's population? How does this significance vary with scale, that of the continent, the country, the geographical region, the county, etc. It is obvious, to all who know anything of the distribution of soil over the earth's surface, that the greatest densities of population are not necessarily located on the most fertile or productive soils, witness the relatively low densities on the chernozem soils of North America. It is also clear that the distribution of the indigenous population, or of an earlier wave of settlers, did not always reflect the distribution of soils. Their form of occupance may

PHOTO 3

Peasant Settlement, Barbados -- Peasant settlement is often confined to the more rugged terrain due to the demands of the plantation system.

PHOTO 4

Peasant Settlement, Barbados -- Village and Plantation.

have been other than agriculture. In certain cases where the indigenous population was settled on the best agricultural lands, the lesson was lost on the incoming settler or agriculturist, witness the example of the British East Africa groundnut scheme, where lands were considered as desirable for development purposes because

> "...there is a sparse population unencumbered by native or other rights...uninhabited tsetse infected and waterless areas therefore, offer special attraction to the project, provided soil is suitable and rainfall adequate..."[11]

How are process and pattern to be analysed, described and explained? Wagner has recently written about the "pattern - process - pattern" relationship, and he states that rational explanation calls for use of patterns as indices of other patterns through explicit links of process. He suggests that:

> "this relationship, 'pattern - process - pattern', and its reciprocal admit of mapping and diagramming; quantification; ecological, economic, or cultural interpretation; emphasis upon 'man's role'; and even a measure of environmental determinism....Man, today, is still primarily rural. In looking at his distribution upon the surface of the earth, there is an 'expectable' pattern, that is, man will be where the most advantageous physical conditions are to be found, such as fertile soils, well-watered plains, mineral resources, etc. The pattern we observe involves departures from the assumed pattern, due to limitations of the physical environment and cultural variation. The cultural pattern may reflect a connection with the physical one through some identifiable process, though not necessarily."[12]

In the case of the settlement of the Eastern Townships of Quebec, the island of Barbados, or a region of the Amazon, the initial pattern is that produced by the physical environment and, within this pattern, soils are obviously a significant component. By the process of settlement and the development of agriculture and other economic activities, a second, or subsequent pattern or patterns, are superimposed upon the

the initial pattern and a reciprocal relationship will be involved, in that the initial pattern, that of the physical-biotic environment, will have some influence on process and the manifestation of the process itself. This means that settlement of man upon the land and his agricultural and other economic activities will in turn have an influence upon the physical environment. Process will ordinarily involve, among other things, a survey system which will allow for the orderly settlement of man on the land. In most cases, this survey system will be symmetrical and will not, or cannot, take variation of the physical environment into account. Thus, it rarely allows for variation in soil fertility (an outstanding exception is discussed in Chapter 11). In any particularly enlightened settlement programme of the modern day, process may also involve means by which variation in the soils can be counteracted or modified, but this is rare.

Returning to the discussion of the reciprocal nature of the relationship between the initial pattern or patterns and the process of settlement, it is important to keep in mind that many studies in the social sciences, if not the majority, with detailed descriptions of all aspects of people's way of life, have tended to neglect the changes brought about by man in the physical-biological environment in which he lives. Confining one's studies solely to man's historical, political, social, economic or cultural affairs, to the exclusion of other evidence, is possible only on the assumption that human society is superimposed on the earth and can be studied independently of it. This assumption is widespread and common. The same is probably true of many physical-ecological studies. In both cases the pure spatial pattern, the ecological process, or the underlying cultural or economic patterns, are isolated for study by themselves, to the neglect of the reciprocal relationships involved in 'process', the essential link in a rational explanation.

Given the idea of a relatively unchanging and stable physical world, it is easily possible to overlook, neglect, or ignore the infinite variety of man's local modifications of the physical environments throughout the world. Since the history of human modification on the face of the earth has not been clearly and consistently formulated, one might say that its lack has, in turn, contributed to the persistence of the idea of a relatively unchanging physical environment. However, the theme of man as an important modifier of earth conditions is not new, nor has its development been restricted to one branch of science or to the scholars of one country. There are some notable exceptions.[13]

The idea of man as an agent of change on the earth places the study of human activities, social institutions and cultural values in an entirely new perspective. In the 18th and 19th centuries, the customs of primitive societies were studied to illustrate the proposed stages through which advanced civilisations had evolved. But these were studied almost exclusively in their relationship to human society. It is time to see their relationships, as well, to such things as soil, vegetation, animal life and population distribution. While there is wide awareness of this, the materials are yet fragmentary and relatively uncoordinated. One of the dominant forces in today's world is the transformation of the physical environment in different areas by societies acting through cultures, primitive and civilised, with different histories and attitudes towards the land. Human activities are to be seen as a part of the exceedingly complex relationships existing in nature, and we now have a body of knowledge that makes it possible to reach an understanding of the processes at work in these inter-relations between human culture and the physical-biological environment.

Attitude and Perception.

The attitudes of man and his perception of the environment, as a totality, or of its many components, physical, biological and cultural, become extremely significant in the study of these processes at work. How do you determine the nature of man's attitudes in this context, and of his perception of the environment and its components? How does one firstly disentangle the complexity of factors making up the environment of man? How does one, for example, isolate soil within the concept of land, such as the land of the shifting cultivators? Environmental attitudes, biasses and sensitivities vary, but are they variable? How variable are the perceptions of individuals within a group, and of groups? Does the perception of soil by the Macusi Indian of southern Guyana differ from that of the Chimbu of New Guinea? To what extent are individual preferences, attitudes and perception significant within a group? 14

The significance of soil in the pattern of settlement has already been recognised. It undoubtedly varies with time and scale. How do men 'see' or perceive of soil? And what of the past? How have attitudes to, and perception of, soil varied with time, culture and location? Does man, wherever and whoever he may be, see the soil as static stuff to be used up in the course of time? Does he see it as a single component of the environment to be manipulated or modified regardless of other features of the land? Or does he see soil as a component of an ecosystem along with all its complex interrelationships? What have been the attitudes to, and the perceptions of, soil by those who have been involved in the settlement process -- the director of the joint-stock land company in the 19th century, the government surveyor responsible for the division of land, the French seigneur in Quebec, the Jamaican government official in selecting land for a 'land settlement', the shifting cultivator selecting his field and the American frontiersman, on Stanstead Plain, selecting a site for forest clearance.

It is hoped that some answers for the many questions raised in these preliminary considerations will be provided as the thesis develops. Some will not be answered, but at least the asking of them indicates the direction, or directions, in which some research in the social, and perhaps the biological, sciences might profitably go.

Before proceeding to the investigations within a regional context, it is necessary to engage in some more substantive and theoretical considerations.

Some Substantive and Theoretical Considerations.

The objective of this section is to treat in turn:

(i) Soils and Pedology. It is obvious that a working definition of soil, must be provided. In addition, it would appear desirable to outline those characteristics of soil that could conceivably be of significance in considering man's attitudes to, and appreciation, use and perception of soil, now and in the past.

(ii) Soils, population distribution and settlement patterns. Some answers to the questions already raised in regard to the varying significance of soil in time and space will be provided.

(iii) Soils and geographers. How have soils fared in the geographical literature? To what extent have geographers previously asked and answered the questions raised in the preliminary considerations?

(iv) Soils and other social scientists. How have social scientists other than geographers treated soils and soils and men?

(v) Perception of soils.

(vi) Thesis

CHAPTER 2

SOILS AND PEDOLOGY

Before attempting to answer the myriad questions raised in regard to the role of soils in the relations between soils and men, it is important to establish, firstly, the nature of soil and secondly, the range of facts and concepts pertaining to soils with which one could expect man the pedologist, man the government, or company, official, man the 19th century settler and man the tropical shifting cultivator, to be familiar.

Soil. Charles Kellogg's definition of soil will serve the purpose quite adequately:

> "Soil is that part of the outer mantle of the earth that extends from the surface down to the limit of biological forces, i.e. the depth to which living organisms penetrate. Five factors shape the evolution of a soil. They are (i) parent rock, or hereditary material; (2) relief, or the configuration of the land, where the soil lies; (3) climate and (4) living matter, acting on the parent materials, and (5) time." 1

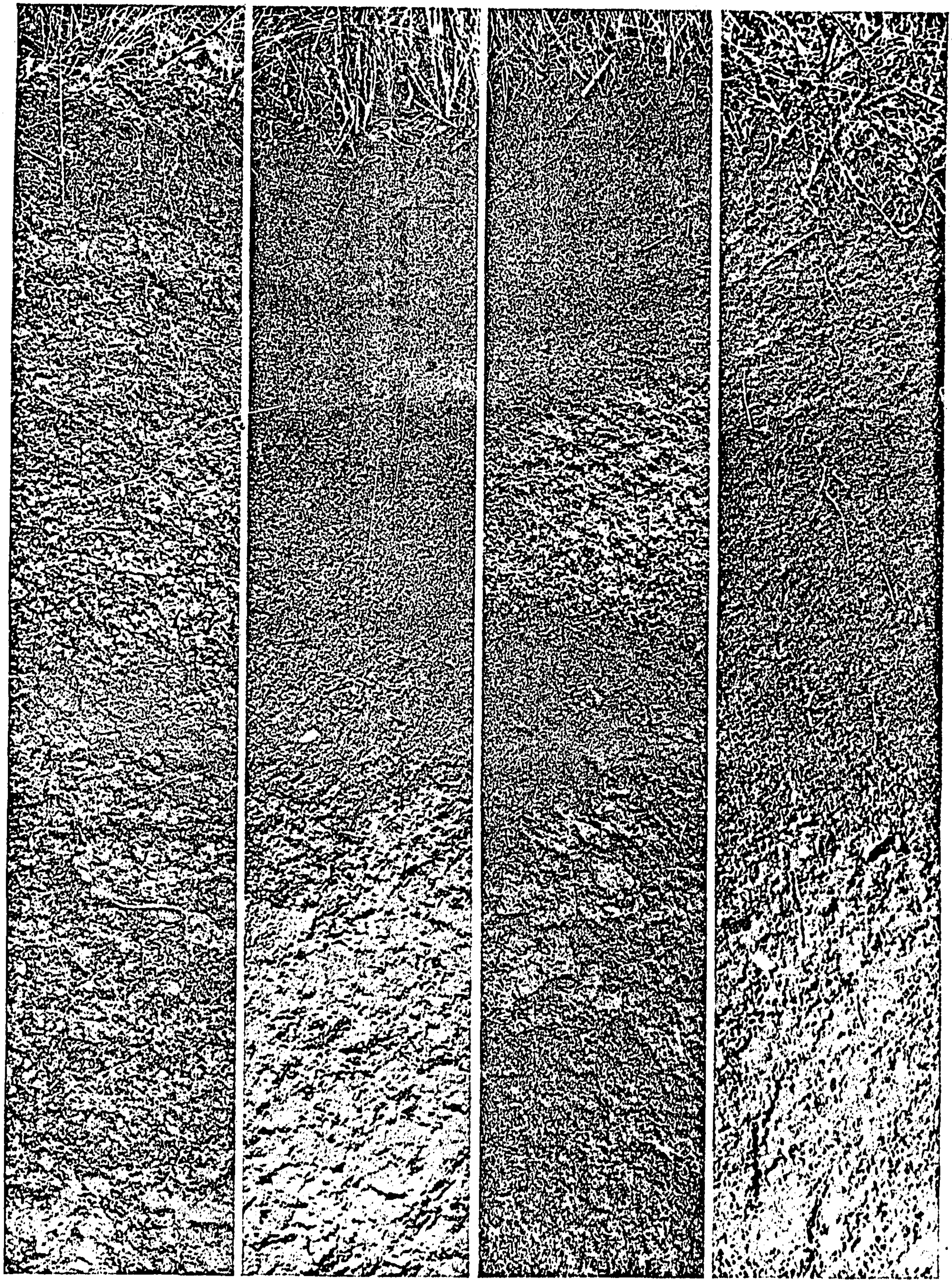
Soil Characteristics and Concepts - General.

Characteristics and concepts are summarised below, it is hoped in a manner that would meet with the approval of a pedologist, though obviously only a textbook could provide a completely adequate treatment.

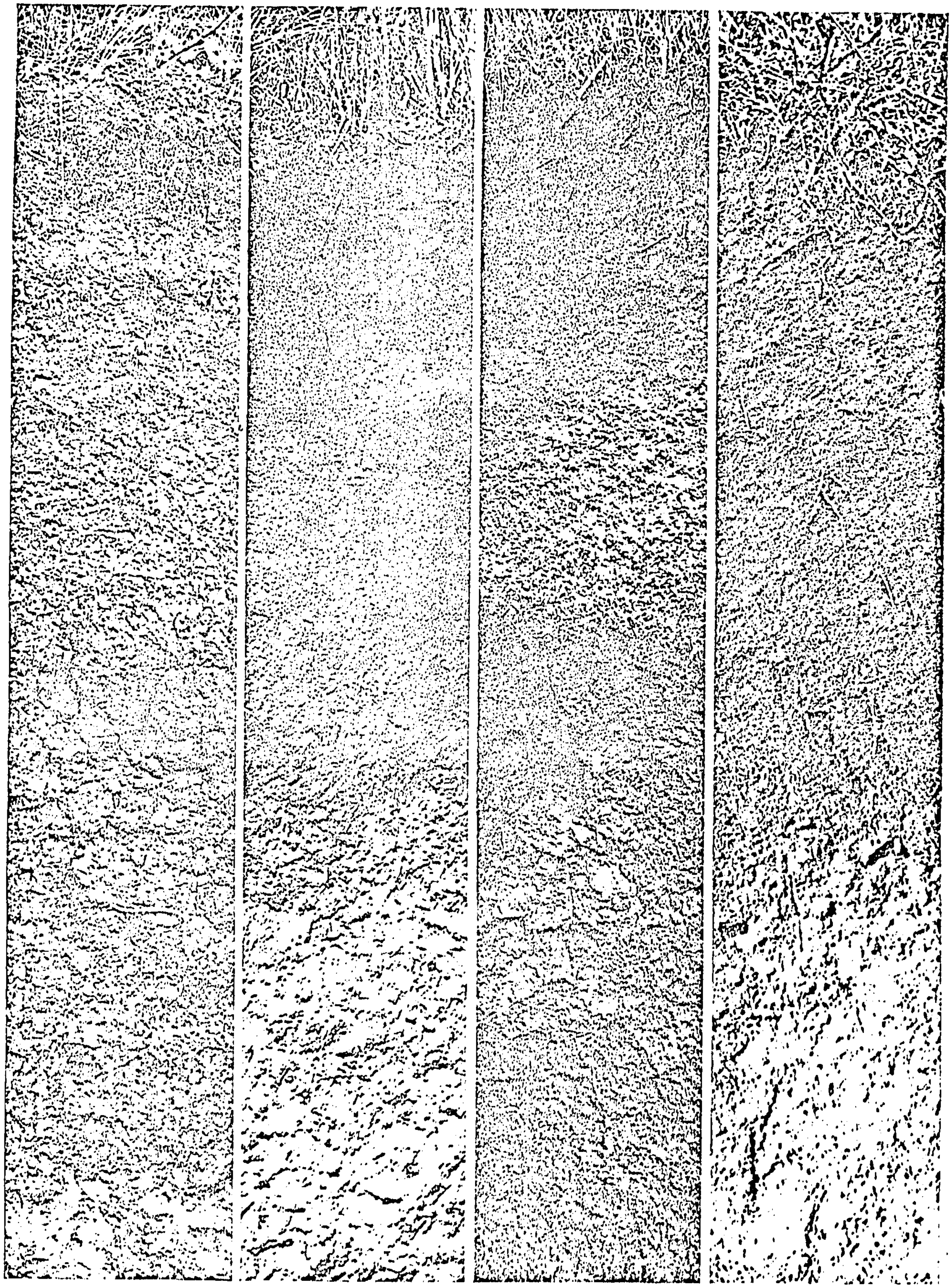
1. Every type of soil has a unique profile.

2. The soil profile consists of a series of differing layers called 'horizons' (See Fig. 1.). The profile is divided into three general levels, A, B, and C, corresponding generally to the surface soil, the subsoil and the substratum or weathered material beneath the soil proper.

3. Soils vary in depth and tend to become deeper towards the equator and thinner towards the poles.



FOUR IOWA SOIL TYPES are viewed in profile. At the left is the profile of the Weller silt loam, a Gray-Brown Podzolic soil. Second from the left is the profile of the Clarion loam, a dark brown Prairie soil. Third from the left is the profile of the Edina silt loam, a Planosol characterized by a gray, leached horizon over a dense claypan. Fourth from the left is the profile of the Webster silty clay loam, a Wiesenböden soil characteristic of regions with poor drainage. All four of these photographs show the soil to a depth of about four feet.



FOUR IOWA SOIL TYPES are viewed in profile. At the left is the profile of the Weller silt loam, a Gray-Brown Podzolic soil. Second from the left is the profile of the Clarion loam, a dark brown Prairie soil. Third from the left is the profile of the Edina silt loam, a Planosol characterized by a gray, leached horizon over a dense claypan. Fourth from the left is the profile of the Webster silty clay loam, a Wiesenböden soil characteristic of regions with poor drainage. All four of these photographs show the soil to a depth of about four feet.

4. Soils vary in structure, texture, stoniness, thickness, colour, surface configuration, weight, wetness and temperature.

5. Most soil horizons are mixtures of sand, silt and clay along with some organic matter.

6. Clay has the greatest influence on the chemical activity of the soil because many of the chemical reactions occur at the surfaces of soil particles, and the clay particles, being very small, are most numerous and offer the most surface.

7. The proportions of sand, silt and clay in a soil horizon determine its texture, which in turn affects its permeability to water and root penetration.

8. There are four kinds of soil structure, granular, blocky, columnar and platy. The first two types are best for plant growth.

9. Texture stays practically constant, but structure can change, or be changed, for better or worse.

10. Organic matter is vital to a good growing soil. It promotes granular structure, aids in retention of plant nutrients, etc.

11. The processes of solution, decomposition, addition and leaching act on the base material and account for most of the differences in chemical composition among soil horizons and types.

12. Soils vary in acidity and alkalinity.

13. Soils contain primary nutrients, - nitrogen, calcium, phosphorus and potassium and secondary nutrients or trace elements, sulphur, magnesium, manganese, iodine, iron, copper, zinc, boron and cobalt.

14. Plants vary in the kind and amount of nutrients they take from the soil.

15. The continual cycle of nutrients moving out of the soil into plants and back to the soil, is perhaps the most important fact of soil dynamics.

16. Climatic change or variation, volcanic ash showers, alluviation, etc. alter the nutrient level of soils.

17. The fertility level of soils varies with such factors as nutrient level, texture, structure, climate, organic content, etc.

18. Soil can influence plant growth through water, light or radiant energy, air (both in the soil and above ground), temperature, plant food, soil reaction, disease, insects, etc.

Concepts about Soils as an Element of an Ecosystem

We do not know precisely when man realised for the first time that plants not only grew out of soil but partially depended upon soils for growth. Those who were present at the beginnings of agriculture, when man learned for the first time that either seed or vegetable matter reproduced its own kind, and that each reproduction could be manipulated by man, probably did not immediately perceive of soil as a vital factor in the growth process. The process of learning about plant growth has to be repeated with every individual human, and the degree of understanding of this process varies not only with individual farmers, but with country, culture, etc.

What are the elementary facts and concepts related to plant growth, of which the farmer or cultivator might have command? It is important to remember the discussion is concerned not only with the less advanced agriculturist, such as the Amerindian of the Amazon, but also with the urban dweller who became a frontiersman in the 19th century and a more sophisticated sedentary agriculturist of the tropical world.

(i) Soil is the place for plants to grow. Soils provide the space in which a plant may grow.

(ii) Man, therefore, owes his life to soil, though only indirectly if he is primarily a meat eater.

(iii) Plants depend physically upon soils, the latter not being merely a 'holder' of plants. This dependence will be expressed at least at the elementary level, in terms of soils being 'good' or 'bad' for certain plants, qualities quite apart from moisture or climate.

(iv) Soils are formed from the rocks on the outer layer of the earth's crust.

(v) Soil is affected by the sun. It is heated and dried.

(vi) Plants depend on the sun and the soil for heat and light.

(vii) Soils are affected by vegetation, i.e. the root structure, and by its influence

(viii) Soils are affected by vegetation, i.e. the root structure, and by influence.

(ix) Soils can be washed away by rain or rivers; they can slip or slide away.

(x) Soils are enriched by, or are better for, organic material obtained largely by decaying vegetation. Black upper horizons indicate soils rich in organic material.

(xi) Ash, likewise, enriches soil.

(xii) Earthworms and other micro-organisms are present in soil to a greater or lesser degree and may be beneficial to soils.

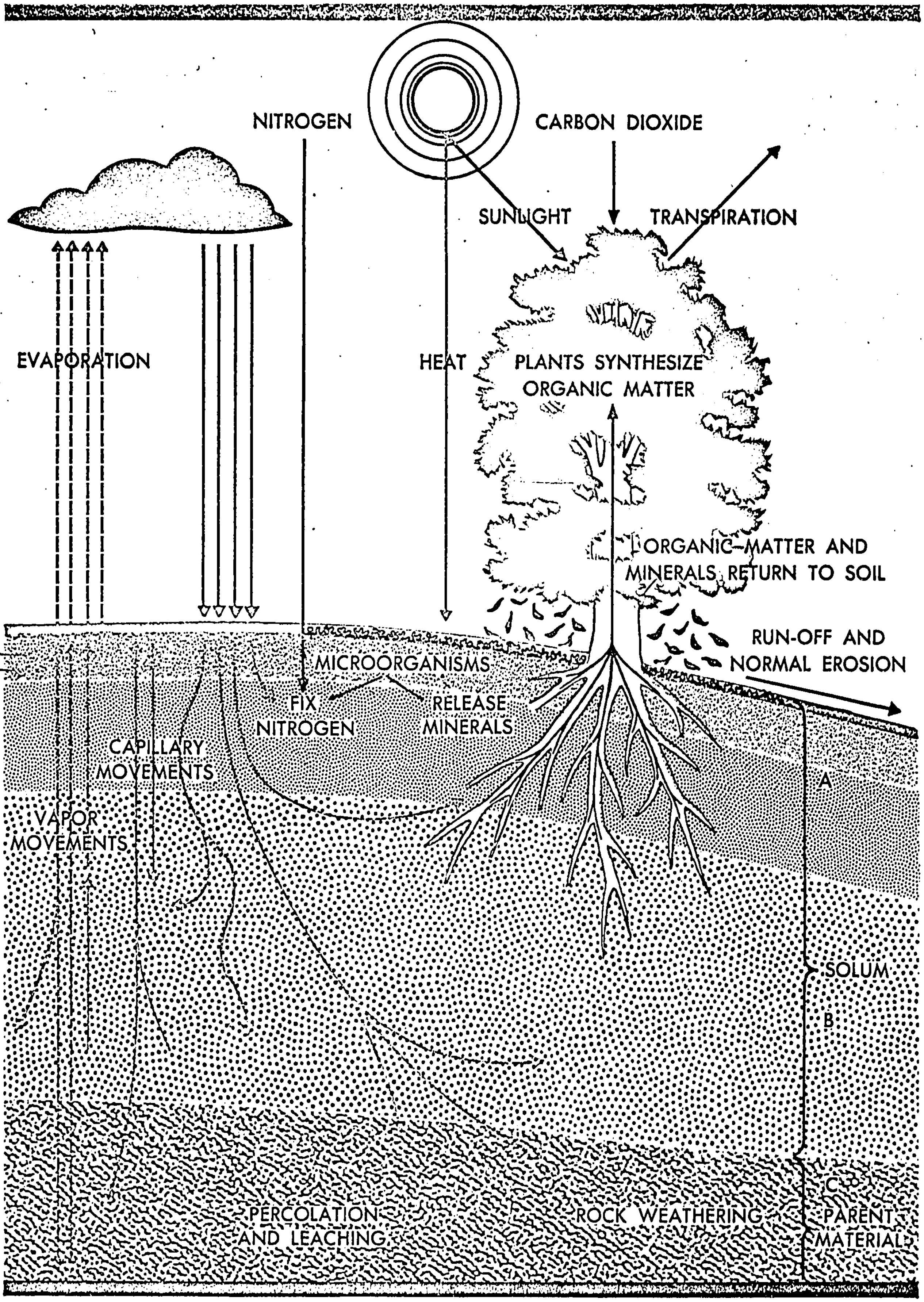
(xiii) The quality or characteristics of soils vary with distance from a stream or river, with slope, with type of vegetation, with elevation and with type of rock. These variations may only be appreciated through the varying performance of crops. Some crops do better on certain rocks, e.g. calcareous rocks or volcanic ash.

(xiv) Some crops grow faster and mature earlier on certain soils.

(xv) Crops vary in their demands upon soils.

(xvi) The behaviour of water in the soil affects plant growth. The amount of moisture in soils varies, and soils vary in the way water drains from them and over them.

FIG. 2.



PHYSICAL AND BIOLOGICAL processes participate in the life of the soil. In the biological process plants remove water and various nutrients from the soil and combine them with carbon from the air. The various plant structures eventually return to the soil and decompose, releasing nutrients for a new cycle of plant growth.

Figure 2 illustrates the physical and biological processes and relationships involved in the typical forest or grassland ecosystem, and can be used to summarise the above outline. How much of this ecosystem is understood by the cultivator?

<u>Concepts related to soil use and potential</u>.

1. Many soil characteristics can be changed. Therefore soils can change for the worse with use. They can be improved in various ways, directly and indirectly.

2. Soils can be improved directly by adding material, e.g. sand to clay, chalk to clay, etc.; by applying nutrients artificially or naturally produced; by mulching; by drainage; by removal of stones, boulders, etc.

3. Soils can be improved indirectly, by the manipulation of plants, - use of legumes; by rotational practices.

4. Soils in use can be improved by weeding, cultivation, application of water, etc.

5. The overall value of a soil is not always judged by the immediate supply of plant nutrients available, but also by ease of use, which includes ease of clearing the vegetation; by depth of soil, which means the amount of raw material available, by months of year available for use and length of growing season, and ease of manipulation or modification of all soil characteristics.

Pedology.

Pedology is the scientific study of soils, their origin and characteristics and their utilisation. Pedological treatises of the past and of the present day are ordinarily concerned with the scientific presentation of the field of pedology, both on a systematic and often on a regional basis. In that they often describe present uses of the soil, and perhaps recommend others, they are concerned with relations between soils and men. However, it is chiefly the social scientist who in this past century has been most concerned in seeking a rational explanation of the relationships between soils and men. Regardless of whether the social scientist, the economist considering soil as a resourceful commodity, the historian considering soil as a site or an influence, the social anthropologist considering soil as a factor in the physical-biotic environment and the geographer perhaps seeing soil as all of these, his degree of success in satisfactorily explaining the relations between soils and men in any particular situation has depended upon his views on man-land relationships, ranging as they do from physical environmental dominance to cultural dominance; the extent to which the physical environment is thought of as relatively unchanging; the success with which soil is studied as a component within a complex ecosystem and the extent to which he recognises the limits of his naïvety. These factors will be elaborated upon in the following sections, except 'the soil and the ecosystem' which it is more relevant to discuss at this stage.

Devons and Gluckman's discussion of the closed "system" raises problems that are particularly pertinent to any discussion of the significance of one component of the environment, such as soil. As they state:

> "any social scientist has to define what he studies within certain limits: he cannot include the whole of complex reality. This limitation is vital if his study is to be manageable. Limitation can be of various kinds - a limitation in time, space, or in the aspect of phenomena which is studied."[42]

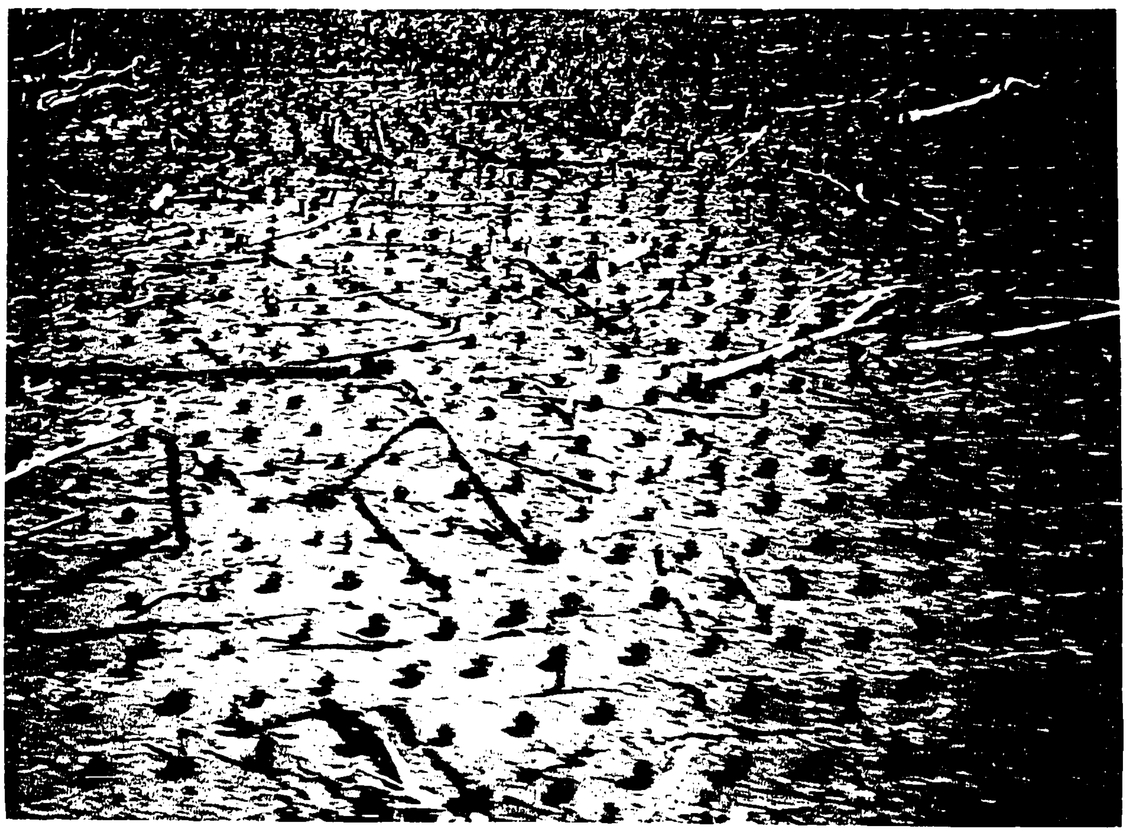
Like plants and animals, soil is validly considered an object of study as a whole and in its own right, but from what point of view can the soil be viewed as a distinct community, similar to and yet essentially different from plant and animal communities? It contains a distinct flora and fauna, it does tend towards a dynamic internal stability and it does possess organization. Its distinctive feature is that its organisation and stability is achieved by means of inorganic, as well as by organic, components and processes. It is in fact the link between organic and inorganic natural phenomena. Soil may also be studied as a natural unit, that is pedologically, but it may also be treated as a distinct component, a unique community within the ecosystem, that is ecologically. The ecosystem is here defined as a functioning, interacting system, composed of one or more living organisms and their effective environments, physical, biological and cultural, considered capable of continued existence. Brookfield has stated that the ecosystem concept provides an alternative concept that does not exclude either man or his habitat, and does not necessarily involve any assumption of possible influences or determinist controls. Use of the ecosystem concept in relation to the subject matter of human geography, places man at the centre of our thinking, without in any way disregarding the whole environment in which he has his being. It permits us to consider and interpret the areal differentiation of phenomena involvingman, his works and the non-human

PHOTO 5

<u>Soil, Dirt, Earth</u> -- Call it what you will.

PHOTO 6

A Coffee Plantation Ecosystem -- Soil is obviously a most significant component of this ecosystem.



environment, but it does not demand that this should be the whole of our endeavour. It allows us to abstract process and differentiation.[3] The whole ecosystem is the seat of complex energy transformations based on photo-syntheses by green plants embracing the food chain and web relationships, and involving other functions of living matter such as respiration and transpiration, as well as the energy changes involved in inorganic reactions within the soil. These are of fundamental importance in the present context, since it is upon these that the whole concept of productivity is based. It is possible to measure man's role in the productivity cycle within the ecosystem which is a "closed" system. Is it possible to look at any phase of settlement, or region of settlement, as a closed system with a number of variables including soil?

The following statement by Ester Boserup does not provide a direct answer to the above question, but it is a useful contribution to any discussion of the problem posed. In a consideration of the conditions of agricultural growth, the author states that the very distinction between fields and uncultivated land is discarded and, instead, emphasis is placed on the frequency with which the land is cropped. In other words, it is suggested that we consider a continuum of types of land use ranging from the extreme case of truly virgin land, that is land which is never cropped, through land cropped at shorter and shorter intervals, to that part of the territory in which the crop is sown as soon as the previous one has been harvested. It is the intention, by this new approach, to provide the framework for a dynamic analysis embracing all types of primitive agriculture, those which proceed by cropping a single time, after which it is left fallow for a generation or more, as well as types of agriculture with continuous cropping of virtually the whole area several times a year.

Once the time-honoured distinction between cultivated and uncultivated land is replaced by the frequency of cropping, the economic theory of cultural development becomes compatible with the theories of changing landscape propounded by natural scientists. The fathers of the traditional economic theory - in agreement with the natural scientists of their own time - regarded as immutable natural conditions, many features which scientists now consider to be man-made and, in particular, the distinction between naturally fertile land and less fertile land was considered a crucial element in the agricultural change.

By contrast, when the analyses are based upon the concept of frequency of cropping, there can be no temptation to regard soil fertility exclusively as a gift of nature bestowed upon certain land, once and for all. Thus, soil fertility, instead of being treated as an exogenous or even unchangeable "initial condition" of the analysis, takes its place as a variable, closely associated with changes in population density and related changes in agricultural methods."[4]

The adoption of the concept of 'frequency of cropping' would undoubtedly be most beneficial, however, in any consideration of the potential for change, especially greater frequency of cropping, the analyst should not overlook the indigenous cultivators' awareness - or ignorance - of the actual, rather than the supposed, potential of the soil for increasing the frequency of cropping.

CHAPTER 3

SOILS AND POPULATION DISTRIBUTION

The major objective of this brief chapter is to raise questions rather than to provide answers. One major question has already been asked, that is - what is the significance of soil in explaining population distribution at scales ranging from the world, to a small coral limestone island, such as Barbados, or a savanna of 5,000 square miles.

Ackerman has stated that:

> "men are to be found in numbers only where there is a supply of fresh water usable through the techniques with which their culture has armed them; in mature agrarian civilizations numbers are a function of the amount of level land in combination with the amount of water available, for the industrial cultures numbers of people probably have a calculable direct relation to the amount and quality of industrially usable minerals available to an area".[1]

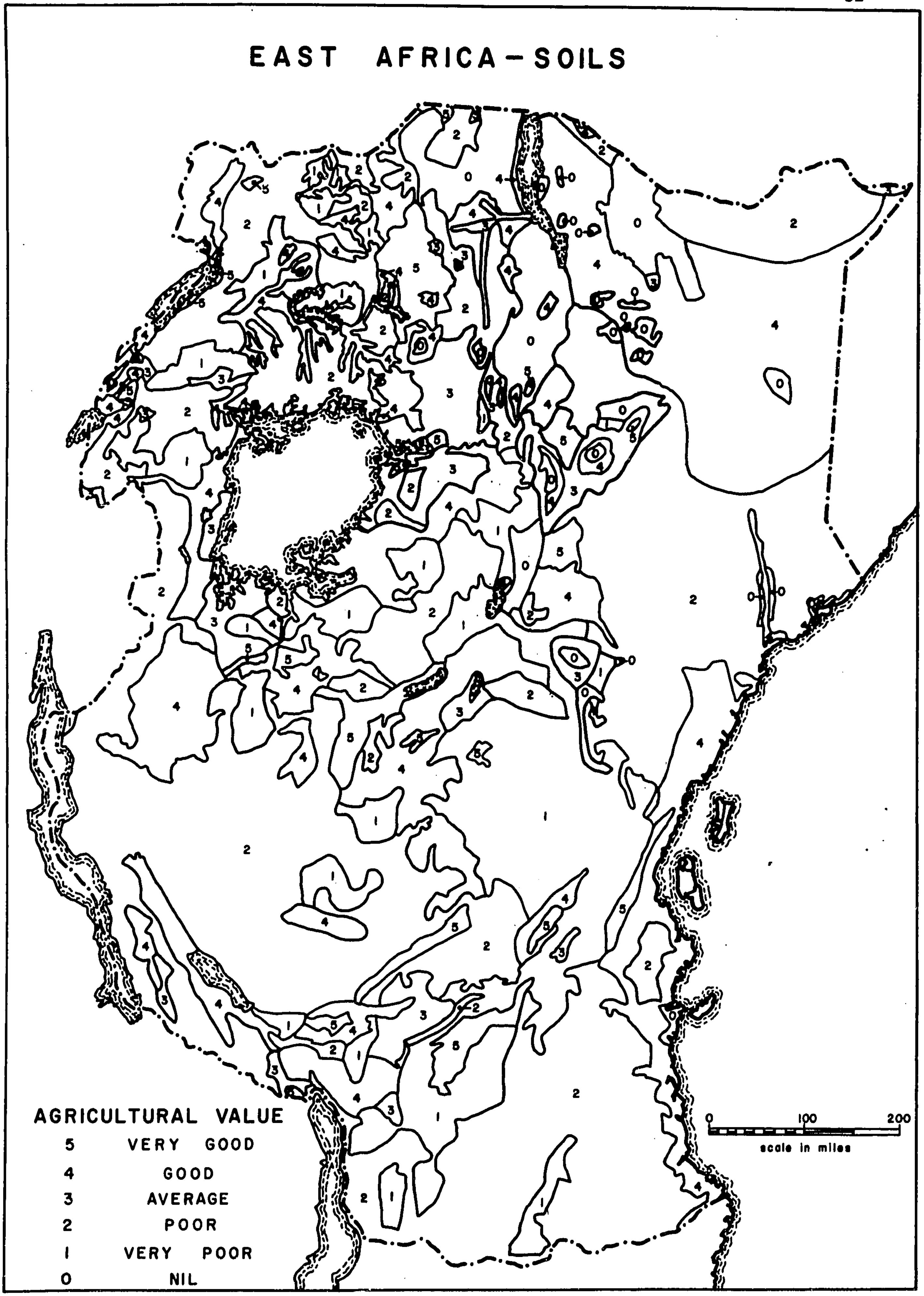
Where do soils fit into this picture? John I. Clarke states that:

> "Like any other factor of the physical environment soils are difficult to isolate as an influence upon population distribution, but their influence is undeniable ... We shall also remind ourselves that the attractiveness of soils depends upon man's agricultural interests and techniques".[2]

Looking at the continent of Africa, Kimble has concluded that:

> "the grass population map of tropical Africa - taken in its entirety - is not strictly comparable with any other distribution map for the region...Attempts to show close connections between population density and soil quality have likewise been a little disappointing.... Generally speaking, the full discriminatory influence which soil fertility can have on the distribution of population is felt only where permanent agriculture of the European type has been developed."[3]

These three statements should serve to illustrate the hazards inherent in calling upon soils to explain gross or even detailed population distribution patterns. How far would soils explain the distribution of the population in East Africa? Peruse the following map.


EAST AFRICA - SOILS
AGRICULTURAL VALUE
5 VERY GOOD
4 GOOD
3 AVERAGE
2 POOR
1 VERY POOR
0 NIL
0 100 200
scale in miles

CHAPTER 4

SOILS AND THE GEOGRAPHER

Soils and man/soil relationships have long been a concern of the geographer. Elementary pedology is included in the training of most geographers. Most regional courses include the presentation of material on the soils of the region and, especially, on the relations between soils and crop distribution. Texts on soils, elementary and advanced, and soil reports of the local region, one's own country and other countries of the world, are usually found on the library shelves of most geography departments. Any geographer conducting studies of a region, land use, rural settlement or agriculture, hopes that a soils report exists, otherwise he is likely to sample soils on a limited basis and send them off for analysis.

In more recent years the geomorphologist, the climatologist and the biogeographer have looked more closely at soils, with the result that the geographer has made a significant contribution to the general study of the ecology of soils, or the relations between soils and vegetation or land use. For a useful example and a good bibliography, see the paper by R. P. Moss on "Soils, Slopes and Land Use in a part of Southwestern Nigeria". [1]

Geographers have otherwise written about soils and man/soil relationships in the following types of contexts:

1. Soils and their geographical significance

    - as treated by Huntington, Semple, Taylor and other 'environmental and 'stop-and-go' determinists.

2. Systematics treatments

    - as found in most introductory texts. No advanced text on soils has yet been written by a geographer.

3. <u>Soils in regional studies</u>

   - these tend to vary according to the available detail on soils, the emphasis in the study and the geographical philosophy of the author.

4. <u>Land use and land classification studies</u>

   - geographers have become involved in such studies, especially since the early 1930's, as conservation and planning programmes have become the vogue. Since the end of World War II, geographers have become heavily involved in such studies in tropical areas.

5. <u>Agricultural and/or agrarian studies</u>

   - probably more attention has been given to soils in this type of study than in any other type.

6. <u>Settlement studies</u>

   - in historical geography, pioneer fringe studies, settlement prospects, settlement patterns, etc., have also called for a great deal of attention to soils.

7. <u>Terrain analysis</u>

   - a recently developed field of investigation among geographers which has called for detailed attention to soils.

8. <u>Location Theory</u>

   - in many locational studies, substantive and/or theoretical soil becomes a 'factor'.

9. <u>Population distribution</u>

   - the significance here is obvious and will be discussed in more detail later

10. <u>Medical ecological studies</u>

   - have increasingly turned to soil, and man's use of it, as an important ecological variable.

In all of these studies, the attention given to man/soil relationships and especially to attitudes to, and perception of, soil will largely depend upon the individual geographer's viewpoint on the more fundamental philosophical issue, that of the nature of man/land relationships.

If the geographer, or any other social scientist for that matter, provides an explanation in terms of physical environmental dominance, or of environmental determinism, that is if he considers that the physical, natural, or geographic, environment hasdetermined, controlled, or ordered human action and living which are passively submissive, then he would no doubt place no value on a knowledge of man's attitude or or perception of soils.

If his geographic viewpoint is that of man adapting to nature, the emphasis is upon the limits set by the physical environment in which man may choose possible courses of action by way of response or adjustment to them. There is no suggestion of man changing the physical environment, but rather of being at liberty to choose between a wide range of physical environmental possibilities and he may at times make the wrong choice.

The idea of landscape harmony, where the emphasis is upon ecological balance, is another viewpoint and one in which man is credited with a recognition of the best ways of acting in co-operation with physical resources.

The point of view that man modifies the earth's surface has long been of concern to geographers. Brunhes has defined geography as the description and analysis of the result of the work of men, considered as geographic agents, as actors modifying the surface of his planet.[2]

The final point of view is that of cultural dominance or cultural determinism; the view that man's actions are determined by his culture rather than by the physical environment. Emphasis is placed upon cultural ideas and values and social organisations which lead to the origin, development, persistence and use of certain behaviour patterns and technology. This point of view is very close to what Saarinen has designated 'cognitive behaviorism' and which he states:

> "assumes that a person reacts to his milieu as he perceives and interprets it in the light of his previous experience."[3]

In initiating any discussion or consideration of the above points of view, it is important to establish that the oft-used expression 'man/land' relationships, is so abstract as to be virtually meaningless, unless the phrase is fully explained. Land, a term often used synonymously with nature, natural environment, the earth, the physical setting, etc., refers to the whole complex of the physical and biological environment. The significance of any element of this environment will vary greatly from one location on the earth's surface to another. The significance of soil, physically and biologically, is less in the Canadian Arctic and subarctic than in Barbados or the Netherlands. Obviously, the significance of soil to man, and man's awareness of soil and its uses and qualities, will vary according both tothe physical extent of soil and with man's numbers.

In viewing man as an agent of change, it is necessary always to appreciate that 'man' refers to that unique biological being that possesses culture. He is capable of studying and learning from the past. He is able to work in groups and communicate with his fellows, present and future. Dominant factors of the physical and biological environment or restrictions of habitat are overcome or modified by culture. What becomes a natural resource depends upon the culture through which a people view their environment and make their appraisal.

All the points of view summarised above, with the notable exception of 'determinism', would benefit from attention to man's attitude to, and perception of, the elements of his physical environment, perhaps more so in the case of 'cognitive behaviorism'.

An exceptionally useful conceptual framework in which to consider man/land relationships is that of the ecosystem. Fosberg's original definition of the ecosystem has been modified by the author (with Fosberg's permission) to read: the ecosystem is a functioning, interacting system, composed of one or more living organisms and their effective environments, physical, biological and cultural.[4] Brookfield stated of Fosberg's original definition:

> "use of the ecosystem concept in relation to the subject matter of human geography places man at the center of our thinking, without in any way disregarding the whole environment in which he has his being, it permits us to consider and interpret the areal differentiation of phenomena involving man, his works, and the non-human environment, but it does not demand that this should be the whole of our endeavour; it allows us to abstract process from differentiation."[5]

In arguing for the addition of 'cultural' to Fosberg's original definition, the author has previously stated that even though 'man' is encompassed by the definition, the 'biological' man is affected by his culture more so than any other element of the biological environment.

CHAPTER 5

SOILS AND THE SOCIAL SCIENCES

Devons and Gluckman, in the introduction to their most stimulating book entitled Closed Systems and Open Minds: the Limits of Naiveté in Social Anthropology,[1] made the following statements:

(i) "The most striking objects in the social field are the actions, the thoughts, and the feelings of the individuals, within a cultural and historical tradition in a physical environment in which they operate through material objects. Clearly the biological endowment of individuals and their personalities, both in general and in the particular variations, have important effects within the social field and the anthropologist has to study these effects."

(ii) "...problems arise when we consider the wider physical and biological environment within which men live; geographical position, topography, climate, soil and other resources, flora and fauna, endemic and epidemic diseases, all have an important effect on social life. Must the anthropologist delineate accurately the inter-relation between these phenomena and study climatological, ecological and other systems? Or can he again take these phenomena for his purposes, as simple, though he knows them to be complex?"

(iii) "The anthropologist may want to study a particular group or set of relationships or domain of activities, which is only part of a larger or more complex social field. How far is it possible to isolate these areas of the field for significant study? In this situation the incumbents of roles in the social relations study may occupy other roles in a whole series of relations. Must all be studied, to understand one? Since wider social systems in smaller areas of relations have long histories, far longer than the period which anthropological study investigates, how do we decide when to cut short our exploration of the past?"

(iv) "These are some of the problems which the anthropologist may meet in trying to isolate one aspect of reality for his own analysis and the aspects of analysis studied by other disciplines, or in trying to close off his own field of analysis from the rest of reality."

(v) "In our first planning of this book, we treated the various issues as coming under one general head: the problem of whether we had to be sophisticated or could afford to be naive, about both the events and the aspects of inter-relationships which bordered our field and method of study. We call this "the limits of naiveté", but early in our discussion we realized that we were dealing with several closely inter-related issues. First, any social scientist has to confine what he studies within certain limits: he cannot include the whole of complex reality. This limitation is vital if his study is to be manageable. Limitation can be of various kinds -- a limitation in time, space, or in the aspect of phenomena which is studied. With the limitation goes simplification, which also seems necessary in order to isolate what appear to be the essential features of the problem under examination. Within the field thus delimited and isolated, the social scientist assumes that there is a system of inter-relations which can be considered separately from the rest of reality. Such systems are, so to speak, "closed"....as well as using a "closed" system, the social scientist has to make assumptions about aspects of the phenomena which are studied by other specialists. These assumptions are often, and we argue, advisedly, naive."

Though the many problems posed in the above quotations were presented for the benefit of anthropologists, they should be of the greatest significance to all social scientists. What social scientist can ignore the actions, the thoughts, and the feelings of individuals? Which one can fail to appreciate the "limits of naiveté"? Many have, judging from the historians and economists who have ignored the physical realities of the environment in explaining the past course of events, or in producing models to predict the future course of events, and likewise the geographer who has ignored culture traits and the value system of the people he studies, and especially the perception those people have of their physical environment.

Devons and Gluckman quote Dr. Audrey Richards in Land, Labour and Diet in Northern Rhodesia in order to illustrate one of the problems of both abridgment and naiveté. They state:

"Dr. Audrey Richards in 'Land Labour and Diet in Northern Rhodesia' a masterly study of the Bemba social system in relation to production, distribution, and consumption of food, admits her lack of skilled knowledge of types of soil, agricultural methods, and so forth: but she stresses how important she considers these subjects to be, and how she therefore carefully recorded the Bemba's knowledge on these subjects. We here draw attention only to her statement (which wisely is vague enough), that '...because the land problem is not so acute in this area, as it is in many parts of present day Africa, we cannot conclude that there are no tribal rights as to its use...' This statement was made not as an abridgement of agricultural findings but as an assessment by an anthropologist and by the Bemba themselves; and the conception that the Bemba have "plenty" of land, must be accepted only in those senses. The Ecological Survey of Northern Rhodesia, published after Richards' book, emphasised that, under traditional systems of land usage, the area necessary to sustain a family of four in perpetuity might lie between 200 to 470 acres. In this sort of situation, the anthropologist should make clear that such statements as that 'there is an abundance of land' or (to quote Richards) that 'the land problem is not so acute...,' are made as statements without foundation in agricultural research. In the light of subsequent ecological and agricultural research, the apparent wide stretches of bush in Bemba country, probably concealed growing scarcity in some provinces. Richards, in her analysis, discusses problems of land tenure as if a real abundance of land prevented disputes arising and in other ways affected social life: we do not know that her assumption was incorrect, but we cite this example to show how careful an anthropologist must be before building an argument on a "fact" which needs to be established by another science."[2]

Which science? The authors undoubtedly had in mind the science of ecology and "biological ecology", not "sociological ecology". However, the "ecology" that Gluckman and other social scientists came to know in Africa in the 1940's and to benefit from, to a very considerable extent, was a particularly enlightened ecology. As Gluckman, in the foreword to W. Allan's book on The African Husbandman,[3] states:

"in the 1940's Northern Rhodesia (now Zambia) was fortunate in having in its Department of Agriculture a number of brilliant research men. Besides those working on the problems of farming, crops, and forestry, three of them worked on the margins of agricultural problems, where these involved social relations among the African people of the territory....Mr. Trapnell worked out a mode of classifying the soils on ecological characteristics which enabled the department of Agriculture to make fairly rapid classifications of suitability of different areas for different types of agriculture, and in addition he made analyses of the use of land in African agricultural systems and of the amount of land different systems required. Here, Mr. Allan, the

Deputy Director of Agriculture, developed a method of calculating the carrying capacities in terms of population, of various indigenous and changing agricultural practices on different types of soils. Allan further formulated a mode of working out critical population density for different systems, a point beyond which the land would begin to deteriorate. This was a theoretical analysis of high practical importance. In making these analyses, Allan was led into investigating what people were dependent on, particular sets of land, as well as into investigating the social organization, distribution, and consumption of crops. He had to enquire into family and other forms of social structure, and into the effect on these of labour migration, useful forms of cash cropping. Trapnell was given the opportunity of classifying the soils on the basis of ecological characteristics, largely because a soil chemist in his government survey team was sacrificed during a period of retrenchment in the 1930's. Without the sacrifice, a detailed soil survey might have been undertaken and the agriculturalists might well have tried to rely upon it for their forecasts of land needs. As Allan stated 'it is not enough for the purposes of the field agriculturalist, merely to describe and name a soil type, or to assess its productivity in such general terms as nil, low, medium and high. This may well be regarded as an essential beginning but a good deal of experiment and experience is required to take the findings of soil science to the actual cropping potential of soils in the field. For example, we cannot assess with any certainty the response of soils to a certain fertiliser treatment simply by reference to analytical figures for available plant nutrients; and it sometimes happens that when a soil is in fact fertile, given suitable climatic conditions, when according to the description and chemical analysis one would expect it to be very poor.' However, Allan does not deny the value of or the need for soil survey in field experiment, indeed the lack of such data and the lack of such scientific services was felt as a severe handicap to the ecological work. The basic conception behind Trapnell's survey was that in an underdeveloped country, the study of vegetation in relation to soils, climate soils, and other environmental factors, and the classification of plant associations in accordance with these factors,should provide the most practical single guide to agricultural and forestry potentialities. To Trapnell and Allan the ecological method of distinguishing vegetation -- soil types -- had the advantage that the land units distinguished in this way could be related fairly readily to African traditional knowledge and practice, and to quote Allan 'for this purpose, ecological criteria have the great advantage that the units they define are recognizable to the African and they enable us to see the habitat through the eyes of the inhabitants and to understand its potentialities and limitations for a people with no material resources but the hoe, the axe, and the labour of a small group of workers.'" 4

However, Richards, in the early 1930's, was unable to refer to the published works of ecologists and pedologists, nor can many social scientists working in both underdeveloped regions, and some developed regions, of the world today. There are settled parts of southern Quebec in which there has never been a soil survey. In many underdeveloped regions, social scientists are still having to make assumptions as Richards did, but one would hope, with less risk.

The field research and published results of a number of archaeologists and anthropologists working in and around the Amazon basin, again raises questions about assumptions, abridgment and naiveté. Meggers[5], an archaeologist, has proposed the figure of 1,000 as the upper limit for settlement size in the rain forest of the Amazon, because of the dependence of the economy and culture upon slash and burn agriculture, the nature of which is attributed to rapid soil exhaustion. Many others similarly assert that the technique of slash and burn leads to migratory shifting agriculture, because it is impossible to maintain villages in the same location for more than a few years. Carneiro refutes this assertion and states that:

> "we see therefore that the mere fact of practising shifting cultivation does not necessarily prevent a society from maintaining an essentially sedentary community."[6]

He later states:

> "the successive clearing, planting and abandoning of adjacent areas of the forest, is therefore a factor in bringing about periodic village re-location, but to say without further qualification that soil exhaustion caused the village to be moved, would obviously be a misleading over-simplification....a variety of factors, capable of affecting settlement patterns must be known in some detail before we can be sure of why any particular society has moved its village. Lacking this information we are not justified in assuming that the village must have been moved because of soil exhaustion."[7]

Carneiro firstly seeks an answer to the problem of exhaustion of soil fertility. He suggests that the experimental evidence available to us today does not support the explanations of shifting agriculture based upon rapid exhaustion of soil fertility, and he suggests that:

> "since this evidence has appeared in the sources generally unfamiliar to anthropologists, it seems worthwhile to cite some of it here".[8]

He firstly reviews results from the United Kingdom and Missouri, but he is not slow to point out that this work was undertaken in temperate, not tropical areas. He then continues with a discussion of experimental evidence from Southern Nigeria, the island of Viti Levu, Fiji, and Central America, and comes to the conclusion that:

> "we see that the abandonment of a plot after a brief period of cultivation can best be understood, not as a necessary consequence of rapid soil depletion in the tropics, but rather as the most economical way of carrying on subsistence farming under the prevailing conditions of technology and environment".[9]

There is good reason to suspect, and in fact, an increasing amount of evidence suggests that tropical soils vary as much as sub-tropical and mid-latitude soils, so that in some respects it was a naive assumption on the part of Carneiro when he uses evidence from southern Nigeria, Fiji and Central America, in order to interpret conditions in the Amazon Basin. There is no absolute proof that he is entirely wrong but there is evidence that his assumptions may have been somewhat false.

Devons and Gluckman asked the question - "Must the anthropologist delineate accurately the inter-relation between these phenomena and study climatological, ecological and other systems? Or can he again take these phenomena for his purposes, as simple, though he knows them to be complex?" One of the most effective and component responses to this question is the employment of the 'ecosystem' concept by Clifford Geertz in Agricultural Involution - The Process of Ecological Change in Indonesia.

In reference to environmental determinism and possibilism, Geertz has stated that:

"The undeterminacy on either side here actually stems from a serious conceptual defect the two approaches share. Both initially separate the works of man and the processes of nature into different spheres - 'culture' and 'environment' - and then attempt subsequently to see how as independent wholes these externally related spheres approach attempts to achieve a more exact specification of the relations between selected human activities, biological transactions, and physical processes by including them within a single analytical system, an ecosystem".[10]

"As one specifies more fully the precise nature of a people's adaptation from the geographical side, one inescapably specifies, at the same time and to the same degree, their adaptation from the cultural side, and vice versa. One delineates, in short, an ecosystem within which certain selected cultural, biological and physical variables are determinately interrelated, and which will yield to the same general mode of analyses as ecosystems within which human organisms do not happen to play a role". [11]

Geertz discriminates between two different sorts of ecosystems, with two different sorts of dynamics - one centering on swidden agriculture, one on wet rice agriculture - in terms of which the striking differences in population density, modes of land use, and agricultural productivity of Inner and Outer Indonesia can be understood. He characterises swidden agriculture as:

"multicrop, highly diverse regime, a cycling of nutrients between living forms, a closed-cover architecture and a delicate equilibrium",[12]

and the system as:

"on open field, monocrop, highly specialized regime, a heavy dependency on water-borne minerals for nutrition, a reliance on man-made waterworks, and a stable equilibrium".[13]

CHAPTER 6

PERCEPTION - in the Social Sciences, Geography, and of Soils.

Most of the significant work in the above fields is to be quoted from and discussed in subsequent chapters. For that reason, contributions to the field of 'perception of the environment' will only be classified and briefly surveyed at this stage. A few contributions, not discussed to any extent in subsequent chapters, will be given closer attention.

Of very considerable value to any survey of the literature on perception, especially in geographical studies, are recent works by Saarinen[1] and Lowenthal[2], both of whom have previously made significant contributions to the social scientist's understanding and appreciation of 'environmental perception and behaviour'.[3]

The discussion and bibliography in Saarinen and Lowenthal adequately covers the contributions in the social, physical and biological sciences, and to a certain extent in the humanities. As Lowenthal states:

> "The authors here represented (in Environmental Perception and Behaviour) go beyond geography's traditional forays into mathematics, economics, geology and astrophysics, to enter the equally difficult but fruitful fields of metaphysics, behavioral psychology, the history of ideas, social anthropology, and architecture".[4]

Saarinen gives attention to social and development psychology, psychoanalysis, anthropology, sociology and psychiatry. In concluding his survey of the relevant literature in the behavioral sciences, he states that there is an increasing trend to research in perceptual studies and that the reason for it is that perception is a 'key concept' in understanding man's adaptation to his physical and social environment.[5]

Both Saarinen and Lowenthal have been at the centre of the geographer's recently developed concern for perceptual studies. This 'concern' is again summarised most ably by Saarinen as an introduction to his substantive work in Perception of the Drought Hazard on the Great Plains.[6] The following would appear to be the most important conclusions of that summary. Firstly, it is clear that concern over perception of the environment and its components, physical, biological and cultural, is not entirely new in geography. Geographers and not only cultural geographers, have long been concerned with perception under the expression 'cultural appraisal'. Saarinen makes special reference to the works of Alexander Spoehr[7], Clarence J. Glacken[8], David A. Hill[9], William Kirk[10], Max Sorre[11], David Lowenthal[12], Yi Fu Tuan[13] and Joseph Sonnenfeld[14] among others. Although many of the above geographers were in fact trying to draw attention more specifically to either the concept of the behavioral environment or the present conception of perception in geography, many geographers both in North America and elsewhere have tended to classify the work of Lowenthal, Tuan, Sonnenfeld and Saarinen, merely as cultural appraisal. Secondly, Saarinen makes it clear that the 'conception of perception in geography', is important in all geography where man is involved. Lowenthal conveys this notion clearly in stating:

> "My epistemological inquiry ... is concerned with all geographical thought, scientific and other: how it is acquired, transmitted, altered, and integrated into conceptual systems; and how the horizon of geography varies among individuals and groups".[15]

Tuan supports this view in stating:

> "The patience of a geographer may be strained by the study of attitudes that appear at times only distantly related to direct terrestrial expressions. But the humanistic study of attitudes demands and repays the same attention we give to the scientific analysis of physical processes. Both approaches lie at the fringes of geography; yet neither can be ignored if we aspire to a catholic appreciation of the earth and its tenancy by man".[16]

Thirdly, geographers have been concerned with 'perception in resource management' and it is in this work that one finds some of the few references to perception of soil, e.g. J. Blaut[17], Peter R. Gould[18] and Philip W. Porter[19]. For example, Blaut asked the question:

> "To what extent do Mt. Chester (Jamaica) farmers perceive soil erosion and its effects?"

Blout went on in farm interviews to investigate the typical 'belief-systems' of the peasants. He discovered that soils were thought of as 'strong', 'fat', 'weak', that they had 'juices'[20]. Blaut had an anthropological background and he worked in the field with anthropologists which, in part, explains his concern with 'perception'.

Fourthly, Saarinen surveys the recent attention to the perception of natural hazards and especially the work of Gilbert F. White[21], Ian Burton[22] , Robert W. Kates[23] and others.

Finally, the debt to other social scientists is acknowledged. At this stage, the author would like to select from Saarinen's references for special acknowledgement, the contributions made to the development of what is really the 'perception' parallel in anthropology, that is ethnoecology, by Conklin[24] and a very early fore-runner, Bronislaw Malinowski[25]. The ethnoecologists have been concerned with what people believe to be their own resources and with the concepts of commensuration. Conklin's recent contribution will be discussed at greater length in Chapter 13. The following quotation from Malinowski provides some measure of his very early contribution to the field of ethnoecology, and to our understanding of the perception of the environment by tropical cultivators:

> "In order to appreciate this mythological cycle of ideas, we must keep in mind the relation of magic to

practical work as this is conceived by the natives. The short myths of first emergence have in the Trobriands a very close connexion with magic, since this latter has always been brought by the ancestors from underground (Ch. XII, Sec. 1). The gift of fertility bestowed by the mythical founders and wielders of magic on the richest districts of that region is without exception conceived in a two-fold manner, magical and natural. The natives realise that on sandy, brackish and stony soil neither yams nor taro, and still less taytu, could ever grow. If you ask whether one could start any plantation or garden on the precipitous slopes of the Amphletts, on the barren sands of the Laughlans or on the windswept, brine-drenched fragments of the Lusançay atoll, they will answer, no, and explain why most plants cannot thrive there in perfectly reasonable, almost scientific language".[26]

"They have a sound knowledge of the soil and of the crops; in fact they distinguish between six or seven types of soil and know well which variety of crop is best adapted to swampy, heavy soil, to black humus, and to the light and stony ground of the dry regions. Thus, although there is no word corresponding to 'waste land', the natives know and can explain that no garden is possible on coral stone".[27]

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CHAPTER 7

THE THESIS

THE MAJOR OBJECTIVE OF THIS THESIS IS TO INVESTIGATE THE ROLE OF SOILS IN THE PROCESS AND PATTERN OF SETTLEMENT IN SELECTED AREAS OF BOTH THE MID-LATITUDES AND THE TROPICS, AS A MEANS OF TESTING A VARIETY OF HYPOTHESES USED TO EXPLAIN THE NATURE OF THE RELATIONS BETWEEN SOILS AND MEN. SPECIAL ATTENTION IS GIVEN TO THE SIGNIFICANCE OF A PEOPLE'S KNOWLEDGE, ATTITUDES TO AND PERCEPTION OF SOILS IN TRYING TO EXPLAIN RELATIONSHIPS WHICH VARY WITH THE PROCESSES OPERATIVE, PHYSICALLY AND CULTURALLY. IN THAT MISCONCEPTIONS ABOUT THE PHYSICAL NATURE OF TROPICAL SOILS HAVE PLAYED A MAJOR ROLE IN MID-LATITUDE MAN'S INTERPRETATION AND EXPLOITATION OF THE TROPICAL ENVIRONMENT, THE DEVELOPMENT OF THESE MISCONCEPTIONS WILL BE DISCUSSED.

INCIDENTAL TO THE MAIN THEME, LAND DIVISION WHICH IS A MANIFESTATION OF BOTH PROCESS AND PATTERN, WILL BE STUDIED IN THE HOPE THAT A COMPARISON AND EVALUATION OF SYSTEMS EXTANT IN BOTH THE MID-LATITUDES AND THE TROPICS WILL SUGGEST WAYS IN WHICH UNSETTLED LANDS OF THE DEVELOPING COUNTRIES COULD BEST BE SUB-DIVIDED FOR THE PROPER UTILISATION OF ALL RURAL RESOURCES AND FOR THE FULL BENEFIT OF ALL RURAL INHABITANTS.

PART II

P R O L O G U E

An investigation of the history of settlement and land utilisation in southern Quebec, both in parts of the St. Lawrence Lowlands and the Appalachians, provides the opportunity to analyse the process of settlement and to comment further on a number of the questions already raised in regard to the relations between soils and men.

More particularly, the Appalachian region will be investigated from the following points of view:

(i) The significance of soils in decision-making in the process of settlement.

(ii) The influence of the township survey system upon the possibilities of the proper selection and utilisation of soils.

(iii) Government land policy, in theory and practice, including road construction.

(iv) Attitudes to land and the perception of soil in the clearance of forest.

In the Lowlands, the organic soils have been selected for special attention because their relatively recent utilisation illustrates admirably how, under unique circumstances, that of organic rather than mineral soils, the availability of a management technique may well make all the difference between the development and the lack of development of 'neutral stuff' into the category of a resource.

CHAPTER 8

APPALACHIAN QUEBEC - THE ST. FRANCIS TO THE CHAUDIERE

Appalachian Quebec is to be investigated from both a regional and a topical point of view, so it is fitting that a physical setting be provided (also see Figure 3 and Photos 7 and 8).

From the southern boundary of that section of the St. Lawrence Lowlands lying between Quebec and Trois Rivières, there rises rather abruptly to the south, a typical section of the northern Appalachians. This disected upland region is traversed in a northeasterly direction by three distinctive ranges of hills, namely, from northwest to southeast, the Sutton, Stoke and Border Ranges. Averaging 1,800 feet in elevation, these hills reach a point of greatest elevation in Mt. Gosford (3,800 feet), a prominent peak of the Border Range. Between the ranges a series of distinctive upland surfaces have been reduced to a rolling and moderately steep relief. Numerous lake basins and residual knobby peaks are typical.

The two major drainage channels of the region, the St. Francis and the Chaudière, both south-bank tributaries of the St. Lawrence, have cut beyond the Sutton and Stoke Ranges to drain the north slopes of the Border Range. At the same time, they provide excellent routeways through the region from the St. Lawrence Lowlands into New England by connecting up with tributaries of the Connecticut and Kennebec rivers respectively. Two lesser rivers, the Nicolet and the Becancour, rise in the heart of the region and both have cut deeply into the upland surfaces of the Sutton Range to reach the lowlands. Sections of their valleys have proved extremely useful routeways, particularly in the earlier days of settlement, when

FIG. 3

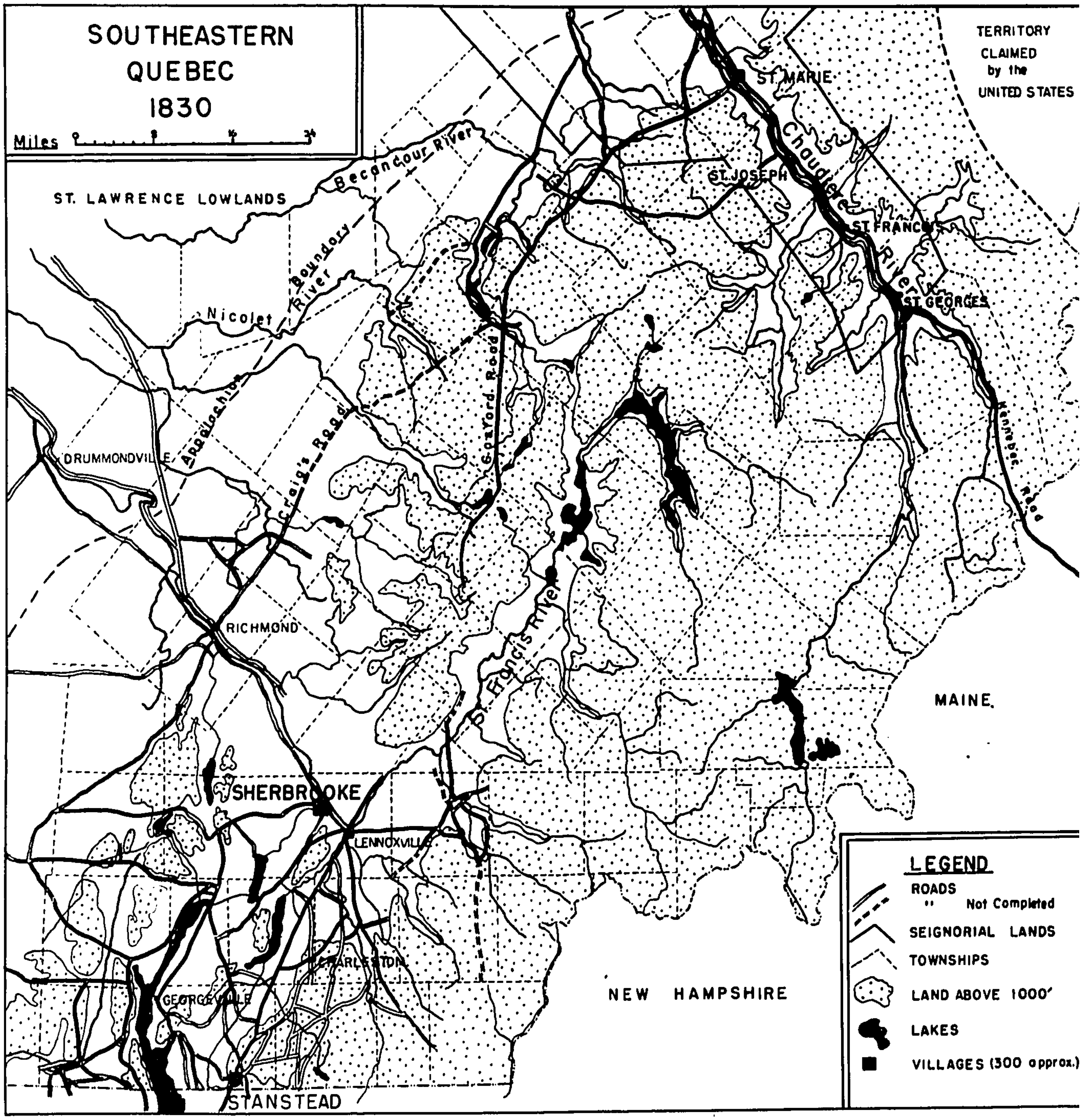

SOUTHEASTERN
QUEBEC
1830
Miles
TERRITORY
CLAIMED
by the
UNITED STATES
ST. LAWRENCE LOWLANDS
Becancour River
Boundary River
Nicolet
Appalachian
Craig's Road
Gosford Road
DRUMMONDVILLE
RICHMOND
SHERBROOKE
LENNOXVILLE
GEORGEVILLE
STANSTEAD
ST. MARIE
ST. JOSEPH
ST. FRANCIS
ST. GEORGES
Chaudière River
Kennebec Road
St. Francis River
MAINE
NEW HAMPSHIRE
LEGEND
ROADS
" Not Completed
SEIGNORIAL LANDS
TOWNSHIPS
LAND ABOVE 1000'
LAKES
VILLAGES (300 approx.)

PHOTO 7

Upper Chaudière Valley

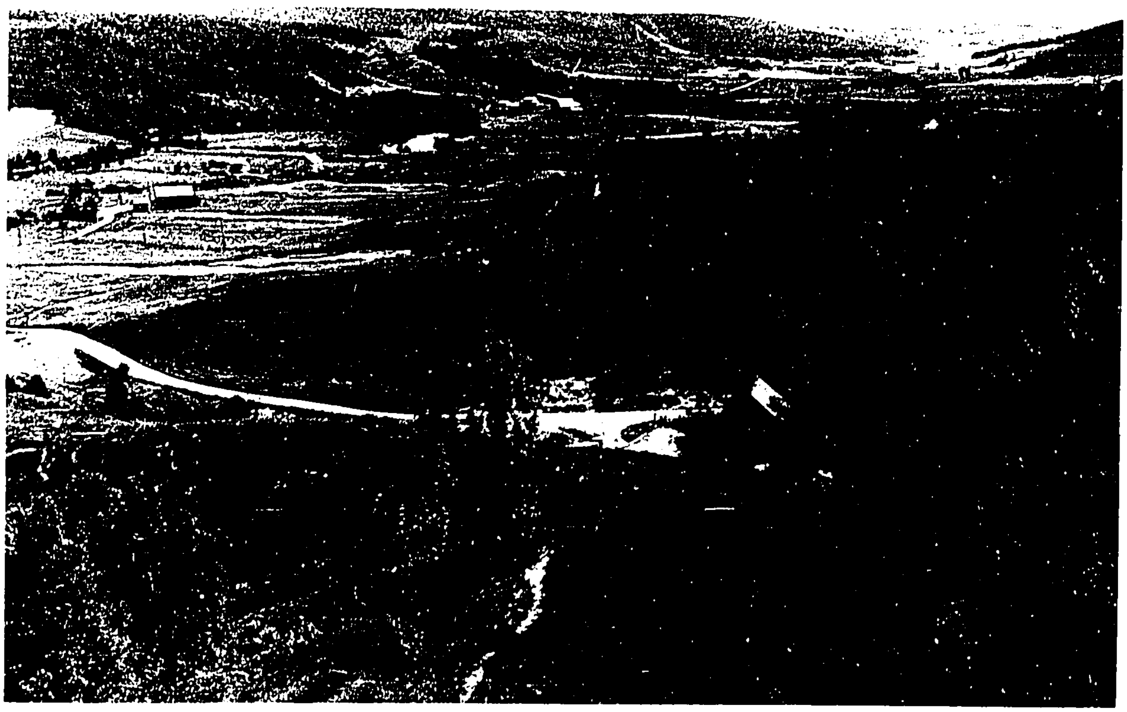


PHOTO 8

Typical Appalachian Upland Surface -- the Beauce Plateau

PHOTO 9

Greensboro Loam -- One of the best soils in the Eastern Townships.

settlers were moving south from the St. Lawrence Lowlands. These major rivers receive a large volume of water from their many tributaries, many of which have considerable fall and are thus ideal water power sites.

The whole of the area has undoubtedly been subject to glaciation and today the greater part of the area is covered with glacial till which varies in depth from a thin veneer to several hundred feet. Glacial outwash deposits are scattered along the valleys of the principal rivers and in several areas overlies lacustrine clay, which is often many feet deep. The latter deposits occur at the surface to a limited extent. In many of the river valleys, flat flood plains formed of fine and coarse sands are quite extensive and suitable for agriculture. The strongly rolling phase of most soils is very stony and on the high ridges outcrops and glacial boulders are common, often rendering the land entirely unsuitable for cultivation.

The soils of the region differ considerably in their productivity and in their suitability for the crops that have been grown in the region.[1] The Greensboro loams[2] are today the most extensively cultivated soils of the region. They are best suited to grain and hay crops, but will also produce fair crops of potatoes, corn and roots, thus it is possible to practise a more diversified rotation on these soils than on most of the others. This latter fact is significant in explaining the diverse, subsistence agriculture that was so typical of the earliest period of settlement. The light sandy loams that are so widespread are suited to potato growing in particular, but unfortunately potato growing has not always been restricted to these soils. During the heyday of potato cultivation, between approximately 1820 and 1840, many soil types were utilised regardless of their suitability.

In fact, throughout the first half of the nineteenth century, there was very little selection of soils by the average farmer. Generally, only the most accessible soils were cultivated. In the main river valleys, the accessible soils, though generally fertile, were suited to specific crops, rather than a diversified rotation. The sandy loams so suitable for potatoes were not the best soils for grain and hay crops, but because they tended to occupy the upland surfaces and ridges which were followed by many of the early roads, they were the most accessible and thus were among the most extensively cultivated.

For those settlers moving north from New England and particularly for those arriving from the British Isles, the climate of the region must have appeared extreme. However, the climate tends to be less extreme than on the lowlands, except in the higher areas to the east where winters can be much more extreme though summers are considerably cooler than those on the lowlands. Sherbrooke's annual daily mean is about 42°F with the warmest month July (67°F) and the coldest February (14°F). Lake Megantic, 700 feet above Sherbrooke, at 1400 feet a.s.l., has an annual mean about 38°F with a July mean of 64°F and a February mean of 11°F. High extremes can reach the mid-nineties and the lows -40°F. Sherbrooke has an annual precipitation of 38 inches with Lake Megantic about an inch more. The proportion during the growing season at each location is about 17%. The frost-free period at Sherbrooke is from about May 17 to September 28, while at Lake Megantic it is from May 22 to September 23. The average is about ten days shorter at the latter location.

The vegetation encountered by the earliest settlers was a mixed deciduous-coniferous cover, with maple, beech, grey birch and some elm dominant on the higher slopes and surfaces, balsam fir, old field birch, maple and occasional pine on the lower slopes, while in the poorly drained areas at all levels, hemlock, cedar, black spruce, tamarack, alder and willow were typical.

Settlement Pattern -- 1830.[3]

Prior to commencing the more detailed analysis of the settlement process, it would seem fitting to present a general picture of the state of settlement towards the end of the first fifty years.

A traveller journeying from Quebec to Stanstead in the year 1830 would probably have recognised several centres or foci of clearance and settlement, namely the Chaudière Valley, Megantic County, Shipton Township (east of Richmond), the St. Francis Valley (including the Drummondville settlement) and the Sherbrooke-Stanstead region. In all areas the cleared land rarely extended far beyond the colonisation roads, lakeshores and river banks. Even in the more advanced areas such as the Stanstead Plain, halves or quarters of townships were still held by speculators. Beyond these partly cleared areas there existed a densely forested upland terrain, across which were scattered but a few isolated forest clearings. All of these regions of settlement within southeastern Quebec could have been distinguished by any one or a number of landscape features. All the settlements were at different stages of development so that the state of forest clearance varied as well as the type and number of houses, farm buildings, mills, potasheries, etc. The dominance of one group of people or the other also influenced many features of the landscape.

Settlement on Stanstead Plain was about thirty years in advance of settlement in Megantic County so that the log cabin and tree stump cultivation so typical of the pioneer 'front' was not so typical of Stanstead Plain in 1830. On many farms in Stanstead County the greater part of the forest cover had been removed, stumps had already disappeared, permanent pasture had been sown, gardens and orchards developed and farm buildings erected. In Megantic County, particularly along the banks of the Becancour River, a considerable number of recently arrived settlers were sowing their first crops in rough clearings, living in tents and putting in what little spare time they had on the improvement of roughly formed roads.

The most striking contrast within the region, however, existed between the predominantly French-Canadian seigneurial settlements of the Chaudière Valley and the American frontier region within Stanstead and Sherbrooke Counties. Joseph Bouchette and other travellers in the region contrast the American frontier-style farm buildings and agricultural practices developed against the backdrop of a township survey, with the more mature seigneurial landscape so typical of the Chaudière Valley and of the greater part of the St. Lawrence Lowlands.

There is no doubt that the use of the township survey system within the Eastern Townships and the use of the seigneurial or long-lot survey system in the Chaudière Valley resulted, at least during the nineteenth century, in a contrasting pattern of forest clearings and settlement.

Of the settlers, the Americans were the dominant group, numbering approximately 16,000. Their settlements extended from the border, across Stanstead Plain, along the shores of Lake Memphremagog into the St. Francis Valley to the edge of the St. Lawrence Lowlands and north along the track that later became the Gosford Road into the heart of Megantic County. The flow of American settlers reached a peak in the year 1830 and rapidly decreased during the following two decades. Prior to 1800, commencing actually in 1783 when the first squatters appeared on Hall Stream, a branch of the Connecticut River, the settlers were predominantly United Empire Loyalists who entered rather surreptitiously, since the Canadian Government was at that time trying to direct them elsewhere in Canada. This early group of settlers had a significant effect on the development of the landscape of the region, for it was due to the pressure that they applied on the Government that there was included in the Constitutional Act of 1791 a clause providing that subsequent land grants in Lower Canada might be made in seigneurial tenure or in free and common soccage, the latter being the form of tenure to which they were accustomed.

From 1800 to 1830, southeastern Quebec was essentially an American frontier. The settlers moving north during this period were often described as Loyalists and have since been termed Loyalists by many historians, but the majority were typical frontiersmen in search of new land. Thus by 1830 one could trace in the landscape of the region, many features typical of American frontier settlements.

The French-Canadians in 1830 were the second group in the region, forming approximately a third of the total population. They were largely confined to the seigneurial settlements along the lower and middle Chaudière valley, but by 1830 they had begun to expand on to the western fringe of the Beauce Plateau and were at the same time entering the Bois Francs country from the rather densely settled Nicolet and Yamaska seigneuries. No permanent settlement was made in the latter region until 1832. A few French-Canadian families were living in the village of Sherbrooke in 1830, but there were none located in either Megantic or Stanstead Counties.

The Irish were the second largest English-speaking group, but though they had by 1830 advanced from the counties of Dorchester and Beauce in the northwestern part of the region, along Craig's Road and the Gosford Road into Sherbrooke County, their numbers were small compared to the Americans. However, they were particularly significant in aiding early French-Canadian settlement in the heart of the protestant communities of the townships. One of the many hindrances to French-Canadian expansion prior to 1830 was the difficulty of establishing and maintaining a Roman Catholic church in an English-speaking, protestant community, but once the church was established by the Irish Catholics, French-Canadians often followed. For example, one finds that in 1833, only ten years after Irish Catholics settled in Eaton Township, Sherbrooke County, several French-Canadian families arrived.

A fourth group, Scottish emigrants, had only just arrived on the scene in 1830. They settled in Inverness Township, Megantic County. Finally, small numbers of English and Scottish settlers were established in the St. Francis Valley by 1830.

It has already been stated that 1830 was the year in which the northward flow of American settlers reached a peak. Colonisation from the British Isles now became the more significant. This change was one of the effects of the war of 1812, for the government of Lower Canada now looked more to Great Britain as a source of colonists to bar the southward expansion of the French-Canadians.

Soils in the Process and Pattern of Settlement.

In the process of settlement, soils can be of significance at all stages, but probably more particularly at the following stages:

1. When the region is being looked at, or to, as a potential area for settlement, either from another region of the same country or, as was the case in the 19th century, from Europe.

2. When plans are being formulated for the opening up of the region for settlement and decisions are being made in regard to the most appropriate survey system.

3. When land policy is being formulated and decisions must be made as to the methods and means of the distribution of land; if land is to be sold, are soils to be considered in establishing values?

4. In advertising for, or at least in notifying potential or 'would-be' settlers, are soils mentioned and what is the foundation for the claims made?

5. When settlers reach the country or the region, do soils play any part in the decision-making that finally results in locating them? What is their own prior knowledge and understanding of soils and will it be of any assistance to them in selecting and developing their farm in a new land or region?

6. Once settlers have entered the region, what choice do they have? Are they provided with the opportunity of selecting the part of the region and the lot? Do they settle on the land in some organised manner, as in the seigneuries of the Lowlands, or do they travel along a colonisation road and select a lot at random?

7. If selection is possible within the system of settlement, what is the basis of the settler's choice? To what extent do local or regional preferences, or biasses guide the settler?

8. Once on his lot, how are soils managed? Does the settler select crops on the basis of the soils available?

How did Appalachian Quebec come to be considered as desirable for purposes of agricultural settlement, and did values placed upon the soils of the region play any part? The first impressions of, and ideas about the region no doubt came from contact with the Abenaki Indians, who were located, during the 19th century, on the lower St. Francis River valley. The Abenakis hunted and fished in the Appalachians and grew the occasional field of corn. What they reported about the corn yields is not documented, but many of the early works on the Eastern Townships refer to the Indians' corn growing so well.

The French Canadians settling in the seigneuries established in the Chaudière Valley in the mid-18th century, and the earliest American frontiersmen who crossed the border in the region of the upper Connecticut River system, were also sources of ideas about the soils of the region. Of course, the values they established were the result of experience on good alluvial terrace soils which, though significant in the Appalachian region, were not widespread. Reference has already been made to the French-Canadian expansion into the Bois Francs region, which corresponds to the piedmont zone between the north front of the Appalachians and the Lowlands.[4] There are some excellent soils in this region, and this, a few French-Canadian squatters discovered as they ventured away from the densely settled seigneuries to the north during the latter part of the 18th century.

These contacts were amongst the first and, no doubt, they resulted in some contribution to the general impression of the region that was now being established. Perhaps of even greater importance than the reports about the soils, was the general picture of the land presented and one in which the quality of the forest was most significant. As with travellers, settlers and others in many parts of the world, not only in the 18th and 19th centuries but also in earlier times and at the present day, the vegetation cover was taken to be an important indicator of the quality of the land. The magnificent hardwoods on the slopes of the Chaudière Valley, in the Bois Francs region, on the upland surfaces adjacent to Lake Memphremagog, and in the St. Francis Valley, suggested a very rich land to both settler and government official alike. So 'rich' in fact that Joseph Bouchette, for a time Surveyor General of Lower Canada, described, in his The British Dominions in North America (1832), the selection of flax as an initial crop because the soils at the outset were 'too rich' for the production of grain.[5]

Once the Government of Lower Canada decided to open the region to settlement, a region hitherto considered as a useful buffer zone between the Lowland seigneuries and 'Les Américains', a series of decisions had to be made. Firstly, and of the greatest importance, was the choice of a survey system.

According to the Constitutional Act of 1791, the granting of seigneuries was to continue, but provision was made for grants in freehold if the applicant so desired.[6] This opened the way for the adoption of a township system similar to that used in New England. The township granted in 'free and common soccage' has been described precisely by Bouchette:

Free and Common Soccage.

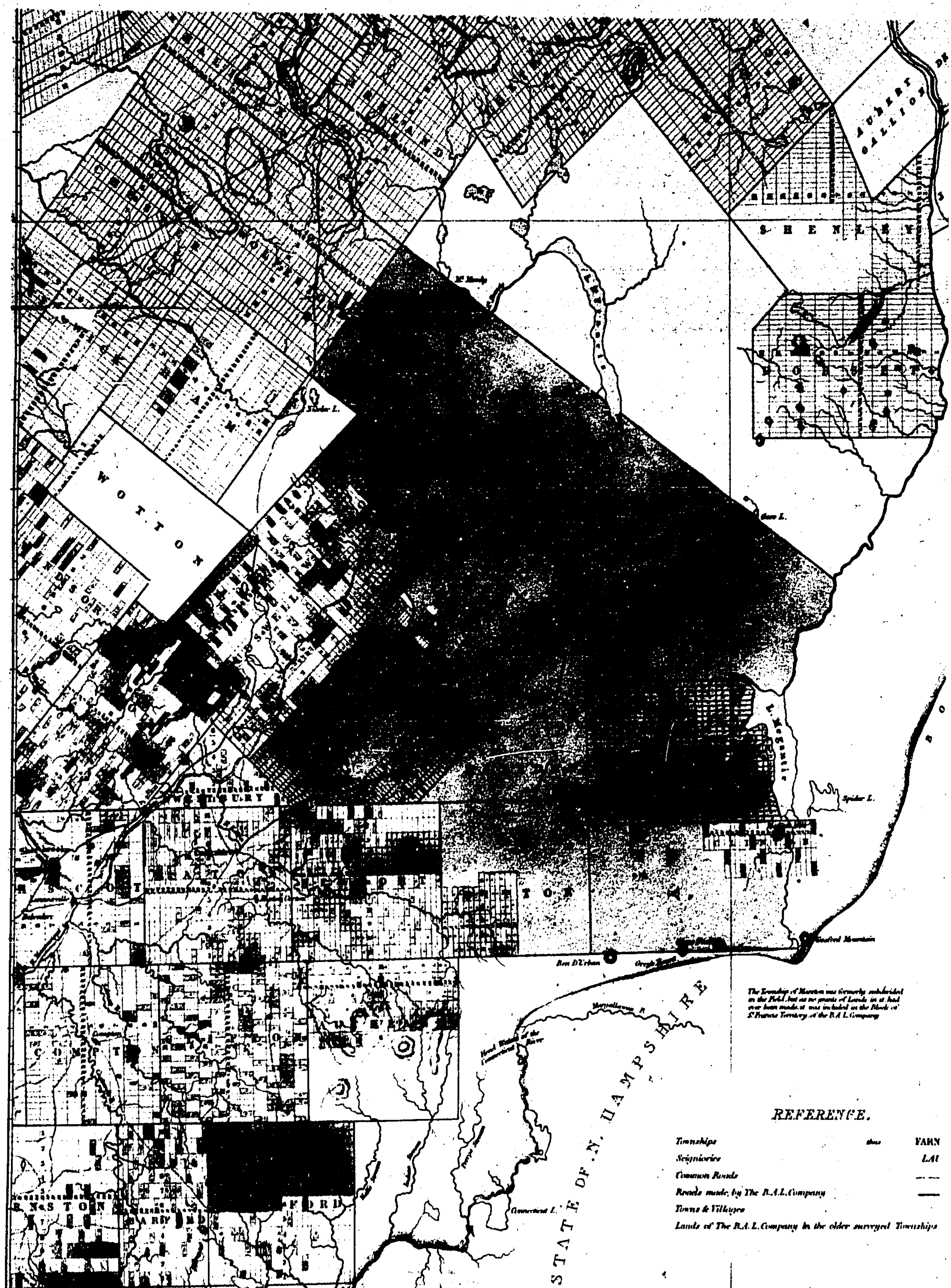
"The most exact content of ten miles square, the usual dimensions of an inland township, as prescribed by the warrants of survey, is 61,000 acres, exclusive of the usual allowance of five acres on every hundred for highways. This quantity is contained in a tract of 10 miles and 5 chains in length, by 10 miles 3 chains and 50 links in perpendicular breadth, or such other length and breadth as may be equivalent thereto. A rectangular township of this admeasurement contains eleven concessions or ranges of lots, each lot being 73 chains and 5 links long, and 28 chains 75 links broad. Each range is divided into 28 lots, so that each township contains 308 lots of 200 acres, with the allowance for highways. Of these lots 220 are granted to settlers and the remaining 88 reserved for the crown and protestant clergy. In like manner it may be observed, that the quantity nearest to the content of nine miles broad by twelve miles deep, the usual dimensions of a river-township, is 67,200 acres, exclusive of the allowance for highways. These are contained in a tract of 782 chains broad, by 969 chains and 60 links long or other equivalent length and breadth. A rectangular township of these dimensions contains 12 concessions or ranges of lots, each lot being 80 chains and 80 links long and 26 chains broad, and in each range 28 lots, making in all 336 lots of 200 acres, with the highways. Of this number 240 are grantable to settlers, and the remaining 96 are reserved as before mentioned."[1]

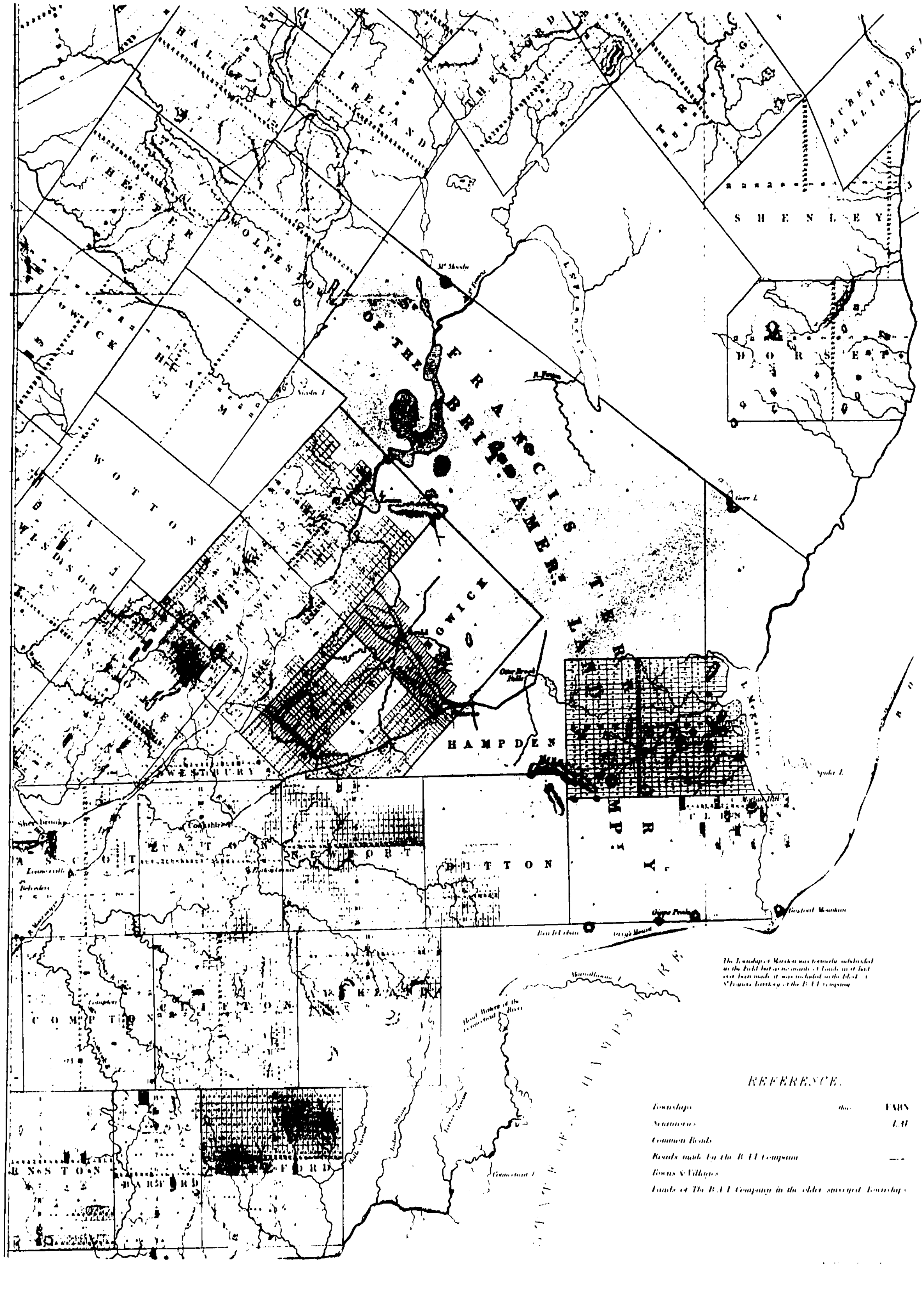
Norman R. Stewart has stated of rectilinear or 'checker board' type land surveys, that:

"as intellectual abstractions devised on drafting boards, such plans do not necessarily mesh with physical realities; nor do they make allowances for cultural predilection of human groups whose social fabric is closely woven around village life."[2]

Lynn Smith, an American rural sociologist, has long expressed views on the influence of survey systems and some of these will be discussed in Chapter 11. Meanwhile the following statement would appear to be most pertinent to the discussion:

"the system of survey used in land division practically sets the limits for and largely determines the possibilities in rural organization. Although the best system of land division cannot guarantee efficient social organization by itself, a poor system can effectually block the best effort....the familiar checkerboard system in which lands are plotted into squares: townships, sections,


WOTTON
SHENLEY
Spider L.
STATE OF N. HAMPSHIRE
REFERENCE.
Townships
Seigniories
Common Roads
Roads made by The B.A.L.Company
Towns & Villages
Lands of The B.A.L.Company in the older surveyed Townships


SHENLEY
DORSET
AUBERT GALLION
WOTTON
HAMPDEN
WESTBURY
DITTON
REFERENCE.

> and sub-divisions of sections has for the great majority of farmers resulted in holdings or farmsteads which form either a square or a combination of squares. No doubt this is a most convenient and efficient system of dividing lands for the purposes of surveying and recording, but not from the standpoint of the people residing upon the land. And, after all, it would seem that their desires and needs should far outweigh those of surveyor and recorder."[9]

It is not the author's objective to establish whether or not the township system was a good one under the circumstances, but rather to decide what scope it offered for the proper utilisation of soils. [For example of township survey pattern see Figure 4].

The following observations can be made:

(i) A system, such as the one adopted, could not take the nature or quality of land into account in determining township boundaries, except that the size of the sub-division could be varied according to need and to quality of the land especially the soils.

(ii) However, within a region such as the Eastern Townships, the order of surveying the individual townships could well be influenced by quality of land.

(iii) In the early stages of settlement, the order in which townships were surveyed and opened up for settlement was greatly influenced by the routes chosen for colonisation roads, and the primary function of these roads was not always colonisation. There were also military and trade considerations. In the first 40 years, that is until 1830, very few of the roads were influenced by the township survey. They almost invariably followed the upland ridges, often at elevations above 1500 feet. Even though the ridges were generally areas of stony, light soils, road construction and maintenance was easier than in the valleys, and here were

FIG. 4 (a)

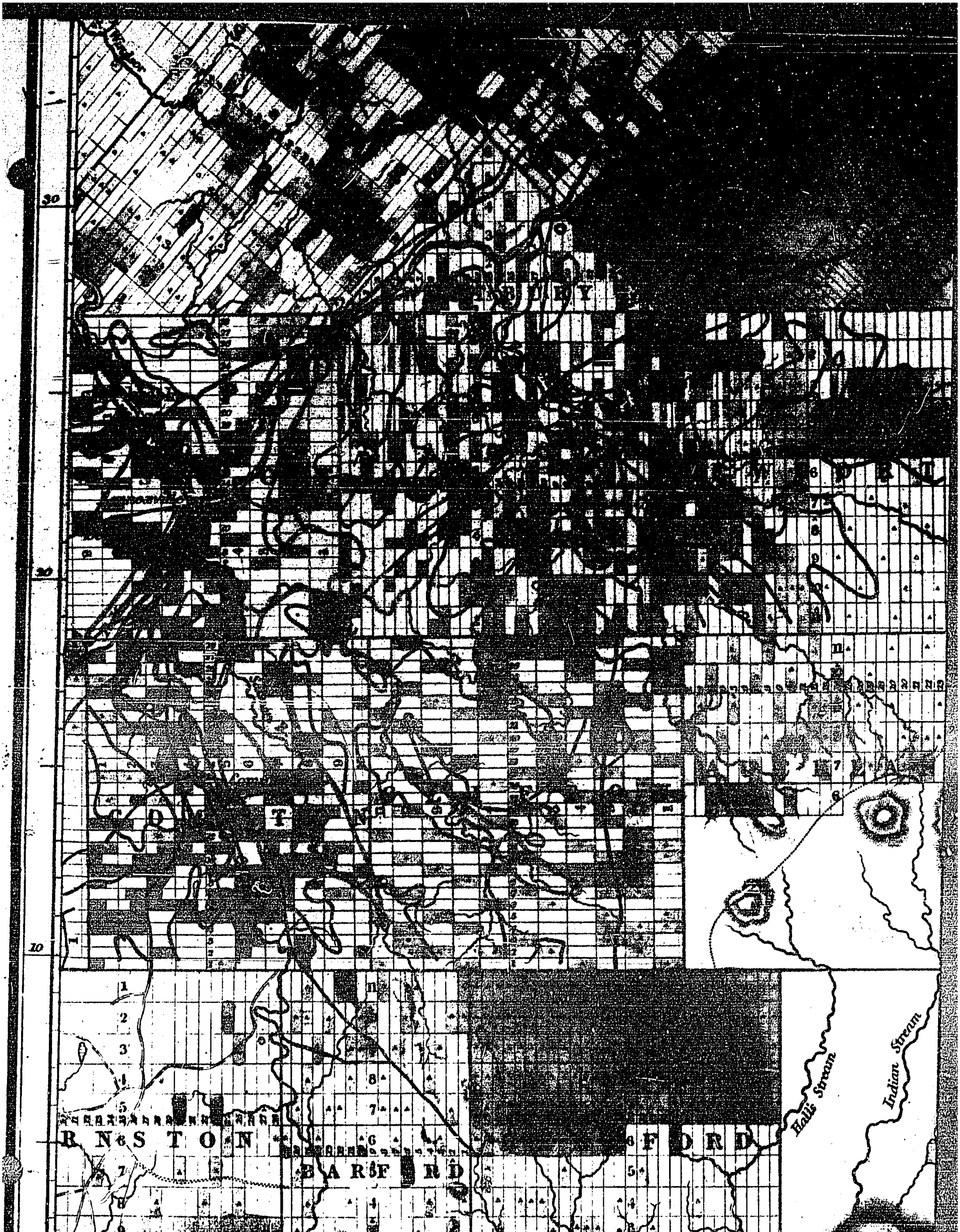
Soils and Settlement 1830

1. The lots coloured red have been occupied though only a part of each lot has so far been cleared i.e. of 1830.

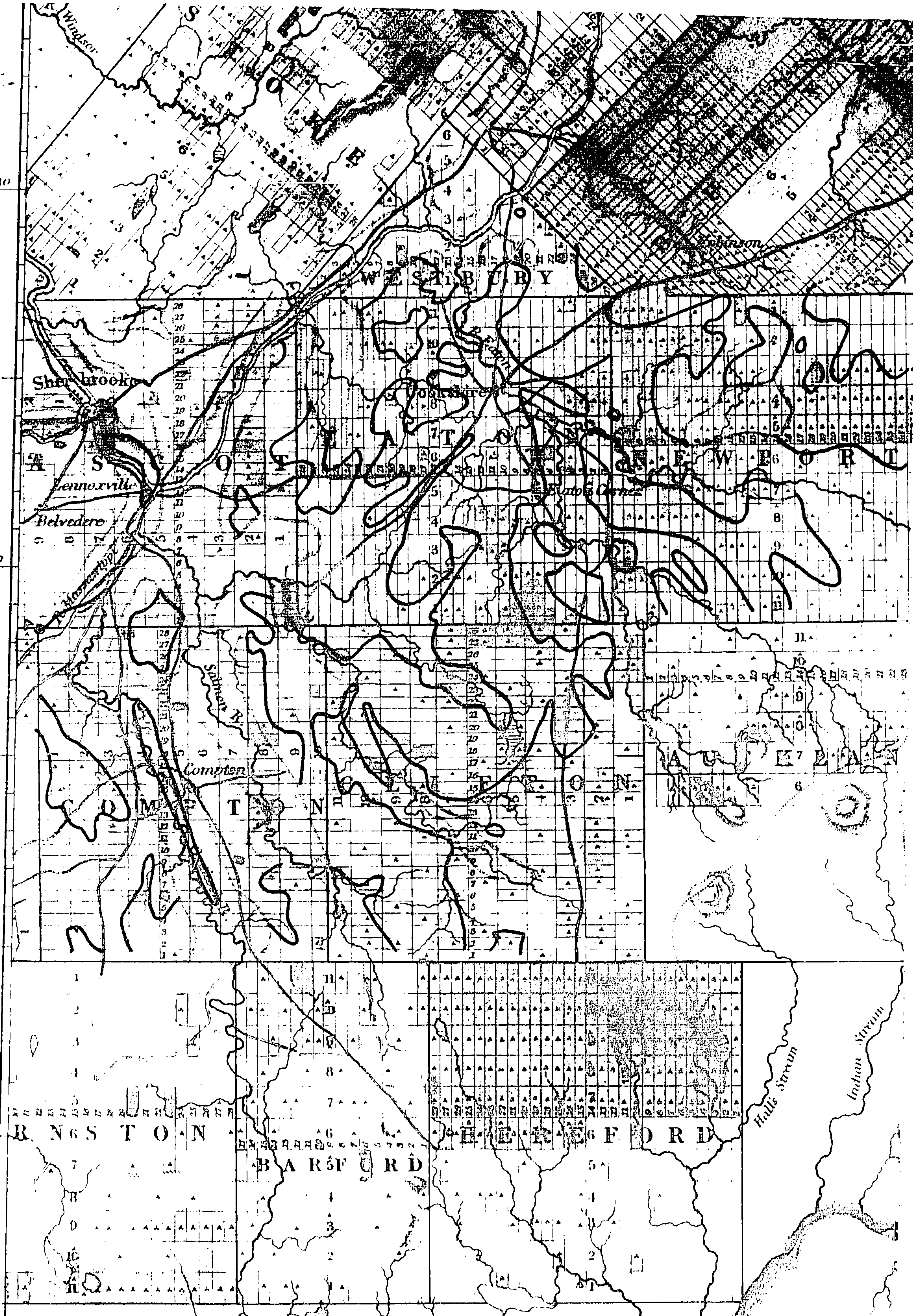
2. The red lines encircle areas of good, loam and sandy-loam soils. The black lines encircle areas of fair to good sandy and clay-loam soils.

3. The dark shading indicates lands owned by the British American Land Company.

4. The influence of the colonisation roads is obvious.



Hall's Stream
Indian Stream
BARFORD


Windsor
WESTBURY
Robinson
Lennoxville
Belvedere
Cookshire
Eaton Corner
NEWPORT
Compton
Salmon R.
COMPTON
AUCKLAND
Halls Stream
Indian Stream
BARFORD
HEREFORD

the best hardwood forests, source of potash and maple syrup, two of the mainstays of the early economy.

Figure 3 shows the distribution of the colonisation roads as of 1830. A study of the Censuses of 1825, 1831, and 1842,[10] indicates very clearly that the colonisation roads were a major influence upon the location of lots settled upon and cleared. See Figure 4a. The latter figure serves to introduce another important aspect of this discussion, that is the distribution of settlement up to 1830, in relation to the contemporary soil map. The reader is referred to the caption to Figure 4a.

Soil maps do not exist for the greater part of the Appalachian region, but the quality of the soils in these unmapped areas has been judged by the author in the following ways: (i) the collection of samples and their analysis, (ii) visual observation, (iii) reports of farmers, (iv) degree and extent of the regeneration of the forest cover.

The author once travelled the Gosford Road and the connecting colonisation roads, from south of Quebec City to Stanstead, close to the Quebec-Vermont border. He took journeys along some of the lesser colonisation roads that branched off along township and range boundaries. The major impression was one of a wilderness created by regenerating vegetation. This theme is one that has been described and explained frequently in literature on the Appalachian system of North America. Where farms are still operated, scenes such as those in Photos 10 , and 11 are typical. The continual piling of stones, brought to the surface by late winter and spring freezing and thawing, may well have put James and Joseph McVety where they are in Photo 12.

PHOTO 10

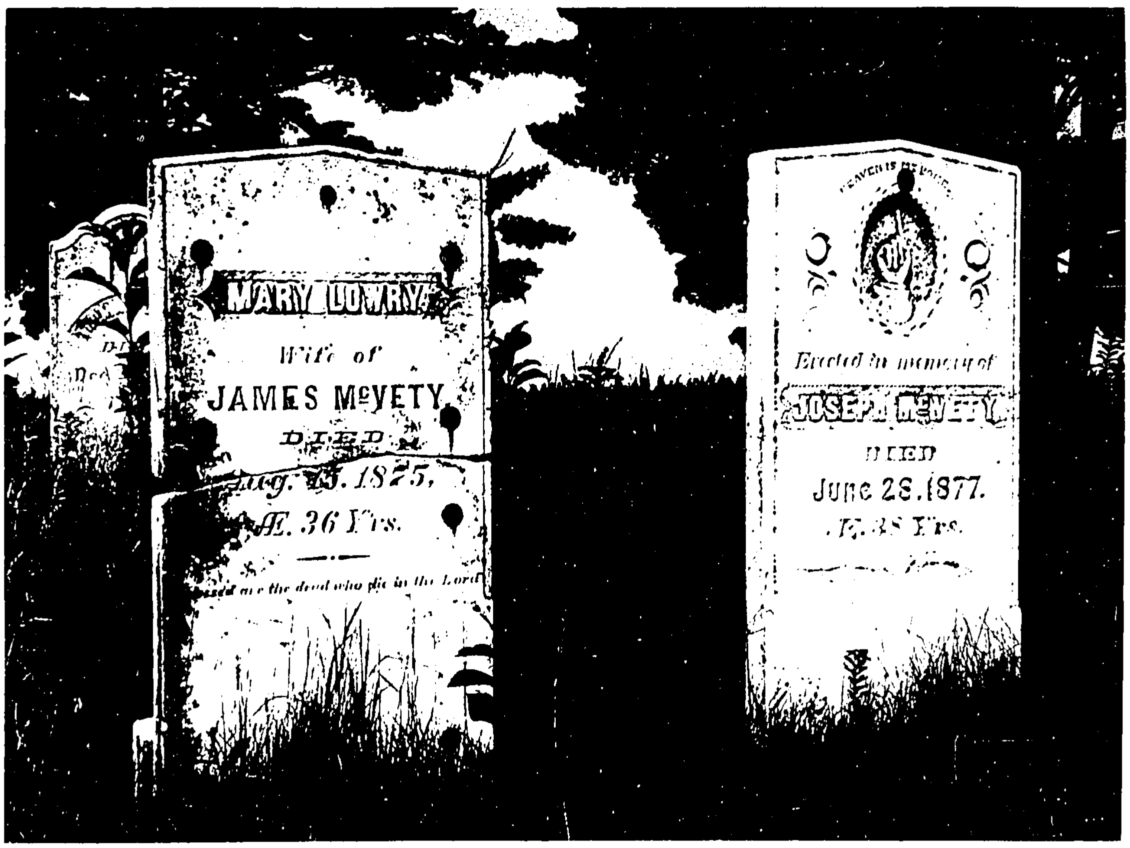
Soils Derived from Till

PHOTO 11

Never Ending Toil

PHOTO 12

The Consequence!


MARY LOWRY
Wife of
JAMES McVETY
DIED
Æ. 36 Yrs.
Erected in memory of
DIED
June 28. 1877.

(iv) Colonisation roads or 'range' roads -- it did not matter to the majority who had to make decisions regarding the allocation of lots within a township. The survey could not and never did allow for variation in the quality of soil. In a region of relatively uniform, medium to high quality land, the township survey would not restrict or limit man in the exploitation of, or adjustment to the soils of the region, but within a township survey on rugged terrain, such as that of the Appalachians, rational exploitation, given what knowledge there was of the soils of the region, was almost impossible. The irrationality of the process of settlement that developed, which encompassed and was limited by the township survey, resulted in the need for adjustment to the physical realities, especially the pedological realities, over a period of more than a century. In the landscape this adjustment took the form of abandonment of land, though not always of the entire farm, but subsequently in many areas entire farms were abandoned; the regeneration of the forest; the decline of villages and the complete disappearance of some with consequent depopulation. Photos 13, 14, 15, and 16 serve well to illustrate this typical Appalachian theme of abandonment of land and regeneration of the forest.

(v) The restrictions on rational settlement inherent in the survey were, in many respects, only the beginning. There were, in addition, the following restrictions which further reduced the amount of land available within which the settler could select his lot.

1. The crown and clergy reserves already referred to in Bouchette's cadastral description of the township. The Earl of Durham, in his famous Report, quotes from The Select Committee of the House of Commons on the Civil Government of Canada, 1828: [11]

PHOTO 13

Regenerating Vegetation -- In this and the following three photos, all the area was at one time cleared of forest.

PHOTO 14

Regenerating Vegetation

PHOTO 15

Regenerating Vegetation

PHOTO 16

Regenerating Vegetation

"these reserved lands, as they are at present distributed over the country retard more than any other circumstance the improvement of the Colony, lying as they do in detached portions of each township, and intervening between the occupations of actual settlers, who have no means of cutting roads through the woods and morasses which thus separate them from their neighbours."[4]

This complaint was repeated frequently and justifiably for several more decades. The Durham Report estimated that, of the 6,169,963 acres surveyed in townships in Quebec, 673,567 acres were reserved for the clergy.[12]

2. The Constitutional Act, 1791, stated that no one was to be granted more than 200 acres, but special instructions invested the Governor with discretionary power to grant additional quantities in certain cases, not exceeding 1,000 acres. In fact, many grants of from 10,000 to 50,000 acres were made. The means by which this was possible are discussed by a number of historians and others[13]. These sources approximate the total of various types of large grants as follows:

(i)	to executive councillors	--	75,000	acres
(ii)	to Governor Milne	--	48,000	"
(iii)	as rewards in 2 cases of high treason	--	100,000	"
(iv)	to officers and soldiers	--	200,000	"
(v)	to militiamen	--	450,000	"
(vi)	to 'leaders' of townships	--	1,457,000	"
	If we add to these totals the clergy reserves	--	673,567	"
	and the land sold by the Government to the British American Land Company	--	867,441	"
	we have a total of		3,871,008	"

It is not that all of this land was unavailable for settlement, but a high proportion was held for speculative purposes, and lesser proportions were idle because of abandonment in the case of many of the grants to soldiers and militiamen, and because of the failure on the part of many township 'leaders' to finalise arrangements for the allocation of land to settlers. Figure 4a illustrates the influence, at least in one area of the British American Land Company price policy. However, this company did aid settlement in several areas by the construction of roads, bridges, towns and the provision of supplies to settlers during the first years of settlement.

It can now be seen that the settlers who did approach or reach the region were extremely restricted by the amount of land available and accessible.

Knowledge of, Attitudes to, and Perception of Soils.

Given the restrictions and limitations of the township system within Appalachian Quebec, what opportunities existed for taking soils into account and, of those who were involved in the process of settlement, what did they know of soils?

Of the government officials, those who were most influential were the surveyors-general, the provincial surveyors and their deputies, the county commissioners and commissioners for internal communication. It is difficult to attribute to any one of the above a particular role or significance, but they were all in a position to influence the order in which the townships were to be surveyed and, in the case of the surveyors, their 'surveyors' notes' on the quality of land became significant both when the original township boundaries were surveyed and later when the individual township was subdivided.

One can assume that all surveyors were supposed to know something about soils, or at least about the quality of land. James Murray, Captain-General and Governor-in-Chief of the Province, handed down instructions regarding the procedure for the distribution of land which included a requirement that, when a request was made for land, the applicant had to prove that he could undertake the improvement of the land. When a request was approved, the surveyor-general would be authorised to make a survey of the land and report on its condition. A settler only achieved outright ownership of land by fulfilling a series of conditions which depended upon the nature of the soil on his property. A man on arable land, for example, was expected to clear and cultivate at least three acres in fifty within three years.[14]

Of all the surveyors-general of Lower Canada and Quebec, the most famous was Joseph Bouchette. His two Topographical Dictionaries[15] stand witness of his remarkable knowledge of the province. These references include many reports on soil, though always in simple qualitative terms. The association of vegetation and soil occurs frequently in his descriptions. Bouchette acknowledges that the information contained in his books and illustrations was derived from many documents and official records which he took to be accurate, and was supplemented by results of his own observations and surveys. He also acknowledges that he relied for information obtained locally while on his travels, upon the seigneur and others. He accepted their assessments of the soils on their own land holdings. It is obvious that one must treat his descriptions with care, especially those involving soils. One recalls that he considered some soils 'too rich' for grain.[16] It is doubtful that any of the other surveyors or commissioners had any greater knowledge and understanding of soils than Bouchette, however, this could not be proven.

Before continuing with the analysis of those involved in the process of settlement, brief consideration should be given to the general state of the science of pedology in Lower Canada during this period. The one significant point that can be made at this stage is that - A Treatise on the Theory and Practice of Agriculture by W. Evans was printed in Montreal in 1835.[17] In this book, the author displays a most advanced knowledge of soil science and especially of the benefits of rotation. He states in his text that:

> "in selecting a farm for purchase or hiring it is necessary to attend to a variety of considerations. Those of the greatest importance are the soil, sub-soil, character of surface, aspect, and situation with regard to the market."

The author has been unable to establish how widely the book was read and how many in positions of authority or influence had a like level of knowledge of soil science.

It is possible that one or more of the many 'emigrants' directories or guides', produced by the government or the British American Land Company, may have translated some of the content of this more sophisticated work for the benefit of settlers. F. A. Evans' The Emigrants' Directory and Guide to Obtain Lands and Effect a Settlement in the Canada's[18], which he produced in his capacity as 'Late Agent for the Eastern Townships to the Legislature of Lower Canada', suggests the strong influence of Bouchette's Topographical Dictionaries and the work by W. Evans. Whether or not this is an accurate assessment, the 'land agent' was a most influential person, and the knowledge and understanding he had of soils is significant in the context of this discussion.

Township 'leaders' were influential men in that they were placed in a position where a hundred or more settlers relied upon them, both to select a township and to obtain the grant from the government. It is obvious, from all the literature on the peopling of the region, that the background of these men varied a great deal. Some of the Empire Loyalists who came from the agriculturally advanced 'Middle Colonies' brought with them a rather sophisticated knowledge of, and approach to soils. Others had been 'urban' men and knew little, if anything, about the quality of land.

Of the 'settlers' who came in search of the average-sized holding of 100 to 200 acres, the following types could be clearly recognised:

(i) The 'land butchers' of the professional pioneer type who wanted to realise a quick profit from 'ash' or timber and who practised an extensive type of agriculture for a number of years before moving on.

(ii) The American frontiersman who was a true farmer and had gained experience on good farm land in New England.

(iii) The immigrant from the British Isles who may or may not have had previous farming experience, but who made a genuine attempt to settle himself on the land.

The two latter types were probably able to buy a farm and keep the family on savings for a number of years while the farm was established. However, a high proportion of those who purchased farms left the region within a few years to a decade.

(iv) The squatters and labourers who tried to save sufficient to buy a farm.

(v) And then, there were the 'gentlemen farmers' who had sufficient capital to buy a farm outright and to employ labour.

This classification would have admirably suited Wakefield's 'art of colonisation'.[19]

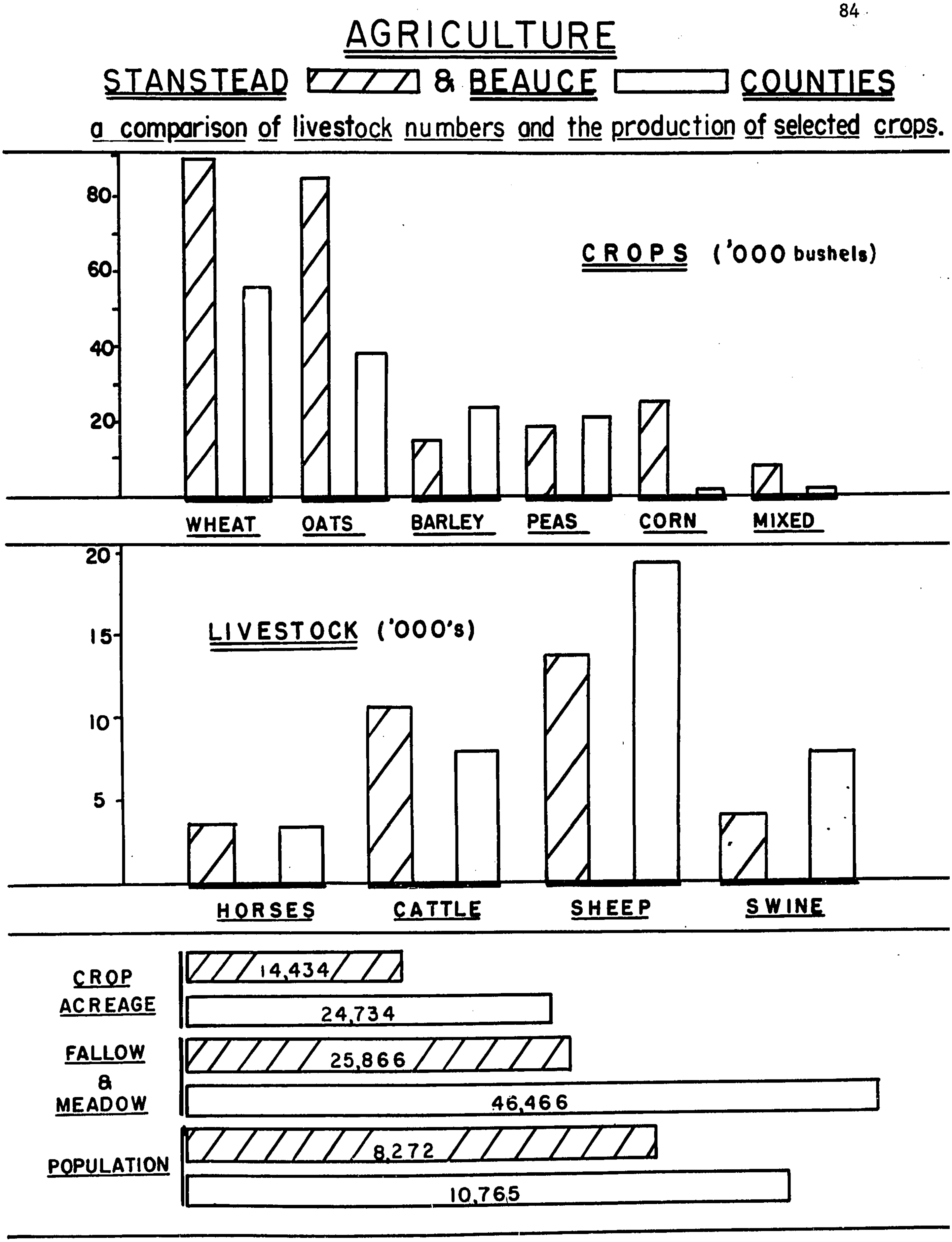
It was probably only in the latter group that one would have found farmers with any reasonable knowledge of soils. Bouchette[20], Jones[21], Blanchard[22], and Minville[23], amongst others, have compared the efficiency of farming in the various regions of Appalachian Quebec. It is difficult to actually evaluate the quality or efficiency of the farming in the two areas. Bouchette[24] in describing the landscape of the townships refers to "cornfields of unrivalled luxuriance, thriving farms and flourishing villages", and throughout his descriptions of townships and counties he praises the appearance of farms, crops and livestock. In reference to the seigneuries of the Chaudière he merely stated that they were in an "advanced and flourishing condition". There is no doubt that farming generally was more productive in the townships per unit of labour and that generally the quality of agriculture was superior among the Anglo-Saxon farmers. (See Figure 5). The latter is conceded by Raoul Blanchard[25] who states:

> "Il est certain que tout au long du XIX^{e} siècle les colons britanniques des Cantons étaient des agriculteurs plus ouverts, moins routiniers que les paysans canadiens".

It is doubtful, though, whether agriculture in the townships was as uniformly efficient and superior as Bouchette and others suggest it was.

Though it was considered that agriculture generally was less productive in the seigneurial lands of the Chaudière than in the townships, the agriculture of the former region was probably superior to that practised on most of the seigneurial lands of the St. Lawrence Lowlands. A factor which favoured the Chaudière over many parts of the Lowlands was the greater variety of relief, soil and forest cover that was likely to occur on any one concession. The concessions were surveyed approximately at right angles to the river, so that many

FIG. 5


AGRICULTURE
STANSTEAD & BEAUCE COUNTIES
a comparison of livestock numbers and the production of selected crops.
CROPS ('000 bushels)
80
60
40
20
WHEAT
OATS
BARLEY
PEAS
CORN
MIXED
LIVESTOCK ('000's)
20
15
10
5
HORSES
CATTLE
SHEEP
SWINE
CROP ACREAGE
14,434
24,734
FALLOW & MEADOW
25,866
46,466
POPULATION
8,272
10,765

of them extended from fertile river meadows, across the well-drained, sandy loams, fine sands and gravelly soils of the river terraces to the clayey soils of the valley slopes and the lighter, stony soils of the ridges. Thus, on any concession, there might be located the ideal soil type for any number of crops and pasture. Unfortunately, these favourable characteristics were not fully exploited. Whilst the French-Canadian farmer gave much more consideration to the conservation of his forest resources than did the Anglo-Saxon farmer of the townships, he was not as capable a farmer. The agricultural implements used were crude. In 1830, he was still using an ancient two-wheeled plough. The rotation practised was of a one-to-four-year variety with half the period in fallow. Most of the manure available was wasted. Many a French-Canadian farmer simply dumped the barn and farmyard manure on the river ice, to be carried away with the spring thaw.

French-Canadian agriculture of this period has often been criticised because it was far too extensive when compared with the more intensive farming systems of New England and the British Isles. In the thinly settled and recently opened up regions, the extensive farming of the French-Canadian was much more economical of labour, but as an area was developed and concessions were divided, cultivation was not intensified sufficiently so that the output per unit of labour was reduced. If it had not been for the ingrained conservatism of the French-Canadian farmer of this period, the Chaudière Valley might have equalled the agricultural productivity of the best farmlands of Lower Canada.[26]

In the process and pattern of settlement of Appalachian Quebec, one other aspect remains for consideration, and that is the way in which the seigneurial survey system of 'range' and 'lot' was applied outside the Lowlands, firstly in the Chaudière Valley and secondly within the township system.

Photo 17 -- illustrates the typical Lowland division and settlement pattern.

Photo 18 -- illustrates a similar pattern of fields, though adapted to a township survey, and the route of an old colonisation road.

Photo 19 -- illustrates the seigneurial system in the Chaudière Valley.

Photo 20 -- illustrates the 'seigneurial' pattern of range and lot within a township in Beauce County.

Photo 21 -- illustrates an attempt to impose the seigneurial pattern on the rugged terrain of the Sutton Range in Arthabaska County.

Photo 22 -- illustrates Anglo-Saxon occupance of similar terrain within the township system.

Photo 23 -- illustrates what appears to be a satisfactory adjustment of settlement to the township system.

The setting in the last photo would appear to provide the settler with the best opportunity of adjusting to the pedological realities of the district.

Photo 17

(See text, page 86)

Photo 18

Photo 19

Photo 20

Photo 21


LINE 46

Photo 22

Photo 23

CHAPTER 9

ORGANIC SOILS OF THE LOWLANDS

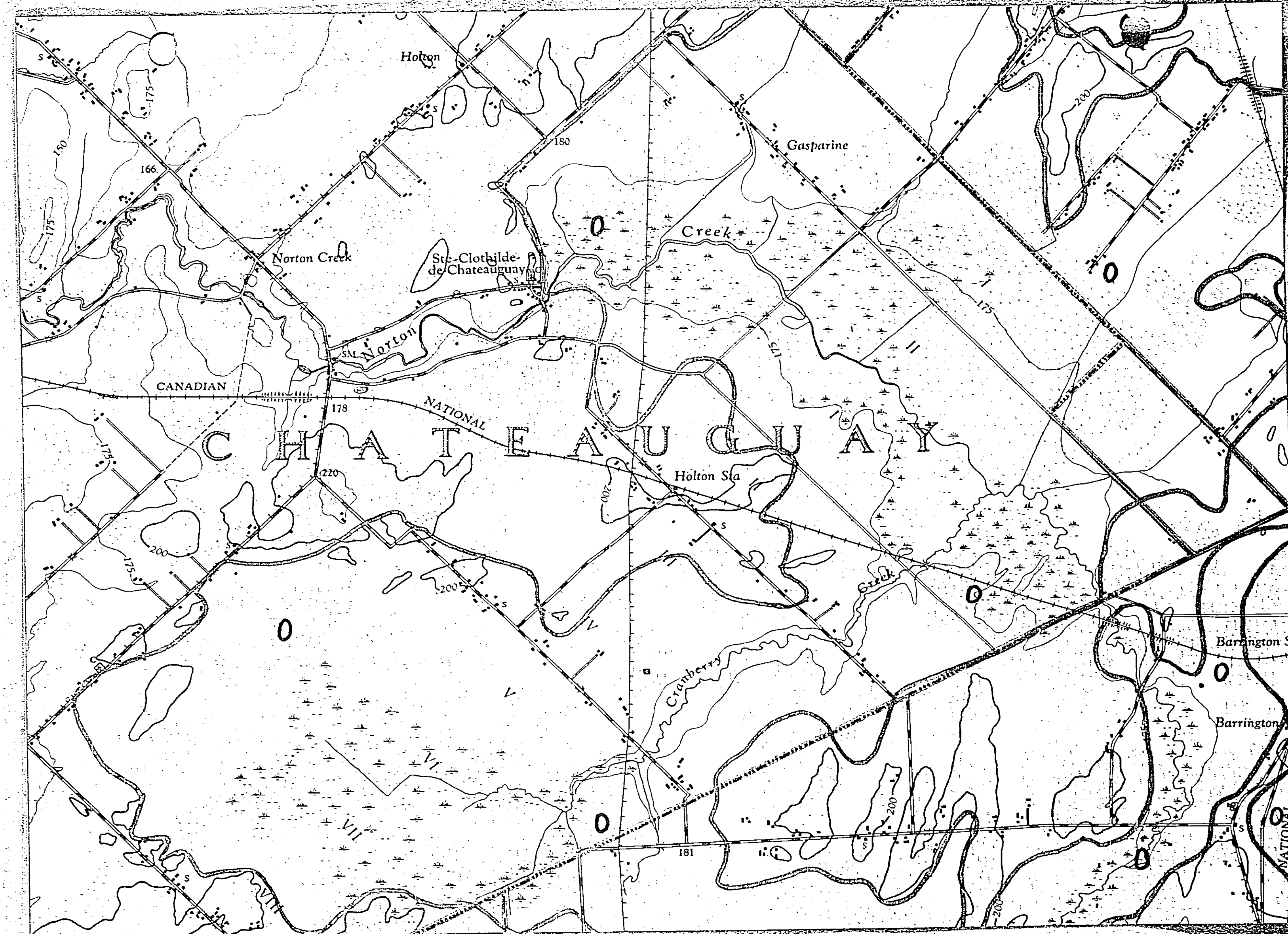
-- appraisal and perception

In the development and settlement of the St. Lawrence Lowlands two extensive soil types were ignored until the immediate post-World War II years. These soil types are the lacustrine and/or glacio-lacustrine sands of the northeastern and eastern regions of the Montreal Plain and the organic soils of the southwestern region. The former are now exploited intensively for the cultivation of tobacco, and the latter for vegetables and small fruits -- they have become 'market and truck farming' soils par excellence.

The organic soils have been selected for closer investigation because their development and utilisation were long delayed in a region from which people migrated in the latter half of the 19th century for want of land. The French-Canadian habitant was diverted, at least to a degree, from migration to New England, by the opening up of soils on the poorer lands of the Laurentians and the Appalachians, while the potential of the organic soils lay unrealised due to the lack of a technique for their use.

The Rideau clays and the variety of loams and sandy loams surrounding the organic soils to the north and east were almost completely settled by the beginning of the 19th century, while to the south, occupation of the gravelly 'orchard' soils on the slopes towards the United States border awaited another fifty years. From the late 17th century when the first seigneuries were established along the banks of the St. Lawrence, F I G. 6

Scale 1:50,000

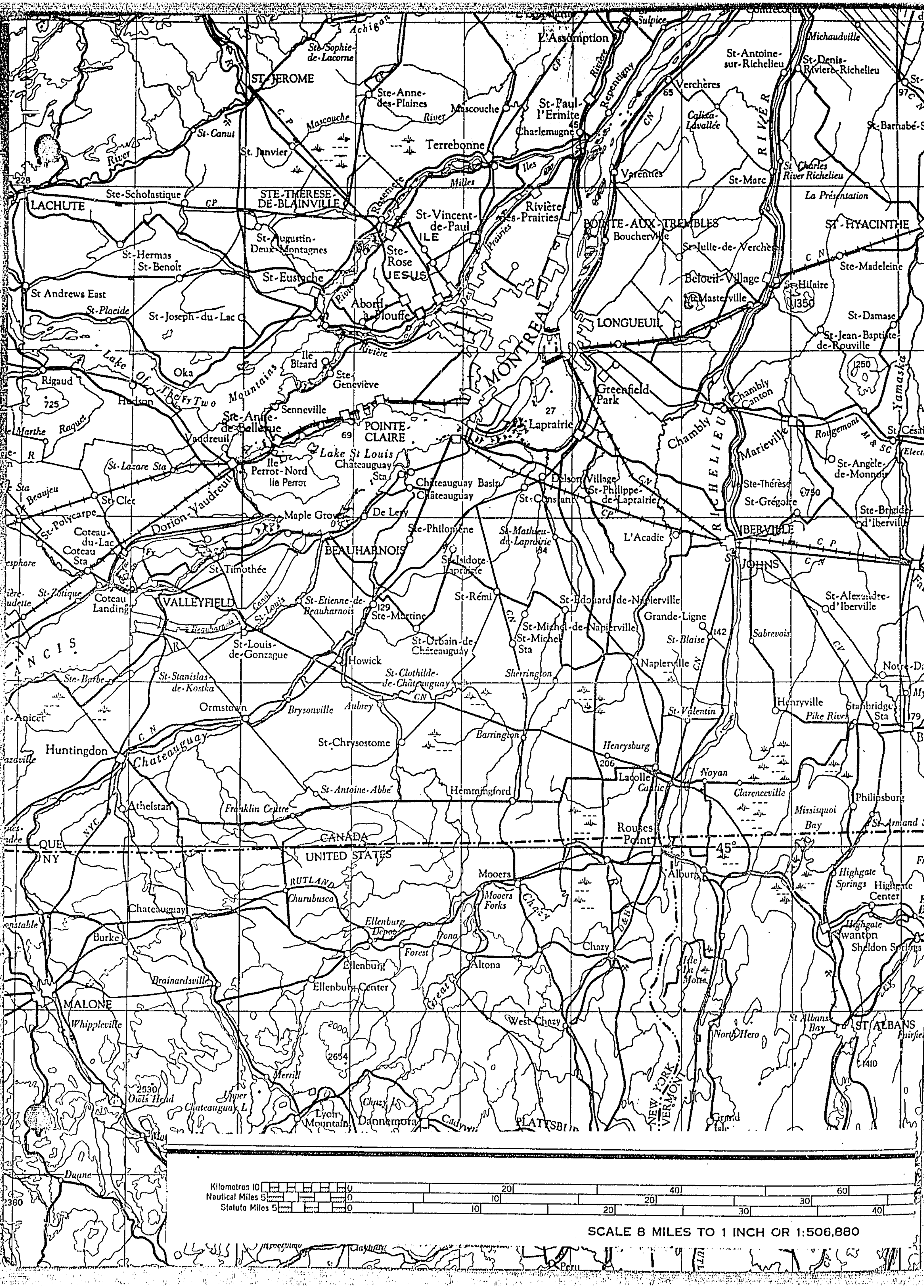

Holton
Gasparine
Norton Creek
Ste-Clothilde-
de-Chateauguay
Creek
Norton
CANADIAN
NATIONAL
C H A T E A U G U A Y
Holton Sta
Creek
Cranberry
Barrington S
Barrington
NATIONAL
175
150
166
180
178
220
200
181

the region of the organic soils was merely good hunting ground. During this century, an increasing number of farmers on farms adjacent to organic soils gradually extended their cultivable area by clearing forest and scrub from the peat and muck soils that overlay mineral soils to a depth of just a few feet. In these cases, the peat and muck was, in time, mixed with the underlying mineral soils which were usually clays. The farmer came to recognise that peat mixed with clay improved the soil for vegetable cultivation, and as Montreal was expanding so was the market for vegetables. A higher value and some perception of the potential of the organic soils were developed. However, large scale utilisation of these soils had to await the creation of an even greater demand. See Fig. 6.

The reclamation of land for agricultural purposes has not been an outstanding feature of Canadian agricultural development, nor would one expect it to be in so large a country with such a low density of population.

However, the history of land development is not without examples of attempts to reclaim tidal lands and inland bogs and marshes. During the latter part of the 17th century and early in the 18th century, the Acadian French successfully transformed tidal marshlands of the Maritimes into excellent pastures and cultivable lands. The task of clearing the adjacent forested uplands held little attraction for the Acadians, so they constructed a series of dykes which held back the high tides of the Bay of Fundy. With the expulsion of the Acadians at the mid-century, these lands were lost to agricultural production for nearly two centuries, for the early English settlers in the Maritimes showed no appreciation of the technique of tidal control that the Acadians had developed. Only in recent decades have these lands been brought back into production.

FIG. 7


L'Assomption
St-Antoine-sur-Richelieu
St-Denis-Rivière-Richelieu
Michaudville
ST-JEROME
Ste-Sophie-de-Lacorne
Achigan
Ste-Anne-des-Plaines
Mascouche
Terrebonne
St-Paul-l'Ermite
Charlemagne
Repentigny
Verchères
Calixa-Lavallée
St-Barnabé-Sud
St-Canut
St. Janvier
River
Varennes
St-Marc
St Charles River Richelieu
La Présentation
LACHUTE
Ste-Scholastique
STE-THERESE-DE-BLAINVILLE
St-Vincent-de-Paul
Rivière-des-Prairies
POINTE-AUX-TREMBLES
Boucherville
ST-HYACINTHE
St-Augustin-Deux-Montagnes
St-Hermas
St-Benoit
Ste-Rose
ILE JESUS
St-Julie-de-Verchères
St-Eustache
Beloeil-Village
St-Hilaire
Ste-Madeleine
St Andrews East
St-Placide
St-Joseph-du-Lac
Abord-à-Plouffe
McMasterville
1350
LONGUEUIL
St-Damase
St-Jean-Baptiste-de-Rouville
MONTREAL
Lake Of The Two Mountains
Ile Bizard
Ste-Geneviève
Rigaud
Oka
Hudson
725
Senneville
Ste-Anne-de-Bellevue
Greenfield Park
Chambly Canton
1250
Yamaska
Vaudreuil
POINTE-CLAIRE
Laprairie
Chambly
Marieville
Rougemont
St-Césaire
Lake St Louis
Ile Perrot-Nord
Ile Perrot
Châteauguay Sta
Châteauguay Basin
Châteauguay
Delson Village
St-Philippe-de-Laprairie
St-Angèle-de-Monnoir
St-Lazare Sta
St-Clet
St-Polycarpe
Dorion-Vaudreuil
St-Constant
Ste-Thérèse
St-Grégoire
750
Ste-Brigide-d'Iberville
Maple Grove
De Léry
Ste-Philomène
St-Mathieu-de-Laprairie
L'Acadie
IBERVILLE
Coteau-du-Lac
Coteau Sta
BEAUHARNOIS
St-Isidore-Laprairie
ST JOHNS
St-Timothée
St-Zotique
Coteau Landing
VALLEYFIELD
St-Etienne-de-Beauharnois
St-Rémi
St-Edouard-de-Napierville
St-Alexandre-d'Iberville
Ste-Martine
Grande-Ligne
St-Michel-de-Napierville
St-Urbain-de-Châteauguay
St-Michel Sta
St-Blaise
Sabrevois
St-Louis-de-Gonzague
Howick
Napierville
Ste-Barbe
St-Stanislas-de-Kostka
St-Clothilde-de-Châteauguay
Sherrington
Notre-Dame
Ormstown
Brysonville
Aubrey
St-Valentin
Henryville
Pike River
Stanbridge Sta
Huntingdon
Chateauguay
St-Chrysostome
Barrington
Henrysburg
Lacolle
Noyan
Clarenceville
Philipsburg
St-Antoine-Abbé
Hemmingford
Athelstan
Franklin Centre
Missisquoi Bay
St-Armand Sta
CANADA
UNITED STATES
QUE
NY
Rouses Point
45°
Mooers
Alburg
Highgate Springs
Highgate Center
RUTLAND
Churubusco
Mooers Forks
Chazy
Chateaugay
Ellenburg Depot
Burke
Forest
Swanton
Sheldon Springs
Ellenburg
Altona
Brainardsville
Ellenburg Center
Isle La Motte
MALONE
Whippleville
West Chazy
St Albans Bay
ST ALBANS
North Hero
2000
2654
1410
Merrill
2530
Owls Head
Upper Chateaugay L
Chazy L
Lyon Mountain
Dannemora
PLATTSBURGH
NEW YORK
VERMONT
Grand Isle
Duane
2380
Kilometres 10 0 20 40 60
Nautical Miles 5 0 10 20 30
Statute Miles 5 0 10 20 30 40
SCALE 8 MILES TO 1 INCH OR 1:506,880

It has been estimated that there are at least 250,000 acres of peat and muck lands in Eastern Canada, especially southwestern Quebec, yet only in recent decades has any of this land been cleared of forest and developed.

Location and Nature of the Organic Soils of Southwestern Quebec[1]

The region of southwestern Quebec is bounded to the north by the St. Lawrence River, to the south by the United States border and to the east by the Richelieu River, a southbank tributary of the St. Lawrence. The city of Montreal and its southshore communities lie at the northern apex of this triangular shaped region and no point in the region is at a greater distance than 50 miles from Montreal. The surface of the region slopes northward from the United States border, first abruptly from an elevation of about 500 feet and then almost imperceptibly between the 300 foot and 125 foot contours. Major road and railway connections between Montreal and the United States move almost directly across the plain. See Fig.7.

Over the greater part of the region the relief reflects the structure of the underlying sedimentary formations which are either horizontal, slightly inclined or folded into shallow synclines. Towards the border the sedimentary formations overlap the northern-most flank of the Adirondack Mountains, they are consequently tilted to a greater extent. The physiography of the Lowlands is characterised by a rather complex pattern of flat-topped limestone ridges and low, undulating to rolling morainic ridges with intervening vales and poorly drained depressions. The Chateauguay River and its tributaries is the only clear-cut channel within the region. Drainage of the remainder of the region largely takes the form of somewhat haphazard drainage from one depression to another. The drainage pattern of the region has contributed directly to the considerable difficulties and expense involved in draining the organic soils.

The highly organic soils of southwestern Quebec are described in English as peat and muck soils and in French as 'les sols tourbeux' and 'les sols semi-tourbeux', or 'les terres noires'. These deposits are of varied origin and differ in value to a considerable extent. The most common type of muck soil had its beginning in water filled depressions where the movement of water was slow. Aquatic plants, such as water lilies and pond weed, grew over these areas and as their life cycle was completed the remains settled to the bottom, thus gradually filling in the depressions. As the water became shallow, rush and sedge growth followed and was in turn succeeded by various forms of moss, chiefly sphagnum, where soil and water are decidedly acid in reaction; or by sedge species and water tolerant grasses, where the reaction was mildly acid to alkaline. Some areas were built up entirely in this manner and form the grass and sedge mucks which are usually of very high quality. Where moss predominated, the soils are very acid and of little value. In other instances, a period of tree and shrub growth, following the grass and sedge period, has led to a layer of organic matter, which, when decomposed, is of fine texture and excellent quality. In several locations there is evidence that the layer of aquatic origin, underlying large areas of muckland, has been formed from plants that grew in salt or brackish water. In some areas, the layer contains large quantities of shells that are obviously those of salt water crustacea, which suggests that this layer owes its origin to the final stages of the Champlain Sea.

The typical muck deposit of the above type may have an aquatic or 'jelly' layer up to 10 feet in depth overlaid with 3 to 5 feet of partly decomposed forest debris. Over this, and forming the surface layer, there may be up to 2 feet of well decomposed muck, originating mainly from the sedge and grass species. This constitutes a muck soil of very high quality and one on which the most advanced cultural practices can be followed.

Other areas of muck soil have been built up in comparatively shallow depressions, without the formation of an aquatic layer. On such areas the organic layer is necessarily shallow and the reserve of organic matter much smaller than on the deep mucks. In general, their value is governed largely by the nature of the underlying soil since, as the organic layer becomes thinner as the result of loss by cultivation, more of the bottom soil will be included in the cultivated section of the profile. A clay bottom is most desirable in that muck and clay will form a highly productive soil, when the organic layer has become reduced in depth to a point where cultivation extends into the underlying clay.

Peat differs from muck in that it is partly humified or decomposed plant material, while with muck, decomposition is practically complete. It is generally conceded that when decomposition has progressed to the extent that definite plant remains are not easily recognised in an organic soil, it may be classified as a muck.

Utilisation of Organic Soils -- Techniques

There are four stages in the development of organic soils. These will be summarised only.

Stage I -- Regional Drainage

Regional drainage, which requires municipal, county and provincial cooperation, is vital. In southwestern Quebec, regional drainage required not only the construction of new drains but also the straightening, clearance and deepening of existing drainage channels, and excellent maintenance as well. A high degree of administrative and technical integration is essential.

Stage II -- Clearance and Preparation of Mucklands for Cultivation

The clearance of the existing vegetation cover is a relatively simple matter once the lands are adequately drained. Today, specially equipped caterpillar tractors have little difficulty in pushing aside even the denser forest cover. The debris is piled up and left until winter before being burnt. The winter is the only safe period for burning as fire during summer can readily gain a firm hold in both peat and muck soils.

After clearance, the soils are worked with harrows and cultivators, but not ploughs. It is important to have the lower part of the top layer of soil relatively compact in order to facilitate the upward movement of water by capillary action, and ploughing up to six or seven inches into the soil might loosen this layer too much.

Stage III -- Water Control

The control of water in organic soils at a point where it is satisfactory for plant growth, is one of the most important factors in successful crop production. The high moisture-holding capacity of organic soils usually prevents normal summer rains from penetrating deeply enough to supply moisture for plant roots and because of the open texture of the soil, this moisture is soon lost by evaporation. It is obvious, therefore, that although these soils hold a large amount of moisture, correspondingly large quantities may be required for plant growth, if applied to the surface, because of rapid loss. Summer rains in Quebec are usually inadequate for the requirements of these soils, and to obtain maximum production of most of the vegetable crops in an average season, additional water must be provided.

In most of the typical deep muck areas of southwestern Quebec, the soil profile and the location are ideal for water control. Dams are constructed in the drainage ditches, so that when water is required for irrigation, water can either be collected from natural drainage or pumped in from nearby streams or natural reservoirs. Careful control of water-level in the mucklands is essential to successful development and production.

Stage IV -- Fertility Control

Muck soils are high in organic matter and nitrogen but are correspondingly low in essential mineral elements. In the typical Quebec organic soil, organic matter is often 90% or more of the whole. Total nitrogen is usually over 2%. Manganese and potassium are extremely low. Calcium is usually adequate for most crop requirements and phosphorus is about normal in relation to other minerals. The need of trace elements varies with the crop, but potash is required in relatively large quantities by most crops, and its scarcity in most organic soils is one of the chief limiting factors in crop production.

And then there is maintenance for purposes of continuing production. Frost, wind and disease need special attention for proper use and maintenance.

Since they are dark in colour, muck and peat soils readily absorb heat rays, but because of low conductivity, heat will not penetrate far into the soil. As a result they are slow in warming up to average seeding depth in the spring. For the same reason, frost hazard during the spring and fall, and occasionally during the summer months, is greater than on mineral soils. During periods of low temperature, the heat in the top few inches of soil may be lost rapidly by radiation and the accumulation of cold air at ground level may be sufficient to cause frost. This effect is increased because areas of organic soils are usually low-lying and partially or wholly surrounded by higher land. Due to temperature inversion, the temperature during calm summer nights is usually three to five degrees lower on the muck soils than on the mineral soils. During the last ten years, light frosts have occurred five times in June and once in July. Fortunately, damage was light. However, frosts in May and September have been responsible for serious loss.

Protection against frost can be effected in several ways. Raising the water level in the ditches when frost is forecast, will put more water into the soil, which will absorb and later radiate more heat. Various types of heaters may also be used.

Organic soils are light in weight and when dry are easily blown about by wind. Unless these soils are protected by a vegetative cover, losses from wind erosion may be severe. It is thus the practice to maintain a crop of some sort on the land throughout the summer months. Millet, rye, barley or buckwheat are frequently used as cover crops. Because it is unnecessary to build up organic matter on these soils, growth can be kept to a minimum by occasional clipping with a mowing machine. Cover crops are needed especially after a late commencement of the season, which will preclude the possibility of two crops of vegetables.

Disease is a factor which has not yet received a great deal of attention. It is appreciated though that new conditions are being created with the extensive cultivation of any one vegetable, and that under these conditions, loss from disease would probably be far more serious than with a small scale vegetable producing operation. At the present time, standard preventative procedures are being followed.

Origins of the Techniques.

It is of interest that, at the very time pressure on the settled lands of the Lowlands was becoming critical, that is in the mid-19th century, what was probably the first experimental farm on organic soils was established in Germany. About 1850, the Bremen Muck Experimental Farm was established in Germany to investigate ways of utilising organic soils. It was not until the 1880's that organic soils were given any attention in the United States.

In Canada, the first significant development and utilisation of organic soils resulted from the initiative of Dutch settlers in the early 1930's in the Holland Marsh area of Ontario. Government attention was prompted and a Provincial Experimental Substation was established in 1935. An Experimental Substation was established at Ste. Clothilde, Quebec, a year later. Both stations benefited from experiences in Europe and the United States.

However, it was not until the establishment in 1955 of one large commercial operation, Hardee Farms Ltd., that there was any significant increase in the area of organic soils cultivated. In 1955, there were 2,000 acres of organic soils in production and today (1967) the acreage is 14,000. Almost a half of the acreage has been developed by three large commercial operations, while the remainder is in small holdings.

Why was the introduction of the desirable techniques delayed for so long? The demand for land existed a century ago and the art of drainage was well developed in Europe. Firstly, there was not a real shortage of land, the shortage was of good mineral soils in accessible areas that needed very little drainage. Secondly, a certain level of organisation was needed, and regional organisation on the scale required was almost impossible in Quebec until the mid-20th century, especially where farmers and rural matters were concerned. Thirdly, the 'demand' had to be specific, such as for large quantities of vegetables. This demand was created by rapid post-war expansion of supermarket chains that required not only vegetables but also contractual arrangements. In addition, the rapid expansion of Montreal led to encroachment on extensive areas of those soils that had previously largely satisfied the Montreal demand for vegetables. Some direct resettlement of farmers from these areas, such as Ile Jesus, took place in the Ste. Clothilde region of organic soils.

The techniques required were made available, the demand was created for vegetables particularly suited to production on organic soils and, both the experimental farm and the large commercial operations provided the example.

However, there is one interesting aspect of this development that remains for comment, and that is the attitude to and perception of the peculiar qualities of these soils by the local farmer. The farmers referred to earlier, who had somewhat gingerly moved from mineral soils on to organic soils on their farms, did not consider that they were taking too much of a risk. Philip W. Porter has recently written,in <u>American Anthropology</u>[2], on the concept of subsistence risk. There is little doubt that the concept of 'risk' can be of use in explaining the slow movement of the small farmer on to farms located entirely on organic soils. In 1958, the author questioned 50 farmers in the Ste. Clothilde area, ranging from those on purely mineral soils to the few on purely organic soils. When confronted with the statement and question -- You can see how well vegetable production has been developed at the experimental farm and by Hardee Farms, why don't you either move on to organic soils or clear more of what you have on your farm? -- 90% of the replies suggested an appraisal in terms

Montreal Star

MONTREAL, TUESDAY, JULY 7, 1964

Farmers Hard Hit By Drought

By ROBERT STALL
Star Staff Reporter

SHERRINGTON, Que., July 7 — This Eastern Townships area has just awakened from a drought-besieged nightmare.

Its farmers say that if government help is not immediately forthcoming, results will be disastrous.

For them, the hot dry famine is over but it is replaced by the cold hard facts of survival. Some 500 farms are hopelessly crippled and they are appealing for help.

The lucky ones can look to years of staggering convalescence. The unlucky face extinction. And 18 of them — all family institutions for generations — have already succumbed.

Damage estimates, resulting from a lethal combination of drought and windstorms during the past month, range from 20 to 80 per cent at individual farms. About 500 of the 799 farms suffered more than 50 per cent damage prior to the weekend's rainfall.

The stricken area encompasses the three counties of Napierville, Laprairie and Chateauguay. In their bid for governmental assistance, farmers have banded together with headquarters in this town of 1,500, 30 miles south of Montreal.

Executives of the organization, a sub-committee of the Central Montreal Market Gardeners Association, took Montreal newsmen on a tour of the district yesterday.

The area is normally the richest in the province. Comprising half of Quebec's total number of "commercial farms," the district annually accounts for 80 per cent of the celery grown in the province and more than 60 per cent of total carrot, onion and lettuce yields. But not this year.

Anticipated 1964 losses through the three counties are estimated at more than $2,000,000. The general public will not however feel the effects since Quebec province produces only a small percentage of what its population consumes.

But for Eastern Townships farmers, the situation is approaching disaster proportions.

Aire van Winden, a Dutch immigrant with seven children, is one of the lucky ones. He has worked the area's rich "terre noire" since buying his small 20-acre farm seven years ago. Because he was able to afford reseeding his land after the last windstorm two weeks ago, it will only take him seven more years to bring the farm up to last year's standards.

Most of van Winden's neighbors are in a much sorrier state. They are the majority who cannot afford another reseeding, a process usually involving about 15 per cent of the yearly profits. Some have already reseeded two and three times—after each windstorm.

Immediate Aid Vital

These are the farmers to whom immediate financial aid is a do-or-die question. Almost all buy seeds in the spring on six-month credit plans and repay after the fall harvesting. Few have any capital at present and they cannot get credit.

"We don't like to cry. But we're in trouble for the first time. This is an emergency," said committee chairman Paul Boudrias.

Boudrias himself is not in trouble, owning one of the largest farms in the area. He is almost the only one whose land is protected by a natural windbreak. In percentage his loss will be low but it will still be more than $15,000.

"Western provinces, with federal vote distributions of one per square mile, get emergency aid every time there's trouble. In Quebec, there are 250 votes per square mile and we've never seen a penny," he says.

All executive members of the committee insist that financial assistance, federal or provincial, must come "within 10 days" to be of any use. After that, it will be too late for any planting.

The "very rare" combination of prolonged drought and sporadic windstorms has also created a rare harvesting problem. The usual staggering of crops, to create an almost continual harvest through the summer, is impossible this year.

As a result, the Montreal market will be virtually flooded with Quebec-grown products during the fall — causing a probable price deflation which the farmer will also have to bear.

To date, one federal and 10 provincial investigators have checked the damages. They advocated the need for assistance.

The farmer's committee is in the process of itemizing specific proposals to serve as both immediate relief and long-term precautionary measures. Proposals include:

—Compensation for losses;
—Long-term loans;
—Harvest insurance;
—Installation of wind-breaks;
—Water control;
—Irrigation;
—Artificially-precipated rainfall.

FIG. 8

of risk. 'This is a new idea, and hasn't been tried out long enough', or 'What happens if it doesn't rain at the right time, and a good wind comes, all that dry stuff will blow away', are examples of the types of comments. Figure 8 , an extract from The Montreal Star of July 7, 1964, illustrates most aptly the 'dangers'. Field work in 1966 indicated that most of the farmers had learned a lesson and were paying more attention both to supplemental irrigation and windbreaks.

Their development of an accurate perception of the nature and needs of the organic soils has reached a stage which may well result in further expansion of farms on to these 'risk' soils.

PART III

PROLOGUE

An investigation of the nature and utilisation of tropical soils is a tempting prospect for many reasons, not the least of which is the opportunity it provides for a comparison of use and appraisal by peoples of European origin as well as those indigenous to the tropics.

A summary of the characteristics of tropical soils has been prepared and it forms Appendix I. The reader not familiar with the tropical environment may well profit from reading it.

PHOTO 24

Rain Forest Ecosystem -- Typical latosolic profile, Surinam.

PHOTO 25

Lateritic Profile -- With laterite cap, near Malacca, Malaya

CHAPTER 10

TROPICAL FOREST AND SAVANNA SOILS

- European Appraisals

Within the last two centuries tropical soils have been assessed by European man as being inexhaustibly fertile and hopelessly infertile. The latter assessment tended to replace the former, in time, but both misconceptions were widely held concurrently in the 19th and early part of the 20th century. How was this possible? In some respects the question can be answered readily and easily. Wherever there is ignorance, there are bound to be misconceptions. Even today pedologists have looked intensively at but a fraction of the soils of tropical regions. Scientist and layman alike have tended to generalise on the basis of both misinterpretations and limited facts.

The European world of the Renaissance and the Age of Discovery established high values for a variety of tropical products especially spices, sugar, and woods such as mahogany and sandalwood. There were also reports of delectable tropical fruits, far too perishable to be removed from tropical lands. The lands producing such luxuries must be beautifully endowed. In time the early sailors and travellers came to be impressed by the luxuriance of the tropical rain forest. In South America, the myth of El Dorado spread and took on many forms, and then in the latter half of the 18th century and during the 19th century, the navigator, the scientist, the artist, and the writer, associated in the discovery and opening up of the Pacific and, to a lesser extent, tropical America, gave great impetus to the 'concept' of tropical exuberance and especially to the myth of the fertility of tropical soils.

It is not the objective of this chapter to attempt a complete history of the development of both concepts and misconceptions of the tropical environment, but rather to concentrate on European appraisal of tropical forest and savanna soils during the last three centuries.

It is easy to understand just why the myth of the great fertility of tropical forest soils gained such impetus in the 18th century, for it was during this period that the Portuguese, Spanish, British, French, and Dutch successfully established their respective forms of the 'plantation system' in the tropics. The areas selected for settlement and development were, in most cases, by chance, the limited accessible areas of available fertile alluvial soils on river lowlands and deltas, basic volcanic soils and soils derived from coral limestone.

The Dutch, in contrast to the other European powers, concentrated their efforts in an already densely settled region. Rather than open up new lands, they preferred to reorganise the indigenous systems which had, to that date, been able to satisfy the greater part of the European demand for tropical 'spices'. This productivity, associated as it was with the highest degree of humid tropicality[1] and the most luxuriant rain forest in the whole of the tropical world, suggested a very profitable association between a wealth of soil nutrients and a tropical climate characterised as it was by high temperature, humidity and rainfall. This region was, of course, the East Indies.

Meanwhile in the New World tropics, the myth of El Dorado gathered momentum. The origins of the myth of El Dorado are well known. The myth of El Dorado arose during the first decades after the arrival of the Spaniards in South America. El Dorado, originally fact, not fiction, took the form of an Indian chief who, with body smeared in turpentine and gold dust, sailed to the centre of a lake near the modern city of Bogota to sacrifice gold offerings. El Dorado ultimately became an empire infinitely rich in gold and silver mines. Its location gradually migrated from the high Andes to the upper Orinoco, finally coming to rest in Lake Amuku, Rupununi District, Southern Guyana. Sir Walter Raleigh had said of El Dorado:

> "I have been assured by such of the Spanyardes as haue seene Manoa, the empireall Citie of Guiana, which the Spanyards cal el Dorado, that for the greatnes, for the riches and for the excellente seate, it farre exceedeth any of the world, at least so much of the world as is knowen to the Spanish nation."[2]

In the course of its migrations, El Dorado came to be associated with lost cities in the Amazon Basin. Carvajal, who accompanied Orellano on his pioneer journey down the Amazon in the 16th century, felt compelled to write enthusiastically of the imaginary cities he hoped to see, but did not find. Subsequently, when he wrote of these cities, he in turn assumed that these cities could only have developed in a region of great wealth, not only wealth in the form of gold and silver, but wealth also in the form of fertile soils.

Long after Sir Walter Raleigh's final attempt to discover El Dorado, a British Colonial Office official, reporting home from British Guiana, in 1834, made the following statement:

> "It may with safety be affirmed that British Guiana contains many more acres of land than Great Britain and Ireland united, and it is a far more valuable possession than Mexico and Peru, with all their gold and silver mines....the soil in Guiana is inexhaustible both in quality and quantity and as regards cultivation and colonisation its limits are literally boundless. If cultivation and colonisation proceed here, in advance as they ought to do, it would matter little (insofar as sugar, rum, molasses and coffee are

> concerned) a few years hence if all the islands of the Caribbean Sea were sunk to the bottom of the deep, British Guiana could furnish supplies for the whole world and even then have fresh soil to cultivate."[3]

In the latter half of the 18th century, the exploration of the Pacific by European navigators and scientists began. The empirical observation of nature was already an established part of British maritime practice and this tradition both Captain Cook and Joseph Banks inherited. At this time in history, a vessel such as Cook's 'Resolution' with its relatively spacious accommodation, served somewhat as a travelling laboratory and, as a result, Cook was at a great advantage compared to overland expeditions. Primarily for this reason, the interiors of continents remained virtually unknown, while the islands of the Pacific were visited by many scientific expeditions. In fact, the South Pacific became better known to European scientists than most regions of the tropical world. In the year Cook departed for the Pacific, 1768, another significant event took place, the Royal Academy was established. The formation of the Academy reflected the recognition in England of neo-classical theories of Italian origin. These theories thrived briefly through the discovery of the Society Islands which gave initial support to the belief that a kind of tropical Arcadia, inhabited by men resembling Greek gods, existed in that part of the world. However, it was the empirical approach of the Royal Society which really gained ground by the new knowledge and understanding resulting from the exploration in the Pacific, and in turn it was this experience which became a significant influence, both on the English landscape painters and many of those who were looking to the economic and social possibilities of the tropical world.

The latter impact came about through the employment of professional artists in training, working side by side with nautical and scientific draughtsmen. At all times they were exposed to the influence of scientific and naval officers, trained in the empirical habits of observation. In consequence, their mode of perception became increasingly influenced by empirical habits of vision, to the neglect of neo-classical theories. In time, a crude appreciation of ecological relationships developed, which resulted in landscapes being painted in such a manner that rocks, animals, people, etc. were selected and organised to characterise the type of landscape painted. Alexander von Humboldt was to give the typical landscape a theoretical justification. Two voyagers in the Pacific who had a great influence on Humboldt were William Hodges and George Forster, both of whom accompanied Cook on his second voyage. As Humboldt acknowledged,[4] it was Forster's description of the islands of the Pacific and paintings by Hodges that first awoke in him the desire to visit the tropics.

Humboldt recognised a division of the earth into climatic zones. In the tropics, nature was to be found in its noblest form. In mountainous regions, the traveller could observe in successive altitudes all the vegetable forms of the earth and study the stars of both the northern and southern heavens. Organic development, fecundity, and vitality, increase he claimed as one moves from the Poles to the Equator. Humboldt hoped that the combined efforts of the painter and the poet could provide the European with some idea of the glowing richness of nature in the tropics. As he stated,

"...many of the enjoyments which Nature affords are wanting to the nations of the North. Many constellations and many vegetable forms , -- and of the latter those which are most beautiful (palms, tree ferns, plantains, arborescent grasses, and the finely divided feathery foliage of the Mimosas) remain forever unknown to them. Individual plants languishing in our hothouses can give but a very faint idea of the majestic vegetation of the tropical zone, but the high cultivation of our languages....and the imitative art of the painter, open to us sources whence flow abundant compensations, and from whence our imagination can derive a living image of that more vigorous nature which other climes display."[5]

Louis Choris was one artist influenced by Humboldt and in his Vues et paysages des régions équinoxiales he acknowledged Humboldt's influence in describing the tropical landscape.

"Les paysages situés sans le beau ciel des Tropiques, avec leur végétation gigantesque, presque toujours chargée de fleurs et de fruits, ne ressemblent en rien aux paysages de nos pays, où les longs hivers suspendent et paralysent les ressorts d'une nature qui semble fatiguée et vieille. Quel immense intervalle dans la chaîne végétale, entre le palmier des contrées équinoxiales et les lichens des régions voisines des pôles."[6]

There is little doubt that though the scientific world owes a great deal to this period of exploration and art in the south Pacific, many a tropical myth, which Humboldt surely helped to sustain if not strengthen, had its beginnings in the portrayal of tropical exuberance by scientists, author, poet, and artist.

In the myriad descriptions of the Pacific, there are many references to the fertility of soils. In Montgomery's Pelican Island, one finds:

"and yet the soil untill'd, Pour'd forth spontaneous and abundant harvest"[7]

and in Voyage of La Pérouse Around the World, in reference to a Samoan island:

"this charming country unites the advantages of a soil fruitful without cultivation, and a climate requiring no clothes.

> The cocoa, plantain, guava, orange and grapefruit tree, bestow on those fortunate people, abundance of wholesome nourishment."[8]

And in Otaheite in reference to Tahiti, one finds,

> "Here, ceaseless, the returning Seasons wear
> Spring's verdant Robe and smile through the Year.
> Refreshing zephyrs cool the noon-tide Ray
> And Plantane Groves, impervious Shades display.
> The gen'rous soil exacts no tillers' Aid
> To turn the Glebe and watch the infant Blade;
> Nature, their vegetable Bread supplies, and
> High in Air, luxuriant Harvests rise.
> No annual Toil the foodful Plants demand,
> But unrenew'd to rising Ages stand;
> From Sire to Son the long Succession trace,
> And lavish forth their Gifts from race to race."[9]

From elsewhere in the tropics came reports of fertile soils, high yields and great capabilities. Bennett, in Ceylon and Its Capabilities, makes frequent references to:

> "its fertile soil, immense uncultivated tracts of arable and other land, it is but fair to form a criteria for anticipations of the ultimate result, by that which has already attended it in places, where it has superseded densely-wooded and impervious forests and where the decomposition of vegetable matter had continued through countless ages."[10]

And, on the other side of the tropical world, Robert H. Schomburgk, one of the earliest scientific travellers in the Guianas, stated in regard to British Guiana:

> "It is much to be wondered at that the extraordinary facilities which the colony of British Guiana offers for colonisation, have not promoted emigration of industrious Europeans to this territory. The fecundity of its soil and the great energy of vegetation between the tropics ensures the agriculturalist a succession of harvests; no winter interferes to impede his labour, no blighting hurricane thwarts his prospects, no earthquake spreads its horrors and desolation over the scene of its industry. A uniform climate reigns throughout the year and the soil possesses unequalled richness that extends several hundred miles from the coast, washed by the Atlantic to the sources of those rivers which, if population could be planted on their banks, would offer means for the maintenance of millions and facilities for the most extensive navigation.
>
> With the introduction of industrious immigrants from the Mother Country and the establishment of colonies in the interior, cultivation would

gradually extend and by this advancement, to points of great importance will be secured; the spread of civilisation and the wealth of the colony must increase; and while these labours which are necessary to reclaim the fertile soil from nature and to make it available, are conducive to the health of those who are thus employed, the example of industrious Europeans must have a high moral influence upon the few aborigines who still inhabit British Guiana; and although the latter may be averse at present to cultivate the coastlands, I have no doubt they would tend to their labour if a colony or settlement were formed in the interior."[11]

Back to the old world, and southeast Asia, to the Straits Settlements. Here, many of the colonists were of that class of lower English and Scots gentry accustomed to the management of land, and their thoughts turned naturally to the soil as an outlet for their surplus capital. But first they had to come to terms with the wholly unfamiliar environment. In the first place they grossly overestimated.the fertility of equatorial soils. Even as late as 1830 it was still generally believed that the soil was a reservoir of fertility, only awaiting the investment of capital and the advent of labour from China and the Coromandal coast to yield rich harvests of tropical crops. In Penang, Captain Kyd reputed to report on the agricultural potentialities of the settlement, claimed that the soil "was adapted to all purposes of inter-tropical agriculture", and that there were many spots so rich that any production which the climate admits of may be reared". Agricola writing in the Singapore Free Press enthused:

"the soil is good...the climate fine...the situation excellent, and nought is wanting but the hand of man to bring abundance to our doors."[12]

Optimism about the potentiality of the tropical environment was the keynote of the day. However, rational voices, based upon bitter experience or skilled observation and deduction, could be heard, though weakly. In a mid-19th century Europe and North America, that thrived on myths of El Dorado or Gardens of Eden and that only hesitantly reduced the giants of Patagonia to normal size, in spite of accurate descriptions by Cook and others a century earlier, it seemed impossible to believe that the luxuriance of tropical vegetation was not at least in part a result of the extreme fertility of the underlying soils.

As early as 1783, in The History of Sumatra, W. Marsden wrote:

> "Notwithstanding the received opinion of the Malay Islands, countenanced by the authority of Le Poivre and other celebrated writers.... I cannot help saying that I think the soil of Sumatra is in general rather sterile than rich. It is almost everywhere a stiff red clay, burned nearly to the state of a brick where it is exposed to the influence of the sun. The small proportion of the whole which is cultivated is either ground from which old woods have recently been cleared, whose leaves have formed a bed of vegetable earth, some inches deep; or else swamps, into which the scanty mould of the neighbouring hills has been washed....It is true that on many parts of the coast, between the cliffs and the beach, small plains of sandy soil, probably left by the sea...; and such are found to prove the most favourable spots for raising the productions of the Western world....Every person at first sight and on superficial view of the Malay country, pronounces them the favourites of nature, where she has lavished all her bounties with profusion unknown in other regions, and laments the infatuations of the people who neglect to cultivate the finest soil in the world. But I have scarcely known one who, after a few years residence, has not entirely altered his opinion."[13]

And this was to be the experience of Sir Samuel W. Baker in Ceylon. He describes his experience in the book Eight Years in Ceylon,

> "In my determination to reside at Newera Ellia (in the interior of Ceylon) I hope to be able to carry out some of those visionary plans for its improvement which I have before suggested, and I trusted to being able to effect such a change in the rough face of nature in that locality as to fender a residence at Newera Ellia to something approaching to a country life in England with the advantage of the whole of Ceylon for my manor and no expense of gamekeepers....To carry out these ideas it was necessary to set to work and I determined to make a regular settlement in Newera Ellia. Sanguinely looking forward to establishing a little English village around my own residence. Accordingly, I purchased an extensive tract of land from the government at 20/- per acre. I engaged an excellent bailiff who, with his wife and daughter, with nine other emigrants, including a blacksmith, were to sail for my intended settlement in Ceylon.

I purchased farming implements of the most important description, seeds of all kinds, sawmills, etc., and the following stock: a half-red bull (Durham and Hereford), a well-bred Durham cow, three rams (a Southdown, Leicester, and Cotswold), and a thoroughbred entire horse by Charles XII; foxhounds and a favourite greyhound (Bran). Many were the difficulties to contend against for when the first attempts were made at agriculture at Newera Ellia, no sooner were the oats above ground a few inches than they were subjected to the nocturnal visits of an elk and hogs, and in such numbers that they were almost totally destroyed. A crop of potatoes of about 3 acres of a newly cleared forest land was totally devoured by grubs, the bull and stock were nearly starved on the miserable pasturage of the country and no sooner had the clover sprung up in the new clearings and the Southdown ram got hoven upon it and died. The two remaining rams not having been accustomed to much high living, since their arrival, became pugnacious upon the clover and in a pitched battle the Leicester ram killed the Cotswold and remained solus. An epidemic appeared among the cattle and 26 fine bullocks died within a few days; 5 Australian horses died during the first year and everything seemed to be going into the next world.

The appearance of the soil has deceived everyone especially the black soil of the patina, which my bailiff on his first arrival declared to be excellent. Lord Torrington who was well known as an agriculturalist was equally deceived. He was very confident in the opinion that "it only required draining to enable it to produce anything." The real fact is that nothing will permanently succeed in Ceylon soil without abundance of manure, with the exception of cinnamon and coconuts.

....Can any man when describing the fertility of Ceylon be aware that...newly cleared forest land will only produce one crop of miserable grain called Korrakan.

....The great proof of the general poverty of Ceylon is shown in the failure of every agricultural experiment in which a rich soil is required. Cinnamon thrives, but why? It delights in a soil, sand in which nothing else will grow. Coconut trees flourish for the same reason, sea air, a sandy soil and a dry subsoil are all that the coconut requires. On the other hand, those tropical products which require a strong soil invariably prove failures. Sugar, cotton, indigo, hemp and tobacco cannot possibly be cultivated with success."[14]

The 'white' settlers in the tropics soon discovered that the reserves of plant nutrient accumulated over thousands of years under the tropical rain forest were quickly dissipated and the promised harvest of 'spices' failed to materialise. Moreover, the settlers were accustomed to a rotational agricultural system -- the Norfolk-course or one of its derivatives -- in which stock were integrated into arable farming as were fodder and manure crops. In the Straits Settlements, there were few stock and attempts to introduce others failed because of disease -- on at least one occasion:

> "imported with the commissary of a China expedition which camped on Singapore esplanade in 1840."[15]

Neither was there suitable pasturage for the common lalang, which invaded forest clearings, was so unpalatable that no animal could touch it except possibly the water buffalo, when the shoots were very young. It is not surprising therefore that European planters achieved only limited success until the end of the 19th century.

Captain Richard S. Burton, who was subsequently to gain fame in his search for the source of the Nile, contributed to a more realistic assessment of the potentialities of tropical forest soils while travelling in Brazil in 1868. In his book Explorations of the Highlands of Brazil, he writes:

> "The vegetation of these high grassy lands offers a wonderful contrast to the dense forest of the seaboard and the serra, where the visible horizon may often be touched by the hand. This singular fecundity of vegetable matter, this "plica" of growth, is apt to deceive the stranger by suggesting a fertility and depth of soil. If he will penetrate into the "lush" he will find the true roots running along the surface so as to feed upon every possible inch of shallow humus, and the shallow radical discs of the prostrated giants show that no tap-root has been able to strike down into the ferruginous argile of the huge red clay heaps and mounds, whose core of blue gneiss often lies within a few feet of ground, and when these trees, perhaps the produce of a century, and forced by hot-house atmosphere, with rain and sun ad libitum, are once felled, are followed, as has been said, by a second growth of the paler, yellower verdure, which at once betrays the poverty of the soil."[16]

By the beginning of the 20th century there were still a few optimists writing about the potential of the tropical soils, but by and large it was the extreme pessimists who carried the day.

Examples of continuing optimism are to be found for example in a Governor's Memorandum from British Guiana in 1928, in which there was no direct reference to the soil, but the message is clear and it reads:

> "British Guiana has the unenviable reputation of being far less developed than any other country in the Empire, possessing equal advantages of natural resources, climate, and geographical situations. The nature of the external trade reveals the fact that British Guiana is not pulling its weight in the Empire. Nor is it playing the part which it should in the modern world, where the demand both for an outlet for the congested populations and the tropical raw products required by manufacturing industries is increasing every year."[17]

It is of interest to look at one of the first treatises on the agriculture of the tropics, published in 1909. The work in question is that of Agriculture in the Tropics, an elementary treatise by J.C. Willis. The author states in the preface to his first edition that the tropics cover so enormous an area that it is obvious that he could only write of much of it from reading, though the general principles set forth will apply to all countries. His experience had been confined to Ceylon, parts of India, Java, the Federated Malay States, Brazil -- where he spent two years as Director of the Botanic Gardens, Rio de Janeiro, and it appears that he made at least brief visits to other parts of the New World tropics, especially the West Indies. In his text, he acknowledged that the richest soils to be found in the tropics are in general the volcanic soils that are located in Java, the West Indies and elsewhere and that there were "very good deposited or alluvial soils in Ceylon, India, the Malay States, and in other countries." He then went on to say:

> "Speaking generally, the soils of the tropics are very poor as compared with those of the temperate zone. Instead of the comparatively dark colour and damp look of the latter, which is partly due to the larger content of humus or decaying organic matter, they show a light colour and rather dry appearance in ordinary fine weather, being very poor in humus. Decay takes place so quickly and so completely that there is but little accumulation of its products."[18]

Amongst social scientists, Pierre Gourou, a French geographer, is one of the best known authorities on tropical settlement, agriculture, and soils. His major work, Les Pays Tropicaux, translated under the title The Tropical World, is considered one of the most authoritative texts on the humid tropical environment. Four editions of the text have carried a most pessimistic picture of the agricultural value of tropical soils. The following quotations admirably illustrate this theme:

> "Tropical soils are poorer and more fragile than those of temperate regions. Great care is needed in using them, if their further impoverishment and destruction are to be avoided. These conditions give tropical agriculture a precarious character which is absent from the temperate belt, except in sub-arid regions where the agents of erosion are on the look-out for ground that has been cleared."[19]

> "For climatic reasons tropical soils are poor and tend to become poorer quickly. This would not be so bad if the soil remained in its place and kept a friable structure favourable to agriculture. But tropical soils are threatened with erosion and lateritization, the latter tendency being peculiar to hot, wet lands. Soil erosion is universal, but in tropical regions it assumes a very violent form. The aridity of bare soil exposes it helplessly to wind-erosion in the dry season and to the attacks of tremendous downpours at the beginning of the rainy season."[20]

> "Lateritic soils are no less of a disadvantage. A good deal of the hot, wet regions is covered with soils which are highly lateritic or of pure laterite. Now, laterite is utterly infertile. Composed of hydroxide of iron and of aluminium in variable proportions, it contains no element which is assimilable by plants: no soluble matter, lime, potash, nitrogen, phosphoric acid, or humus. On the other hand, laterite is hostile to vegetation owing to its compact texture and impermeability. The lateritic crusts in Guinea (bowal) and Senegambia are absolutely useless."[21]

> "On the whole, tropical soils are less favourable to man than temperate soils, which are richer and more stable. A study of the composition of the two types of soils always ends in the establishment of the overwhelming superiority of the temperate over the tropical in fertile chemical elements. This superiority is due to the climate, tropical conditions being especially favourable to the destruction of humus, the leaching away of the bases, and to lateritization. Owing to these special conditions, man has not generally secured control of the arable soil in the tropics. It is therefore not surprising that tropical peoples are often few innumber and have not built up higher civilizations of their own. Civilization can be developed only if it rests on a firm control of the soil, and this control is secured with more difficulty in the tropics than in the temperate belt."[22]

There is an essence of truth in most of Gourou's statements but, in nearly every case, he greatly exaggerates. In fairness to Gourou, with whom the author was able to hold discussions during the course of preparing this thesis, he is no longer as pessimistic. In his fourth edition of The Tropical World he acknowledges the error and exaggeration implicit in his attempt to illustrate the poverty of tropical soils. This he tried to do by comparing average yields of a number of crops grown both in the tropics and in the mid-latitudes, a task which most expert agronomists still find beyond them. In the Fourth Edition he states:

> "Is the poverty of tropical soils reflected in their crop yields? It is tempting to think so, for statistics show that the yield per acre of rice or maize is much lower in tropical than in temperate lands, and a comparison of Java with Japan seems to clinch the matter, for in the former the rice yield is 1,650 lbs. per acre and in the latter 4,460. But perhaps it would be better not to make such comparisons, for almost inevitably the items in question will not be strictly comparable."[23]

Meanwhile, Gourou's pessimism has had its impact.

Soils under Tropical Grasslands and Savannas

Soils under tropical grasslands and savannas are as extensive as those under tropical rain forest. For every reference to the potential of tropical rain forest soils, there is probably a reference to the potential of savannas or grasslands both for intensive cattle grazing and agriculture. All the early Europeans visitors to Africa who witnessed the wealth of fauna in lush tall grasslands in the savannas, could be forgiven the enthusiasm they showed for their agricultural and settlement potential, especially as some areas were already quite densely settled. Numerous Portuguese travellers, missionaries and others, journeying in the interior of Brazil, during the 17th, 18th, and 19th centuries, commented enthusiastically upon the agricultural potential of the interior grasslands and savannas. And the optimism survived to the present century. In 1913 Theodore Roosevelt travelled through the interior of Brazil and recorded the results and impressions of his journey in Through the Brazilian Wilderness, a work in which he frequently comments upon the potential of the savanna as for example:

> "North of this marshy plain (the Pantanal) lies the highland Pan Alto, where the nights are cool and the climate healthy....The country is excellently suited for settlement and offers a remarkable field for cattle growing."

And elsewhere,

> "The country along this river is a fine natural cattle country, and some day it will see a great development"

And in regard to the complex of forest and savanna on the approaches to the Amazon, he stated:

> "The country round about is healthy, it is an upland region of good climate...there is much fertile soil in the neighbourhood of the

> streams and in the teaming lowlands of the Amazon and the Paraguay, could readily and with immense advantage to both sides, be made tributary to an industrial civilisation seated on these highlands."[24]

Burton, whose perceptive assessment of some of the forest soils of Brazil has already been quoted, also displayed a fine appreciation of characteristics and variations in the "campos" soils of the Brazilian highlands. Following his comments on the forest soils, he continues:

> "On the other hand the Campo, apparently a heap of stones and stunted grass, inhabited principally by armadillos and termites, is apt to suggest the idea of stubborn sterility, which is far from being the case. I have not yet seen in the Brazil what Mr. Bayard Taylor calls the "spontaneous production of forest from prairie land". Botanists and travellers, moreover, do not agree about the original clothing of the country: some believe that it was always barren of timber; others that it was in old days a primeval forest. The truth lies probably between the two extremes.... The soil greatly affects the vegetation, often, travelling over the Brazilian Campo, we cross a short divide, and find on the farther side the growth assumes almost a new facies, without difference of frontage without apparent cause. But everywhere in the Campos, however barren, there are rich bottoms admirably fitted for the cultivation of corn and in most of them, Capoes or tree clumps, flourish on the slopes, where they are sheltered from the wind and extend along the margins of the streams. Wood, after water, the settlers' prime want, will still last here for many generations."[25]

In the settlement of Brazil, the claims for the superiority of forest land over savannas or campos, for agricultural purposes, has been a major theme. James, Waibel, Carmin, and many others have written authoritatively on aspects of this subject and, of course, the theme is one that appears to be typical of the settlement of nearly all the continents, tropical and extra-tropical. In contrast to the Brazilian tradition, many European immigrants brought with them a tradition of preference for black fertile grassland soils over forest soils. In Brazil and other continents, the boundary of forest and savanna or campos or grassland took on a particular significance because, for the main part, forest occupied the land for several hundreds of miles from the coast, often giving way quite abruptly to some form of grassland or savanna. In Australia, the boundary was no obstacle because the settlers came equipped with flocks of sheep, ready to exploit the grasslands. The cultivator followed in due course. In the United States, the boundary took on a very considerable significance for as W. P. Webb stated in The Great Plains,

> "The Great Plains offered such a contrast to the region east of the 98th meridian the region with which American civilisation had been familiar until about 1840, as to bring about a marked change in the ways of pioneering and living. For two centuries, American pioneers had been working out a technique for utilisation of the humid region east of the Mississippi River. They had found solutions for their problems and were conquering the frontier at a steadily accelerating rate. Then in the early nineteenth century they crossed the Mississippi and came out on the Great Plains, an environment with which they had had no experience. The result was a complete though temporary breakdown of the machinery and ways of pioneering....As one contrasts the civilisation of the Great Plains with that of the Eastern timberlands, one sees what may be called an institutional fault running from Texas to Illinois or Dakota, roughly following the 98th meridian. Up this fault the ways of life and of living changed...the weapons, the method of tilling the soil, the ploughs and other agricultural implements, and even the laws themselves were modified."[26]

Webb comments upon the plight of the settlers,as they crossed the Mississippi,in the following way:

> "East of the Mississippi civilisation stood on three legs -- land, water and timber; west of the Mississippi not one but two of these legs were withdrawn,-- water and timber -- and civilisation was left on one leg -- land. It is small wonder that it toppled over in temporary failure."[27]

Webb may well have exaggerated the impact of this boundary but there is no doubt that it was significant in the progress of the frontier westward across the North American continent.

The concept of the association of the best soils with forest growth is an old one in Brazil, and in some respects, it has developed quite naturally. Settlement proceeded from the coast inwards of which many good soils are located. The frontier advanced via the alluvial soils of river valleys and low gaps in the Serra do Mar, in time to gain access to such rich soils as the Terra Roxa or famous 'coffee' soils. Once the best soils were occupied and while the discovery of others was awaited, agriculture was adjusted to poor forest soils by means of, what Waibel has designated, a 'primitive land - rotation system', a system which left no room for livestock husbandry. Meanwhile, on the interior savannas and on the campos of southern Brazil, a grazing culture developed which ignored the potential for cultivation in either the surrounding forest areas as in the south, or the forested valleys or forest islands, as in Goias and the Mato Grosso. The inhabitants of these regions showed a contempt for the cultivator, a culture trait not uncommon of grazing or pastoral cultures or cattle kingdoms around the world.

In this century as the agricultural frontier did emerge from the forest zone, as in southern Goias, the association of certain crops and land value with a variety of forest and savanna types, became traditional. Waibel and others have described the classification of agricultural alnd that resulted. It is set out in Table 1.

TABLE 1

CLASSIFICATION OF AGRICULTURAL LAND

GOIAS - BRAZIL

1. Mato do Primeira classe - or first class forest
2. Mato do Segunda classe - or second class forest
3. Capuerao - or second growth forest
4. Cerradao - or dense savanna woodland
5. Campo cerrado - or open savanna woodland
6. Campo sujo - or shrub steppe
7. Campo limpo - or grassland or steppe

[See Photos 26, 27, 28 and 29.]

The relationship of these categories to soils and land values is presented in Table 2 .

From the turn of the century, Brazilian governments have recognised the attitude to campos and savanna soils as a major obstacle to the "Marcha para oeste" or the westward expansion of the settlement frontier, and as a result have encouraged certain colonists to settle and experiment on campos soils. Prior to the turn of the century, German colonists, against the advice of the authorities, chose for settlement a campos site in the Campos Gerais of Parana, in preference to a forest site, because of their homeland experience. The result was a complete failure. Half a century later, 100 odd miles from the earlier site, another group of German colonists settled successfully at Terra Nova. One factor that contributed to the success of this colony was the skillful combination of the cultivation of adjacent forest and campos soils, the former under a system of land rotation and the latter under a system of crop rotation. Table 3 illustrates the contrasting yields on the forest and campos soils.

PHOTO 26

Mata Primeira Classé

PHOTO 27

Campo Cerrado

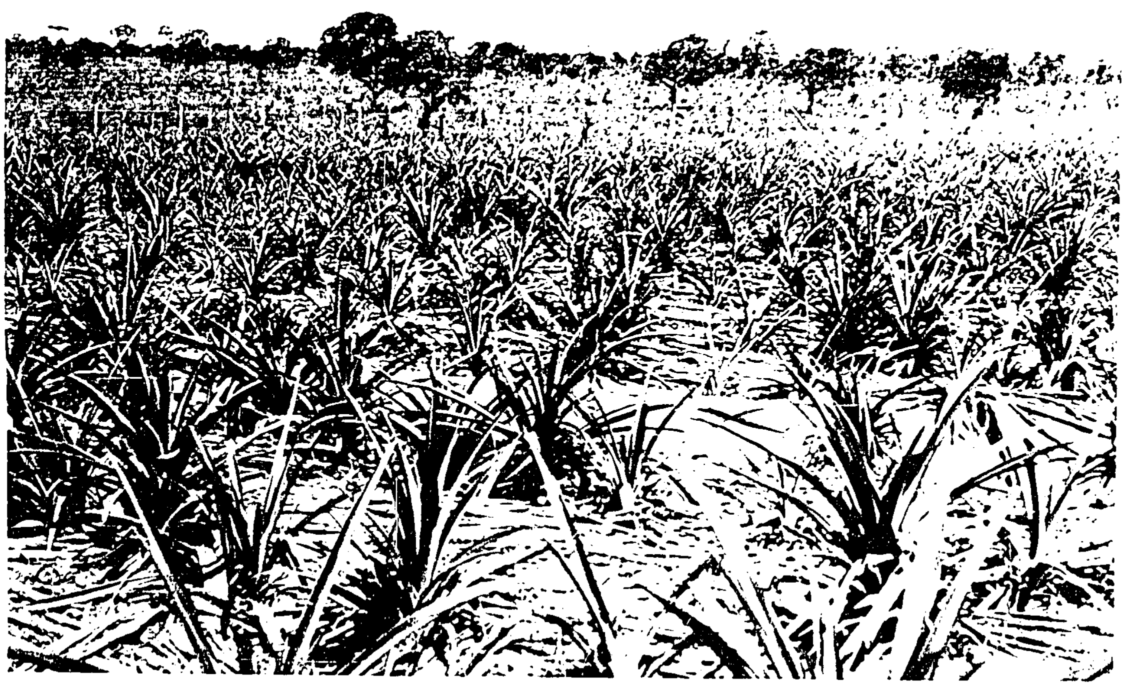


PHOTO 28

Campo Limpo

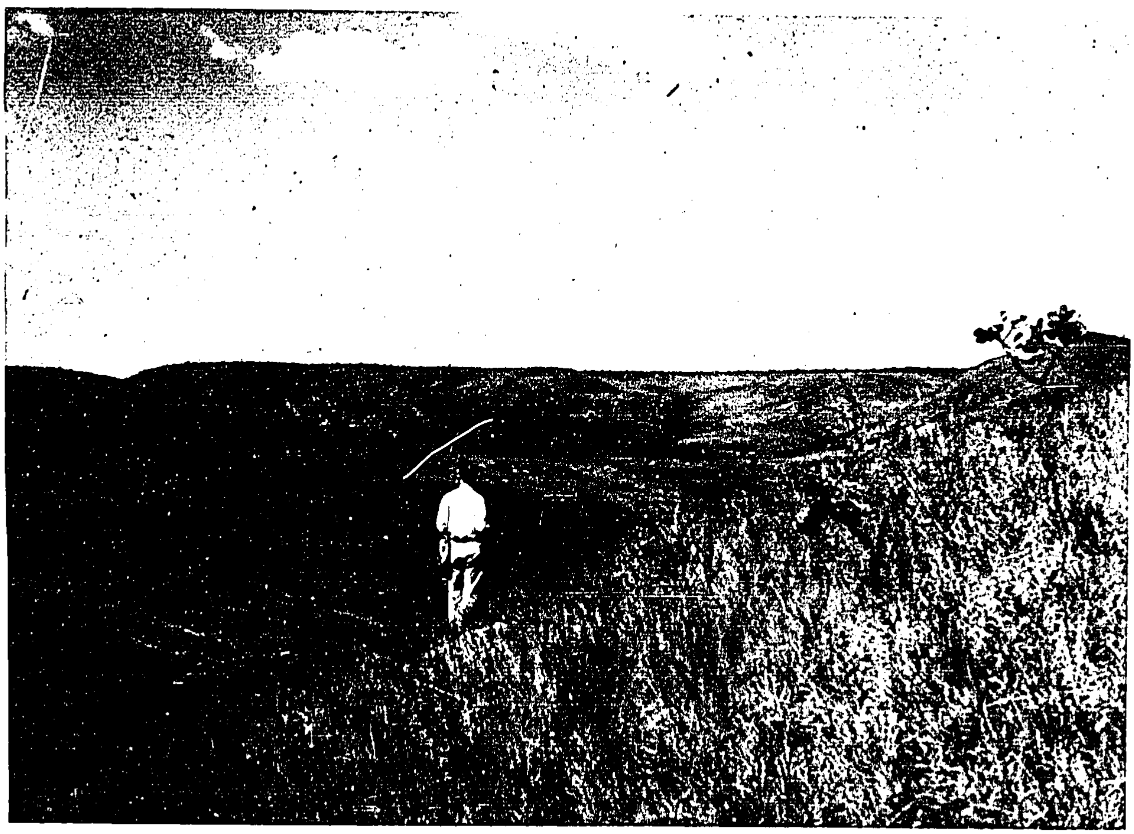


PHOTO 29

Aggradation

AGRICULTURAL PRODUCTION FOR GOIAS, ANAPOLIS PRIMARY TRADE AREA, AND ANPOLIS MUNICIPIO, 1947

Product	Value in Cruzeiros for Goias[a]	Value in Cruzeiros for Anapolis Trade Area[b]	Per cent Primary Trade Area of Goias Production	Value in Cruzeiros for Anapolis Municipio	Per cent Anapolis Municipio Production of Anapolis Trade Area Production
Rice	191,037,390	95,402,986	49	64,060,000	67
Corn	81,434,455	26,498,580	32	8,736,000	32
Mandioca	46,033,880	9,799,780	21	340,000	3
Beans	41,124,260	11,474,710	27	5,263,650	45
Sugar Cane	35,075,400	7,752,208	22	720,000	9
Coffee [c]	25,162,985	14,841,728	58	7,200,000	48
Tobacco	11,328,550	3,083,800	27	900,000	29
Cotton	4,503,820	523,405	11	48,000	9
White Potatoes	2,345,350	1,667,225	71	1,170,000	70
TOTAL	438 ,046,490	171,044,422	39	88,437,650 [d]	51

Quoted from Carmin, p. 139.

TABLE 2

TABLE 3

APPROXIMATE YIELD PER HECTARE OF

CROPS IN TERRA NOVA

	on Grassland	on Forest Land
Corn...............	4,000 kg.	1,500 to 2,250 kg.
Rice...............	3,000 kg.	
Wheat..............	about 1,500 kg.	
Rye................	1,000 kg.	

Two Dutch colonies, one at Carambi and the other at Castrolandia, established in 1911 and 1951 respectively, have also illustrated how campos soils, even though initially low in fertility, could be improved and become productive under an intensive agricultural system characterised by typical Dutch land management methods.

Turning now to the campo cerrado or woodland-savanna soils, Waibel and Carmin both raise doubts about the traditional assessment. Waibel has stated that:

> "throughout Brazil people believe that the Campo Cerrado like other campo lands is not suitable for crop cultivation and can be used only to graze stock. This belief is based entirely on assumption. The argument is that so far crop cultivation in Brazil has been limited to forest land and has never been practised on campo land. There is no doubt that the Campo Cerrado has been avoided mainly for the reason that there is still good forest land available, which under the present agricultural methods (shifting cultivation) produces satisfactory yields. But this does not mean that the Campo Cerrado land is uncultivable. The present situation of agriculture in Brazil might be compared to the conditions that prevailed in Central Europe at the beginning of medieval times. At that time crop cultivation in Central Europe was limited to the best soil, the loess that in the opinion of many scholars supported a campo vegetation. The loess farmer in Germany in about A. D. 500 probably believed that only the open lands could be cultivated and that forest could

be used only for grazing swine. He would be surprised today to see how forests have been transformed into fertile fields and artificial pasture lands. I am convinced that in the not too far distant future there will be a similar change of thought regarding the Campo Cerrado. Although such crops as sugar cane, corn, rice and coffee will probably still be cultivated on former forest lands, less exacting crops such as manioc, pineapple, and cotton will be raised on cerrado lands."

Carmin, who worked intensively in southern Goias in the late 1940's, stated in regard to Mato (forest) and cerrado soils that:

"The field observations made by the author often presented evidence that indicated exceptions to the rule, that campo and cerrado lands are relatively useless for agriculture, but only cursory soil examinations could be made." [29]

Eight years later, when the author travelled with Carmin in the same region, many more exceptions to the rule were noted. Ten years later a research institute located on savanna soils in Central Brazil, was able to state as follows, in a conclusion to one of their publications:

"Tropical agriculture traditionally has developed in areas where the native soil fertility could be exploited. In Brazil the agriculture has developed primarily on lands which were in forest. In the state of Sao Paulo practically all the rich forest soils have been utilised and these once rich soils have become depleted of fertility, and much of the surface layer has been lost through sheet erosion. Today the productive capabilities of these soils are severely restricted.

Many of the campo cerrado soils which have never been used intensively are favourably located for agricultural development. Through the proper use of lime and fertiliser, it is possible that these soils can become as productive as the old crop lands. Evidence has been presented here to indicate the soil fertility components required to produce high crop yields and farming profits. Furthermore, it has been demonstrated by farmers who followed these recommendations that the practices can result in good economic returns." [30]

CHAPTER 11

THE CASE OF THE NORTH PARANA LAND COMPANY OR COMPANHIA DE TERRAS NORTE DO PARANA

-- successful European Appraisal

The North Parana Land Company has been selected for more detailed investigation because it provides an example of successful European appraisal of soil in a country abounding in myth and misconception. Other reasons for the choice are as follows:

1. The author had the opportunity of studying the Company's operations approximately 30 years after they were initiated.

2. The Company was responsible for the most successful colonisation scheme in Brazil and in this period of colonisation, one of the most successful in the whole of the tropical world.

3. The perception of the qualities of the soils of the region, firstly by the man who founded the company and subsequently by company officials, and settlers, is reasonably well-documented.

4. The system of land division used is one that provided for full recognition of the variations in soil conditions.

The lands of the North Parana Land Company cover approximately 500 square kilometers of that physiographic region of southern Brazil commonly known as the Terceiro Planalto, a formation which owes its morphology primarily to alternating layers of lava and sandstone, which are slightly inclined to the west and which are also drained in that direction, that is to the Parana River basin. In the eastern half of the company's land, basic rocks are uppermost with sandstone outcropping in the valleys. To the west, there is an inversion of this disposition and

PHOTO 30

Terra Roxa Legitima

PHOTO 31

Terra Roxa Legitima

and sandstone predominates on the upper surfaces. The major rivers are consequent to the slope towards the Parana basin and the subsequent streams are fairly symmetrically entrenched in the plateau.

The soils of the region correspond closely to this simple geological pattern. The basic eruptives give rise to the famous 'terra roxa' soils, which are locally subdivided into 'terra roxa legitima', the best of the 'coffee' soils which develop on the upper surfaces, and 'terra roxa misturada', the mixed red earth, which generally occur in the valleys where lavas overlie sandstone. Both soils have relatively high natural fertility but their suitability for coffee especially, arises largely from their friability and their retentiveness. Where the lavas are well buried by sandstones, 'terra arenosa' and 'terra vermelha arenosa', or sandy soils occur. The "arenosa" are much lower in fertility and much less moisture retentive. It is estimated that the economically productive period of a coffee plantation without the use of fertiliser is 30 to 40 years on the 'terra roxa' soils and about 15 years on the 'terra arenosa' soils. (See Photos 30 and 31).

The climate of northern Parana results largely from the interaction of three air masses, and of these, the maritime (south Atlantic) tropical air mass is dominant. Its presence results in sub-tropical temperatures and humidity conditions, while continental equatorial air brings a measure of humid tropicality to the region along with heavy rainfall. The latter ranges from 1200 millimetres annually in the west to approximately 1700 millimetres in the eastern limits. The climate is in most respects transitional between that of the remainder of southern Brazil and that of central Sao Paulo. One of the outstanding features is occasional frost, which results from the incursion of polar air. Killing frosts have been experienced once or twice a decade since the 1920's and two severe attacks in 1953 and 1955 were almost a national calamity.

With the possibility of frost, relief, especially aspect, takes on a particular significance. Firstly, temperature inversion will occur in the deep valleys of the plateau without an actual incursion of polar air, however damage is negligible because valley bottoms are generally in pasture. When the penetration of the polar air is strong and deep, the south-facing slopes or "noruegas" (Norwegian) slopes suffer the most. Ordinarily the divides and north-facing slopes experience very little frost. However, in 1953 when the polar air mass penetrated the region via the valleys of the Ivai and Paranapanema rivers, the north-facing slopes suffered as much, if not more.

The story of man's occupance of the region is taken up at the point where Lord Lovat (Simon Joseph Fraser) perceived of North Parana as a region of considerable agricultural potential. It is important, in terms of the objectives of this thesis, to establish why Lovat perceived these potentials where others had not. Poorer, less accessible regions of Brazil had been settled yet this particularly well-endowed region had not.[1]

Firstly, why was Lovat in Brazil? He went to Brazil in the winter of 1923-24 as a member of the Montagu Mission which was in Brazil at the request of the Brazilian Government to conduct an investigation of hitherto unexploited resources.[2] Lovat saw a great deal of Brazil, especially the inner regions, and was impressed with what he saw of the terrain and soils of Northern Parana, and what he had learned about the the nature of the climate. At that time he looked upon the region as a potential cotton growing area. While in Brazil, he also learned enough of the history of colonisation and of the development of the State of Sao Paulo to appreciate why so many colonisation schemes had failed to come up to expectations. He learned of poor planning and especially of inadequate surveying of the colonisation lands themselves, as well as inadequate transportation links with markets.

It is clear from Lovat's background that if anybody was to appreciate the potentialities of northern Parana, it was he, and if colonisation of the region was to be planned and conducted successfully, there were few, if any, more able men available for the task.

Lovat developed an appreciation for the land and husbandry on his family's Scottish estate. At an early stage, he was confronted with the impoverished conditions of the crofters of this estate. He subsequently improved their condition and it was said of him that it is doubtful if any landowner of the times expended such a large proportion of his income on improving the estate, both the land and the lot of the labourers.[3] As a result of his contact with South Africa during the Boer War, he developed plans for land settlement in the Transvaal and the Orange River colony.[4] He subsequently initiated a number of settlements in South Africa and rapidly gained experience in selecting land and settling the farmers upon it. In the course of one of these schemes, the Mushroom Land Settlement, which operated in Swaziland from 1910, he initiated a training farm which was established on one of the estates where intending settlers could spend about two years in preliminary training and in visiting farming areas for the purpose of selecting their land. The next phase of his career was characterised by his involvement in the Sudan. Here he was largely responsible for the introduction of many of the features of land development and settlement that made the Gezira scheme, not only one of the major cotton growing regions of Africa, but also one of the outstanding land development and colonisation schemes in the world.

It was with this backlog of experience that Lovat arrived in Brazil in 1923. It is not surprising then that he initially looked upon some parts of Sao Paulo and northern Parana as potential cotton growing regions. In fact, in 1923 he formed a company which established two cotton producing estates, one in Sao Paulo and one in northern Parana. However, following an initial success, the estates failed due to slumping cotton prices.[5]

Lovat returned to Brazil in 1925 and, with the encouragement of the Brazilian government, he formed another company -- Parana Plantations Ltd. -- which immediately proceeded to acquire 2,000,000 acres of northern Parana for the purposes of colonisation.[6]

To this stage, Lovat had developed certain very definite convictions regarding land development and settlement.

1. From the viewpoint of the National Government or colonial authority, he appreciated the need for continuing settlement and land development and fuller exploitation of resources. In most countries of Africa and South America this was still a pioneering age, for the potential for development and settlement remained unabated in quantity and quality.

2. From the point of view of the industrial metropolitan power, he recognised the insatiable appetite for both industrial raw materials and food supply as well as the continuing need of an outlet for excess population.

3. He appreciated that, from the point of view of both the national government and the metropolitan power, the system of allocating large holdings of land for the purposes of the establishment of the typical tropical plantation or estate had probably come to an end and that most land development in the future must be on the basis of smaller to medium sized individual holdings.

4. Settlers must be carefully selected and well trained if necessary.

5. If land is to be sold to settlers, then the land owners must do everything possible to provide the settlers with a reasonable chance of success. To this end he considered the following facets of land development of the greatest importance:

(i) Careful selection of the land by the Land Settlement Company, and this meant taking into consideration not only relief, soils, climate, drainage, etc., but also a careful investigation of all existing claims to the land.

(ii) A system of land division which would allow for full recognition of physical variation in land quality and a method of survey which would enable a simple registration of land titles.

(iii) Security of tenure.

(iv) Agricultural training, short-term or long-term, according to the experience of the settler.

(v) Encouragement of a 10-year programme which would provide for better balanced production, thus avoiding the ills of monoculture so typical of the settlement of Sao Paulo.

(vi) The association of railway and road building and the establishment of towns with the sale of land and colonisation.

(vii) Very close coordination of land division, transportation, housing and conservation.

(viii) In the context of Brazilian colonisation, he appreciated the need, as did the Brazilian government, for a mixture of Luzo-Brazilians and other ethnic groups, especially Japanese and certain European settlers, who had the reputation of practising more advanced methods of cultivation and conservation.

It is not the purpose of this chapter to relate the complete history of the Northern Parana Company but rather to concentrate on those aspects pertaining to the use and perception of the soil.

Firstly, in order to place the efforts of the North Parana Company in proper perspective, the achievements and problems of colonisation and settlement in southern Brazil up to the 1930's should be reviewed briefly.[7] In many respects the settlement and colonisation activities in southern Brazil in the period 1820-1930 are one of the great achievements of Brazilian economic, social, and political development. As many Brazilian social scientists have stated, this was the period and the region in which the economic and social foundations of true rural democracy were laid. An 'institutional fault' developed along the Sao Paulo-Parana border with the rural economy and society to the north being dominated by latifundia, while to the south a population of free small farmers was settled on the land, largely by means of the active intervention of the Brazilian government. From the vantage point of today, Brazil should be able to look back with great satisfaction upon this period in its history. However, as of 1930, a great many problems existed -- some of which have not yet been solved to the complete satisfaction of the Brazilian government nor of Brazilian society in general.

The Brazilian Federal government and the State governments, especially those of Santa Catarina and Parana, had followed a policy, especially since 1870, of encouraging and assisting the immigration and colonisation of specific national groups because it was thought that these groups could make a significant contribution to the improvement and development of agriculture in Brazil. The agriculture of the Luzo-Brazilian and, by now, that of many of the earlier European colonies was of a very poor quality. It was hoped that the settlement, in their midst, of advanced agricultural groups, would result in a general improvement of agriculture. By and large, this was not to be, for reasons stated very clearly by Waibel:

> "Almost all the colonists of European origin were poor and relatively inexperienced in agriculture. In most cases they were settled in areas far from sizeable urban markets, which in time forced them to practise a subsistence agriculture and to employ primitive agricultural systems."[8]

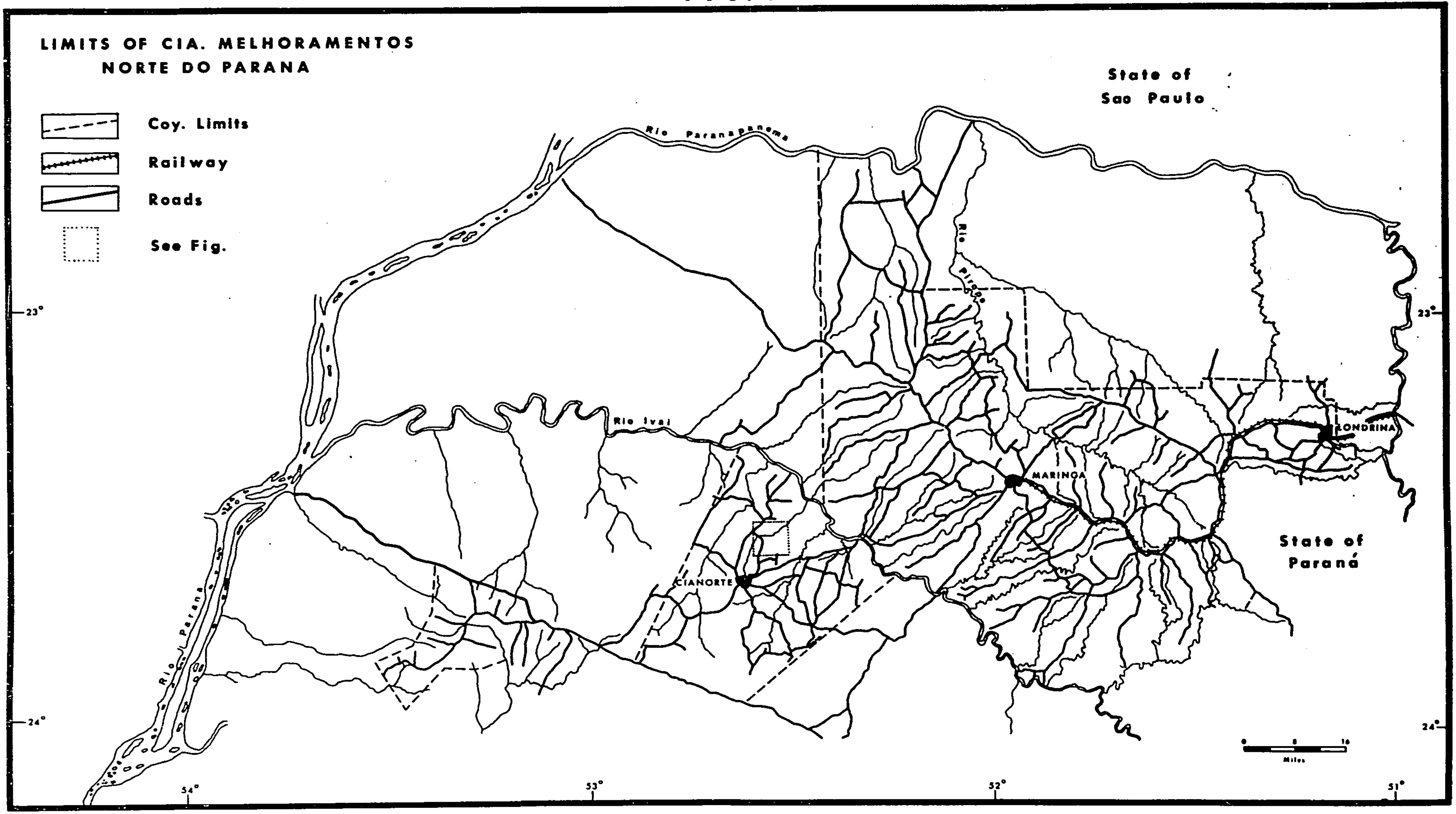
Waibel estimated that in 1954 all but 10 per cent of the colonists were practising either a primitive crop rotation or land rotation, the latter quite often in circumstances where continuous use of land under crop rotation was possible and desirable. Considering that the systems of land rotation was so rapidly adopted, the standard allocation of 35 hectare plots, regardless of the quality of the land, was quite insufficient. However, in addition there was the tendency of the European colonist to develop 'ethnic cysts', a phenomenon which has been described, analysed and explained in a wealth of social, political geographical literature. Perhaps the most serious shortcoming was the completely inadequate transportation network. In the first place, colonists had difficulty in getting themselves and their belongings to the colonies, but the most serious deficiency came subsequently when their agricultural produce needed a market. The necessary roads and railroads rarely existed. Lovat and his company officials were fully aware of this history and of the growing concern of the Brazilian government over its failings.

An excellent survey of the regional development of North Parana has been provided by Dozier and thus there is no intention of repeating that analysis.[9] The following would appear to be the significant stages in the implementation of the policy developed by Lovat and his company.

Firstly, in 1925, Lovat formed the Parana Plantations Ltd., a London company operating two Brazilian subsidiaries. One for colonisation, the Companhia de Terras Norte do Parana, and the other for the development of roads and railways, the Estrada de Ferro Sao Paulo - Parana. Evidence is here immediately provided of Lovat's conviction that the opening up of actual occupation of land must be closely associated with the construction of roads and railways. In the latter case, the extension of the railroad from Ourinhos in Sao Paulo state to Londrina (see Figure 9) was commenced almost immediately.

Secondly, the company proceeded to purchase from the state 12,463 square kilometers of completely undeveloped forest covered land west of the Tibagi river. This 2-year operation involved both the survey of the physical qualities of the land and of the adjustment of all claims

FIG. 9


LIMITS OF CIA. MELHORAMENTOS
NORTE DO PARANA
Coy. Limits
Railway
Roads
See Fig.
State of
Sao Paulo
State of
Paraná
Rio Paranapanema
Rio Pirapo
Rio Ivai
Rio Parana
LONDRINA
MARINGA
CIANORTE
23°
24°
54°
53°
52°
51°
Miles

to the land. Again, here is evidence of Lovat's conviction that the land to be purchased and re-sold must be of a given quality and that security of tenure must be assured. The survey that was conducted at this stage was the first of many and it disclosed that there was quite a considerable variation in quality, especially in soil quality.

Once the property as delimited in Figure 9 belonged to the company, a survey was undertaken of the site that was to become the first city, Londrina, to the division of the property into two hundred thousand hectare sections, each of which were to be developed as a unit -- re-surveyed, opened for sale, roads constructed, etc.

The next stage was one of the most significant as far as this discussion is concerned. It comprised the sub-division of each of the major units. The plan adopted was the sub-division of the land into lots according to a standard pattern though not a symmetrical pattern. Roads were constructed along the heights of all the inter-stream divides and then the lots were stretched towards the rivers and streams (see Figures 10 and 11). In the early stages of the colonisation of Brazil, land was surveyed in traditional Brazilian style, that is back from the waterfront either from the coast line or river bank and roads generally followed the winding river valleys. This system had its advantages and disadvantages. It did allow for adaptation of settlement patterns and farm organisation to features of the natural landscape. However, as water courses and divides follow irregular lines, it is extremely difficult to obtain a precise measurement of the land.

FIG. 10

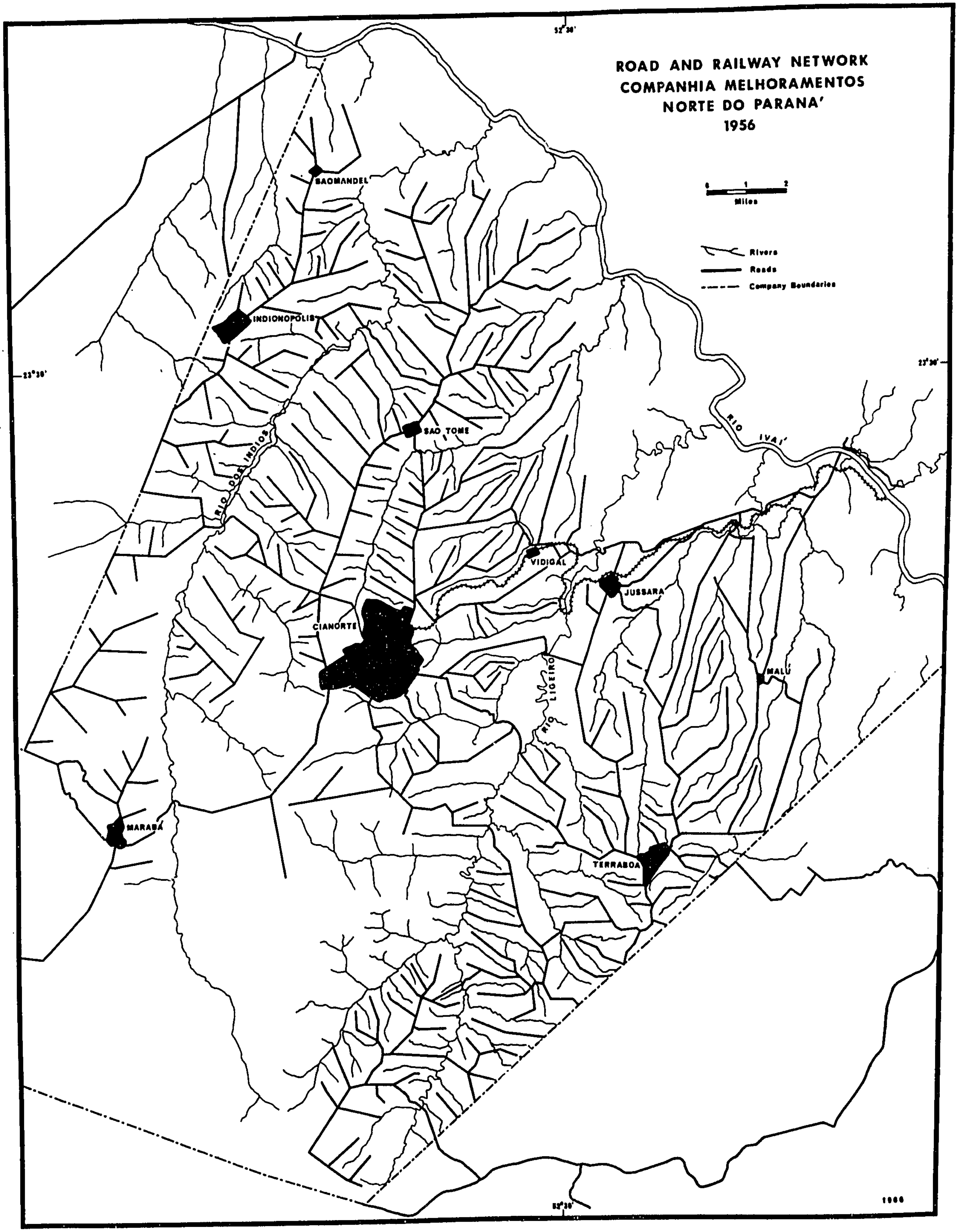
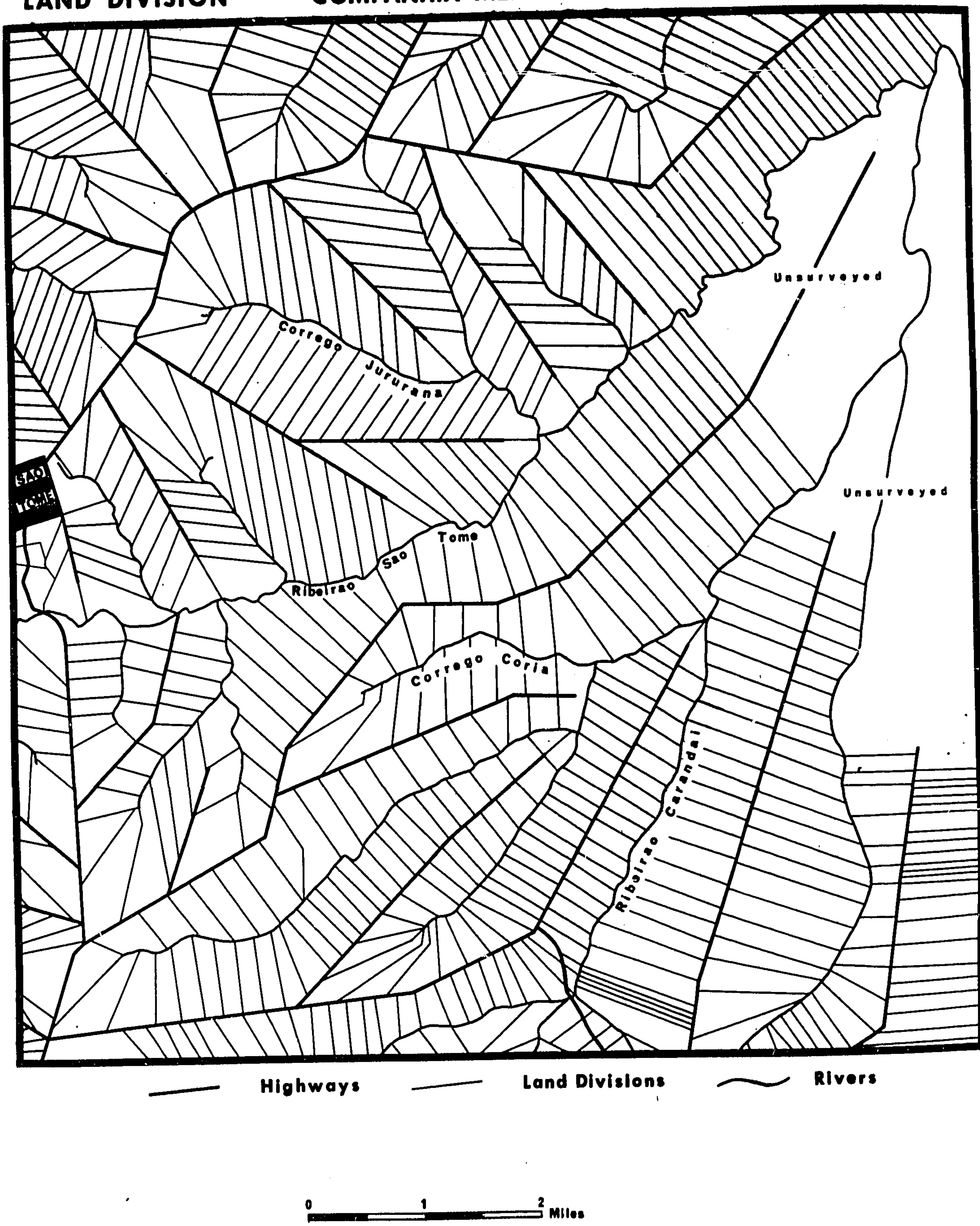

ROAD AND RAILWAY NETWORK
COMPANHIA MELHORAMENTOS
NORTE DO PARANA'
1956
Miles
Rivers
Roads
Company Boundaries
BAOMANDEL
INDIONOPOLIS
SAO TOME
RIO DOS INDIOS
RIO IVAI'
VIDIGAL
JUSSARA
CIANORTE
MALU
RIO LIGEIRO
MARABA
TERRABOA

FIG. 11

LAND DIVISION — COMPANHIA MELHORAMENTOS NORTE DO PARANA'



Lynn Smith, the outstanding scholar of Brazilian settlement and survey, has stated:

> "The manner of dividing the land, surveying the boundaries of rural properties and recording the titles of agricultural holdings, are amongst the most significant aspects of the relationship of man to the land. All three are so closely inter-related that they really constitute a single part of the land system. In the analysis of this situation, in any country, there are two aspects that should be clearly kept in mind: 1) the extent to which land surveys are determinate and permanent, and 2) if the farmers reside on their land, as is generally the case in Brazil and the United States, the extent to which the system in use permits farmhouses to be located near one another, makes for economy of the building, upkeep, and use of roads, electric lines, and other facilities, and allows adaptation of settlement pattern to the natural environment, for maximum adjustment to and benefit from topographical and structural features of the landscape such as slopes, watercourses, soil types, and vegetation."[10]
>
> The first colonies (in Southern Brazil) however, were marred by one serious defect in their system of land division. The irregular jagged line formed by the rear boundaries of the holdings created great complications for future settlement of the area. It also prevented the fullest adaptation of settlement forms and farm layouts to the topography of the area settled. Since the colonists were hewing homes from a wilderness, perhaps a great deal of importance should not be attached to any disadvantages that accrued to future settlers. Certainly the early settlers adopted a pattern well fitted to their own needs.
>
> Gradually, as experience was secured, practices were modified and systems of dividing the land were perfected to higher degrees. This important feature in the relationships of man to the land seems to have reached its highest stage of development in the colonisation projects of the North Parana Land Company and in the official colonies established by the state government of the former fazendas of Santa Catarina. Variations in size of farms sold or allotted are secured by increasing or decreasing the width of the holding, never by modifying the stream - to - divide principle of determining their length. This system is a feature of the long lot farm, thus allowing the surface to capitalize on the social and economic advantages of line - village settlement patterns. At the same time it permits a high degree of adaptation to topographical features, both of the farm layout and of the settlement pattern. It gives each settler access to water, to various kinds of timber and both the lowlands and the uplands. In short each settler participates in all the advantages and disadvantages of the natural setting."[11] (See Photos 32, and 33).

PHOTO 32

Land Use Pattern, North Parana -- Coffee on the divides, pasture in the valley, other crops on the middle slope.

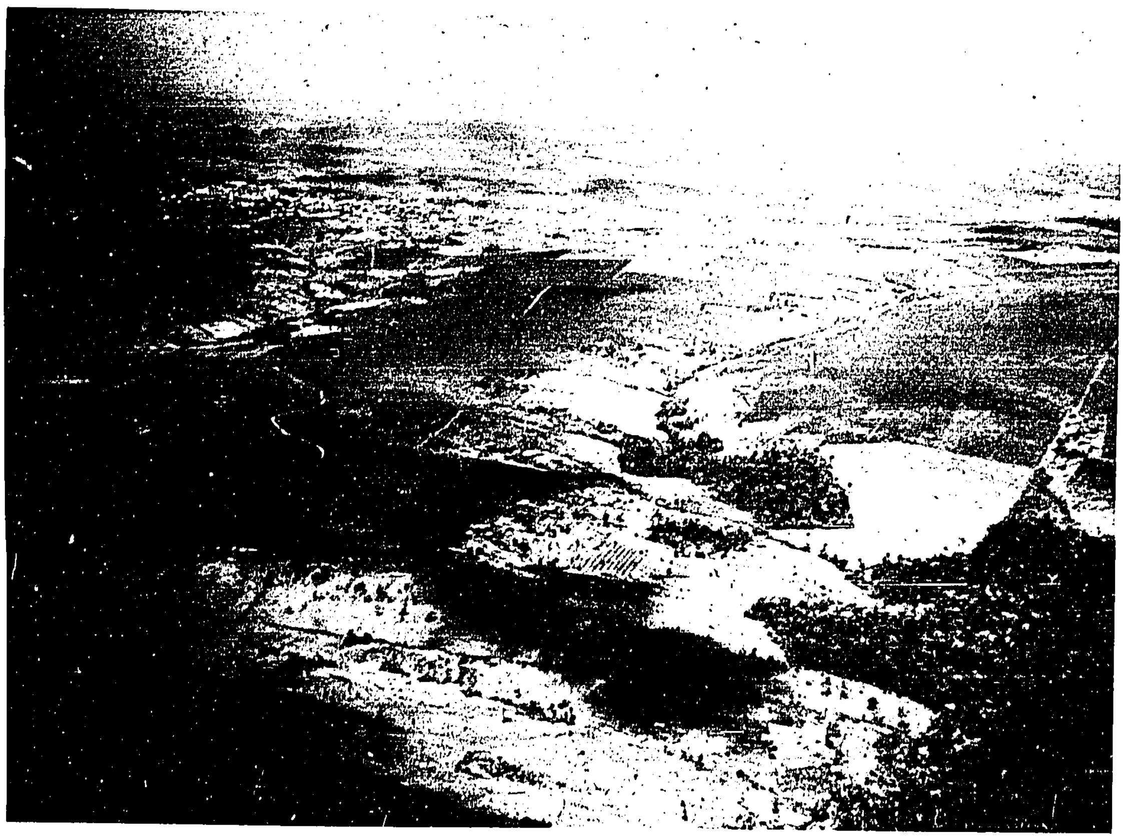
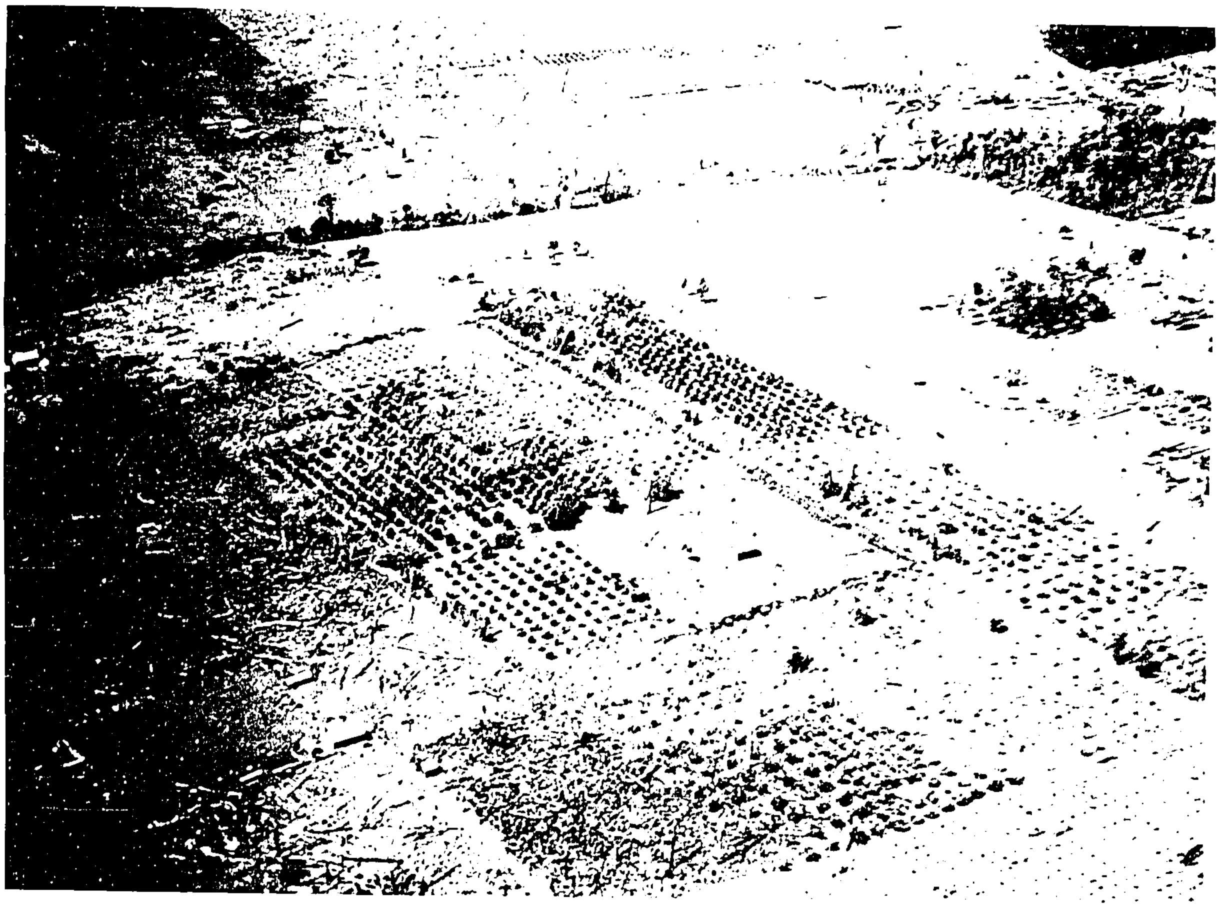


PHOTO 33

Land Use Pattern, North Parana



Apart from urban subdivision, there were two categories of rural lots on the company's land. Small farms or chacaros with a maximum area of about 12 hectares were located on the immediate outskirts of the towns. Beyond, were the smallholdings or 'sitios' of a minimum of 12 hectares and averaging approximately 40 hectares.

Next came the settlers. Contrary to hopes, largely due to the world-wide depression of the early 1930's, settlers arrived somewhat slowly and, of those that came, the majority were Brazilians. Colonists of Japanese origin, either directly from Japan or via the fazendas of Sao Paulo, were thought to be potential settlers of high quality, but Colonia Assai, established in northern Parana in 1931 by the Japanese colonisation company -- the Sociedade Colonizedora do Brasil Ltd. -- diverted a large number of them. Lovat made journeys through Europe in 1931 and 1932, visiting Danzig, Germany, Poland, Austria and met with some measure of success, immigrants from Danzig arriving to settle in the vicinity of Londrina as early as December 1931.[12] However, throughout the history of the colonisation scheme, the proportion of Luzo-Brazilians has remained high.

Where did these settlers come from? Why did they decide to settle in northern Parana and what was their agricultural background? There are no detailed statistics of the place of origin of the settlers, both rural and urban, however, existing reports and the author's own statistics indicate that the majority of those who had not immigrated directly to northern Parana, came from various parts of southern Brazil and neighbouring areas of Sao Paulo and amongst these settlers were European immigrants with a decade or more of residence in Brazil as well as first generation Brazilians of European origin.

What was the cultural background of these people? The following categories can be recognised:

1. Labourers from fazendas in Sao Paulo and to a limited extent from the other states of Brazil.

2. Immigrants who were labourers on European estates or farms.

3. Farmers from various parts of Brazil, who until the move to northern Parana, had operated for purposes of agricultural production a property they either owned or rented.

4. Farmers from European countries who had either owned or rented land.

5. Urban dwellers who were either new to rural life or who had been away from a farm for five years or more.

These people left their European or Brazilian location for a variety of reasons, the majority seeking the opportunity of operating a better farm in better social and economic conditions. Some of the Europeans left because of political and/or religious persecution.

Many of the settlers from southern Brazil of Luzo-Brazilian or European origin had participated in colonisation schemes that were failures because of both poor transportation facilities and poor division of land. In their isolation and neglect they had either not risen above their hoe-bush fallowing type of agriculture, or in the case of European immigrants, had perhaps degenerated to that level. Many of the labourers knew only the planting of coffee, manioc and beans. The selection of land, site, soil and crops had probably never been their concern.

What led the settlers to choose lands in northern Parana? R. Carmin, with whom the author had the opportunity of travelling in Central Brazil in 1956, has suggested that one or more of the following factors are considered by a farmer before he chooses a new place of residence.

"1. Accessibility to market and supply areas.
2. Apparent soil productivity for known marketable crops.
3. Healthiness of site -- malarial areas are avoided.
4. Nearness to areas already heavily settled.
5. Promised success - inducement by government and through private advertising.
6. Proven productivity - areas already producing good crops attract additional settlers.
7. Probability of employment - those people too poor to buy land seek employment."[12]

As Carmin states, the first three factors are the most critical - only those places which possess all three are densely settled. An area may possess two of the three factors but lack the third one and thereby fail to support a large rural population.

Lack of access to market and supply areas was recognised by the majority of potential settlers as a factor vital to success. Many of them had suffered due to the lack of such attributes. Most advertising (samples of which the author was able to view in the files of the company in Maringa) showed the company's block of land at the end of a railway running almost due west of Sao Paulo, along with all the necessary tributary or feeder roads. The most direct road or railroad from potential source regions of settlers were also shown, a feature which emphasised the accessibility of region. According to the company's plans, there were four categories of markets.

1. Overseas

2. Sao Paulo and the larger towns of Sao Paulo state and Parana.

3. The major company towns, Londrina, Maringa, etc.

4. The smaller towns from which the settler was never more than 5 to 6 kilometers distance. Here it is most important to remember that the roads and railroad went ahead of the settlers.

The Brazilian's attitude to land, especially the association of vegetation and soils, has already been discussed in the previous chapter. On the company's lands, campos and cerrado were represented only to a negligible extent. It was essentially 'mata primeira classé' land. The company advertised their land as being occupied by 'terra rocha' soils. That was enough, or almost enough, because most Brazilians knew something of the appeal of the rich 'coffee' soil. This fact, when associated with a statement to the effect that the settlement of the company's lands was a westward extension of the famous Sao Paulo coffee frontier, and one primarily for the benefit of 'sitiante' or smallholder, not the 'fazendeiro', had great appeal. Not that the company was interested in promoting an extension of monoculture, but the appeal and benefits of coffee could not be denied and were not ignored by a company which initially had trouble in finding sufficient and suitable settlers. The company accepted the challenge of coffee, knowing full well that on much of their property only a proportion of each lot was ideally suited to coffee, by organising the promotion of a more rational land use, to be discussed in detail later.

Word of the success on the predominantly 'terra rocha' soils to the west of Londrina and the success of the Japanese colonists at Colonia Assai, located not far from the company's lands to the south of

Londrina, spread rapidly and news of success, spreading by word of mouth and by means other than advertising, is what interested the potential settlers.

Few more healthy areas could be found in the whole of Brazil, what with a near sub-tropical climate, an elevation of 600 to 1,000 meters and moderate rainfall.

Carmin's factors, 4, 5, and 6, have already been given sufficient attention. Those merely interested in employment were not given much encouragement, because it was the small landowner-operator to whom the company was appealing. Subsequently, as the company developed its lands, fazendas developed beyond its property in order to benefit from the excellent transportation facilities and markets. These fazendas did provide employment which, to many labourers, became a stepping-stone to the purchase of a company lot.

In contrast to many parts of the Brazilian frontier, the company's lands held no prospects for the squatter, as the company had clear and definitely established full rights to all the land they occupied.

Of the 100 or more settlers the author questioned in 1956, the majority of whom had purchased company lots since 1940, most were attracted by what they considered as reliable reports of a successful colonisation scheme and success was measured by the fact that there was a lot of very good coffee land thought of in terms of soil and relief, not climate; that prices of land were reasonable (not cheap) and security of tenure was provided; and every property was connected to a road and was never far from a railroad. Further questioning and reports from company officials indicate clearly that many of the settlers, regardless of the reports they had received, did not expect to practice a type of agriculture very different from that they had been used to -- that is some form of land rotation or bush-fallowing. The company, aided directly or indirectly by the better European immigrant settlers, the Japanese immigrants and the best Brazilian settlers, both recommended and set the example of improved land use and cropping system. Their objective was achieved in the following ways:

(i) The basic division of the land, which allowed for full exploitation of the attributes of the land.

(ii) Soil surveys the results of which were made available to prospective settlers. Initially company officials were merely able to recommend land use on the basis of the survey but in later years were able to do so on the basis of a fertiliser programme.

(iii) Through the development of markets categorized earlier, a varied demand existed almost from the beginning of the colonisation scheme, which was an inducement to the diversification of agriculture and land use.

Crops and pasture were adapted to the variation of soil type, slope and microclimate in the following ways:

SOIL TYPE	SLOPE		
	Upper	Medium	Lower
1. Terra Roxa legitima	Coffee	Coffee	Coffee
2. T.r. legitima and misturada	Coffee	Coffee	Pasture
3. Terra arenosa Terra vermelha arenosa, T.R.l., T.r.m.	Coffee	Corn, rice manioc & cotton	Pasture
4. T.arenosa & T. silicosa	Potatoes	Coffee	Pasture and rice.

This chapter clearly indicates that a people's attitude to the land and to components of it are significant in settlement or lack of it. It has also illustrated that the agricultural background, motivation and guidance of settlers is of the very greatest significance in a consideration of the role of soils and in the development of a group's relations to the land.

Also present is evidence of the validity of the 'possibilist' hypothesis.

In the settlement of Southern Brazil, settlers were offered several possibilities. There is evidence of both the correct and the incorrect choice being made. In the case of Northern Parana, every attempt was made to determine the full range of possibilities, and having done so, the correct choices appear to have been made. This is especially true of the selection of a land division system which has allowed for a more rational use of the soils of the region.

CHAPTER 12

TROPICAL FOREST AND SAVANNA SOILS

- Indigenous Use and Appraisal

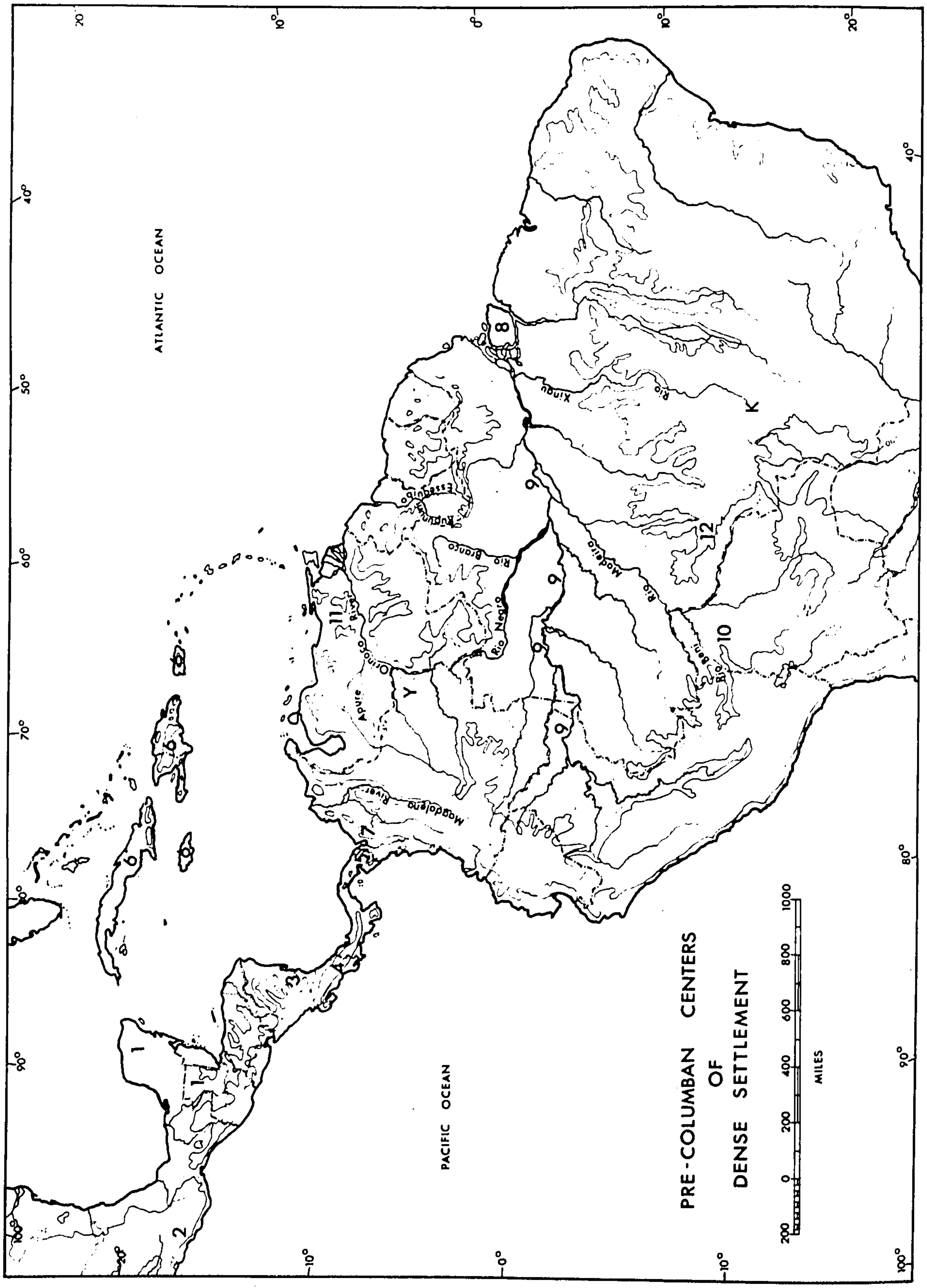
Increasing evidence of dense populations in pre-Columban times, in what are today sparsely settled parts of the New World humid tropics, obviously at least in part, supported by the tropical soils of the region, suggests the possibility of either changes in the physical environment, especially the soils, or changing cultural appraisals of sites in the New World tropics.

There would appear to be value in investigating where feasible, the role of soils in the support of these relatively densely settled pre-Columban populations. If the attitudes to, and perception of, soil by these peoples can be ascertained, there will be a useful basis for comparison with the 'appraisals' of the Europeans as discussed in the previous chapter.

The specific objectives of this chapter are as follows:

1. To describe the location of these pre-Columban centres or regions.
2. To establish, if possible, for each of the locations, the present day nature of the physical environment, especially the soils.
3. To consider the possibilities of changes, either natural or man-made, in the physical environment during the last 2,000 years or more.
4. To establish the nature of the land use and the system of agriculture prevailing in the region during the period,or periods,of dense population
5. To ascertain if at all possible, the relations between man and the soils supporting him in each of the regions, with particular

FIG. 12


PRE-COLUMBAN CENTERS OF DENSE SETTLEMENT
MILES
0
200
400
600
800
1000
ATLANTIC OCEAN
PACIFIC OCEAN
Rio Xingu
Rio Madeira
Rio Branco
Rio Negro
Rio Beni
Essequibo
Rupununi
Orinoco River
Apure
Magdalena River
K
Y

attention to any evidence of the manipulation or management of soils, in such a way as to reflect the nature and/or degree of perception of the soil by the cultivator or others in the society.

6. To explain or speculate on the decline in, or disappearance of, these centres of dense settlement.

Location

On the basis of the writings of Lathrap[1], Denevan[2], Sauer[3], Steward[4], Parsons and Bowen[5], Rouse[6], Meggers and Evans[7], Gourou[8], Cowgill[9], and Carter[10], and others, it has become increasingly evident that many areas within the humid tropics of Middle America and South America, in the period from approximately 2,000 B.P. to the arrival of the Europeans, supported dense populations in comparison with the population occupying these regions today. Figure 12 indicates the general location of these areas. They are from North to South:

1. The pre-Maya and Maya areas of southern Mexico and northern Central America.
2. The south-west coast of Mexico
3. The Pacific coast of Nicaragua
4. Valle Géneral of south-western Costa Rica
5. Eastern Panama
6. Greater Antilles - Puerto Rico, Hispaniola, Cuba and Jamaica.
7. The Cauca, San Jorge and Sinu valleys of Columbia
8. Marajo Island (mouth of Amazon)
9. The central and upper Amazon Valley
10. Llanos de Mojos, Bolivia.

In addition, there is evidence of pre-Columbian occupation of savanna regions based upon agriculture where today the form of occupance is primarily extensive grazing.

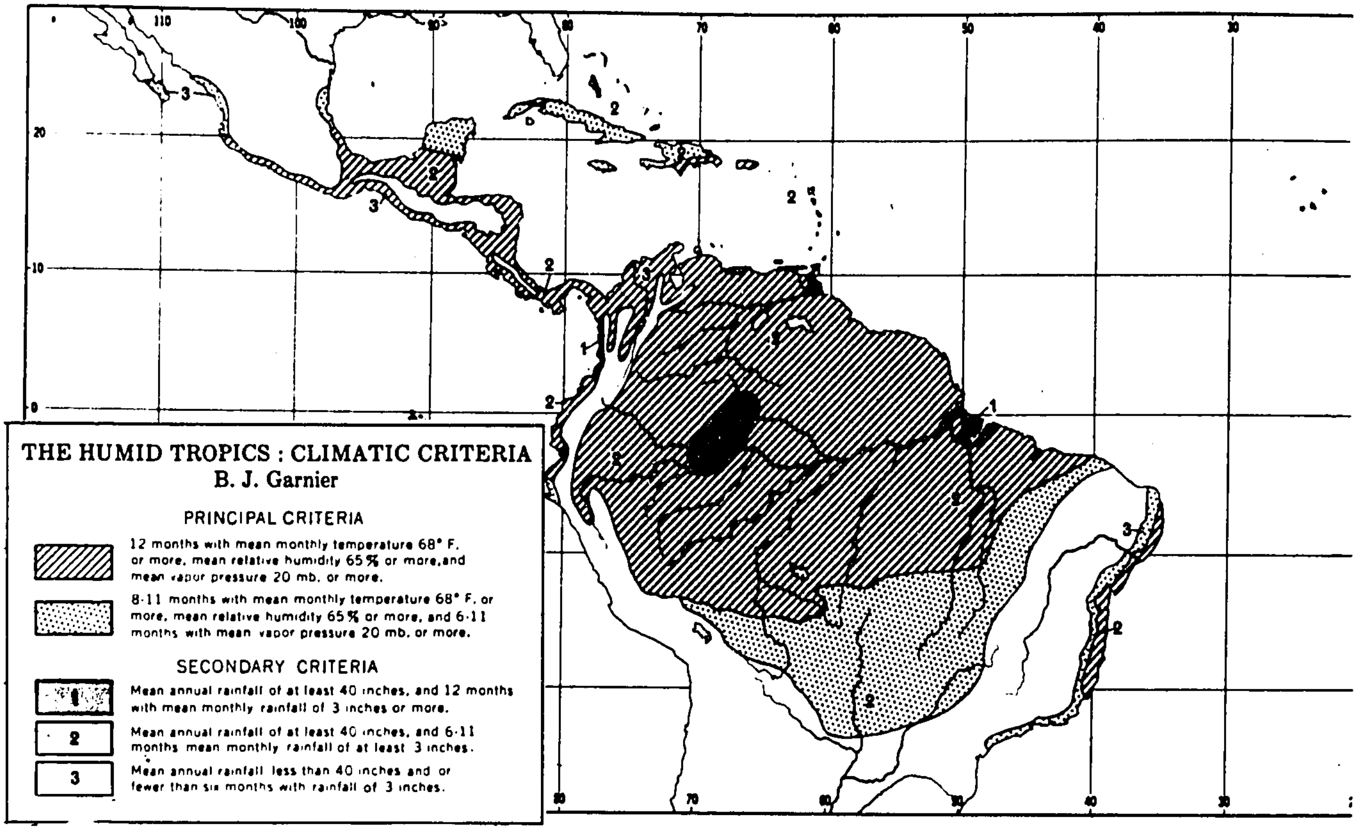
11. Llanos del Orinoco
12. On the Divide between the Rio Guapure and the Serra dos Parecis (Mato Grosso).

These locations should be considered in relation to the distributions as illustrated in Figures 13, 14 , 15, and 16. Associations of considerable significance can be observed. Firstly, the locations are mainly lowland valley or plain sites; secondly, they are all within the humid tropics according to either Garnier or Kuchler; thirdly, all sites are located within the same soil region according to the latest FAO/Unesco Soil Map of the World; fourthly, they are all either on, or adjacent to, Sauer's postulated "routeways"; and fifthly, several of the centres are located on, or close to, savanna landscapes.

For purposes of more intensive analysis, the following regions will be considered:

1. The Maya areas of Central America
2. The Amazon Basin
3. The Llanos de Mojos, Bolivia

FIG. 13


THE HUMID TROPICS : CLIMATIC CRITERIA
B. J. Garnier
PRINCIPAL CRITERIA
12 months with mean monthly temperature 68° F. or more, mean relative humidity 65 % or more, and mean vapor pressure 20 mb. or more.
8-11 months with mean monthly temperature 68° F. or more, mean relative humidity 65 % or more, and 6-11 months with mean vapor pressure 20 mb. or more.
SECONDARY CRITERIA
1
Mean annual rainfall of at least 40 inches, and 12 months with mean monthly rainfall of 3 inches or more.
2
Mean annual rainfall of at least 40 inches, and 6-11 months mean monthly rainfall of at least 3 inches.
3
Mean annual rainfall less than 40 inches and or fewer than six months with rainfall of 3 inches.

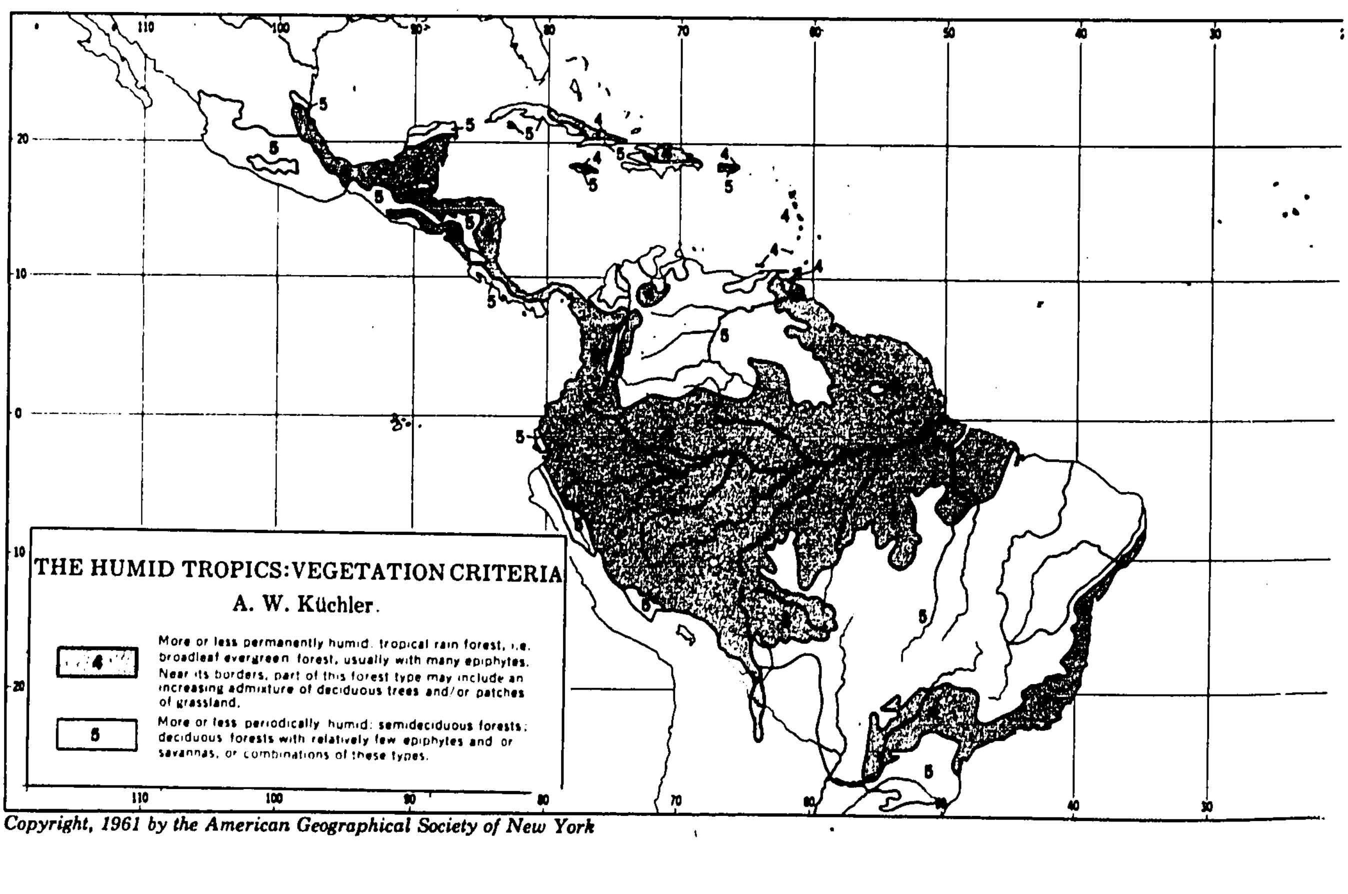

THE HUMID TROPICS: VEGETATION CRITERIA
A. W. Küchler.
4
More or less permanently humid tropical rain forest, i.e. broadleaf evergreen forest, usually with many epiphytes. Near its borders, part of this forest type may include an increasing admixture of deciduous trees and/or patches of grassland.
5
More or less periodically humid: semideciduous forests; deciduous forests with relatively few epiphytes and or savannas, or combinations of these types.

FIG. 14

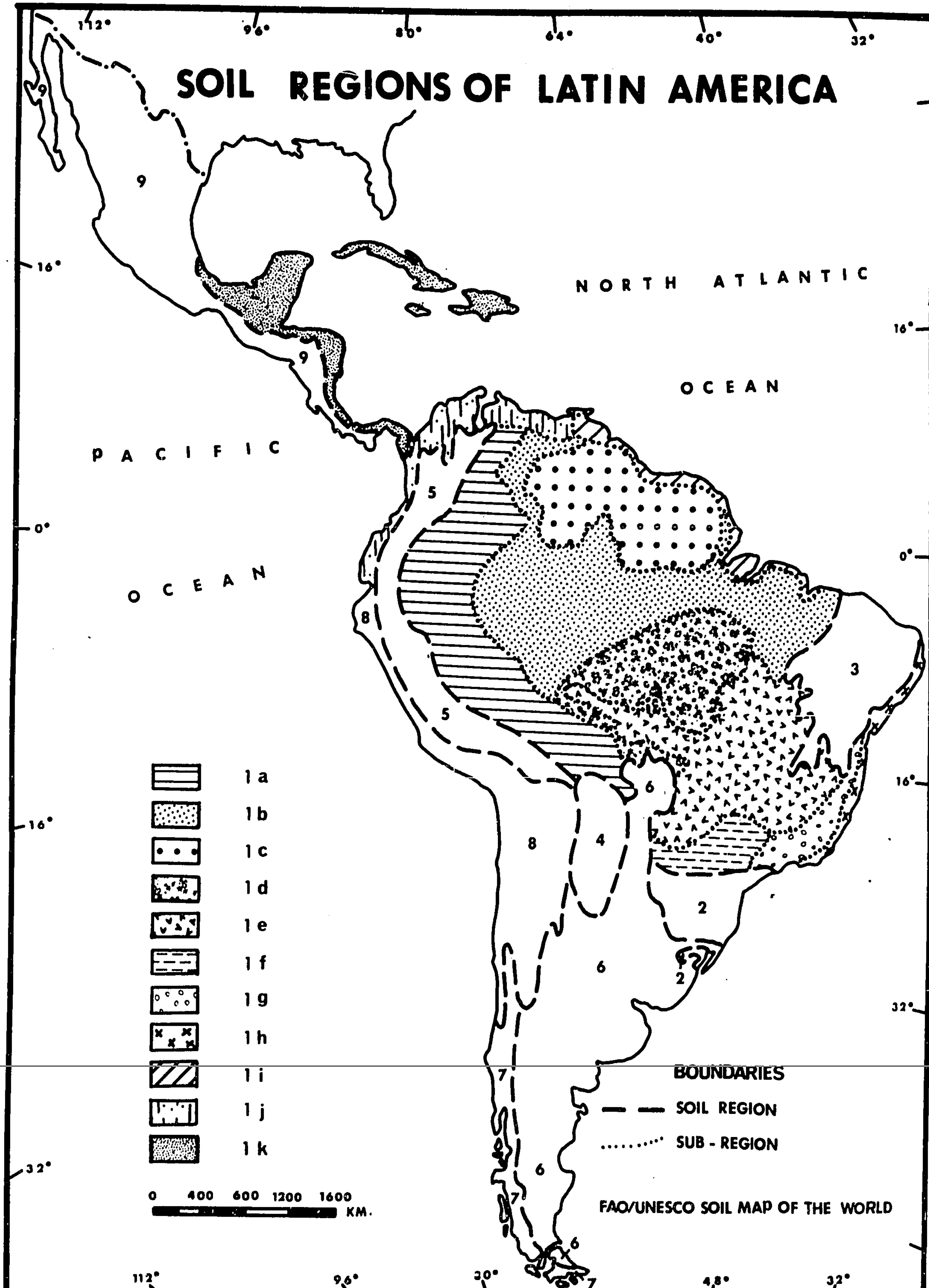

SOIL REGIONS OF LATIN AMERICA
NORTH ATLANTIC
OCEAN
PACIFIC
OCEAN
1 a
1 b
1 c
1 d
1 e
1 f
1 g
1 h
1 i
1 j
1 k
0 400 600 1200 1600 KM.
BOUNDARIES
SOIL REGION
SUB - REGION
FAO/UNESCO SOIL MAP OF THE WORLD

FIG. 15

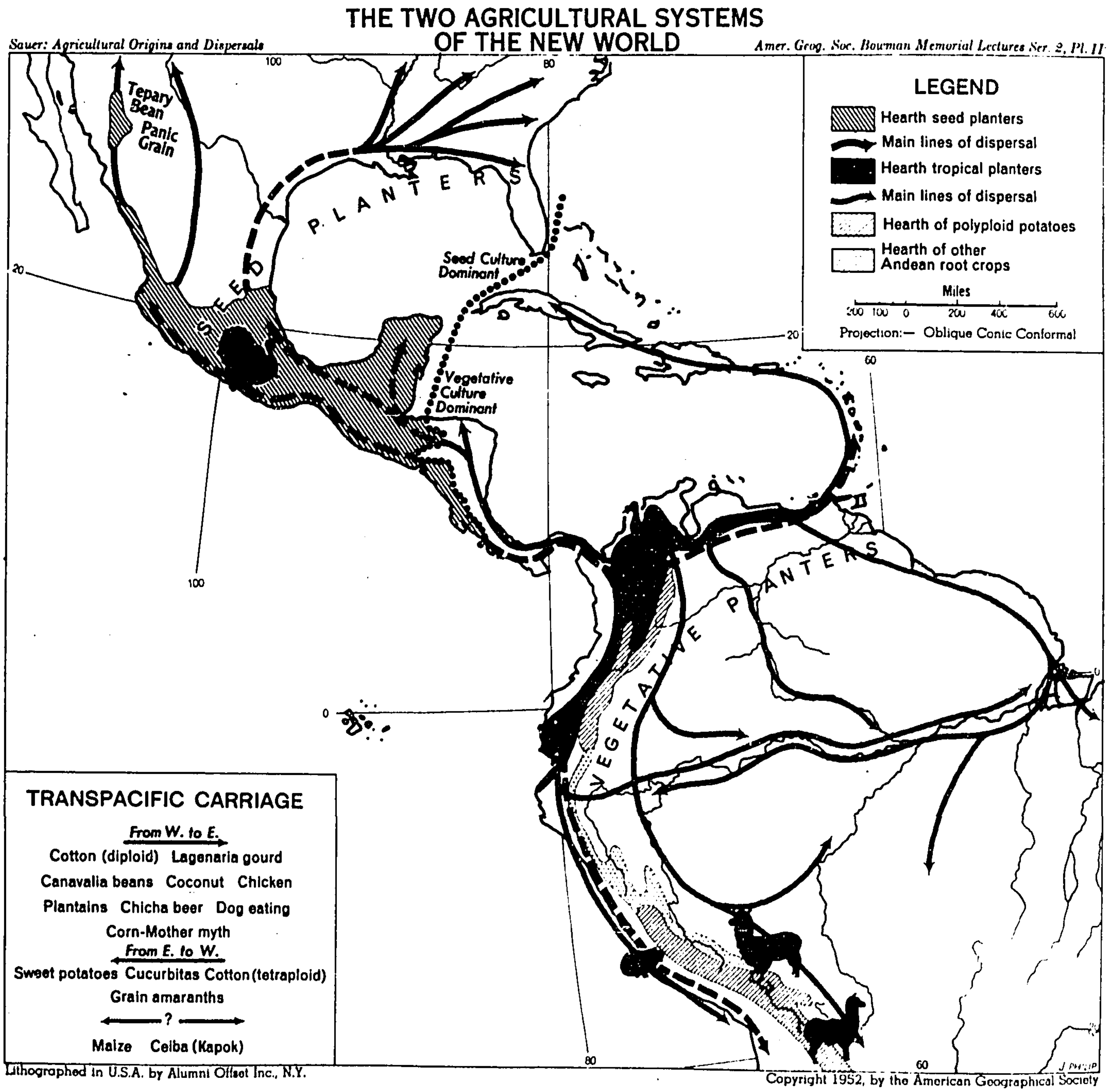
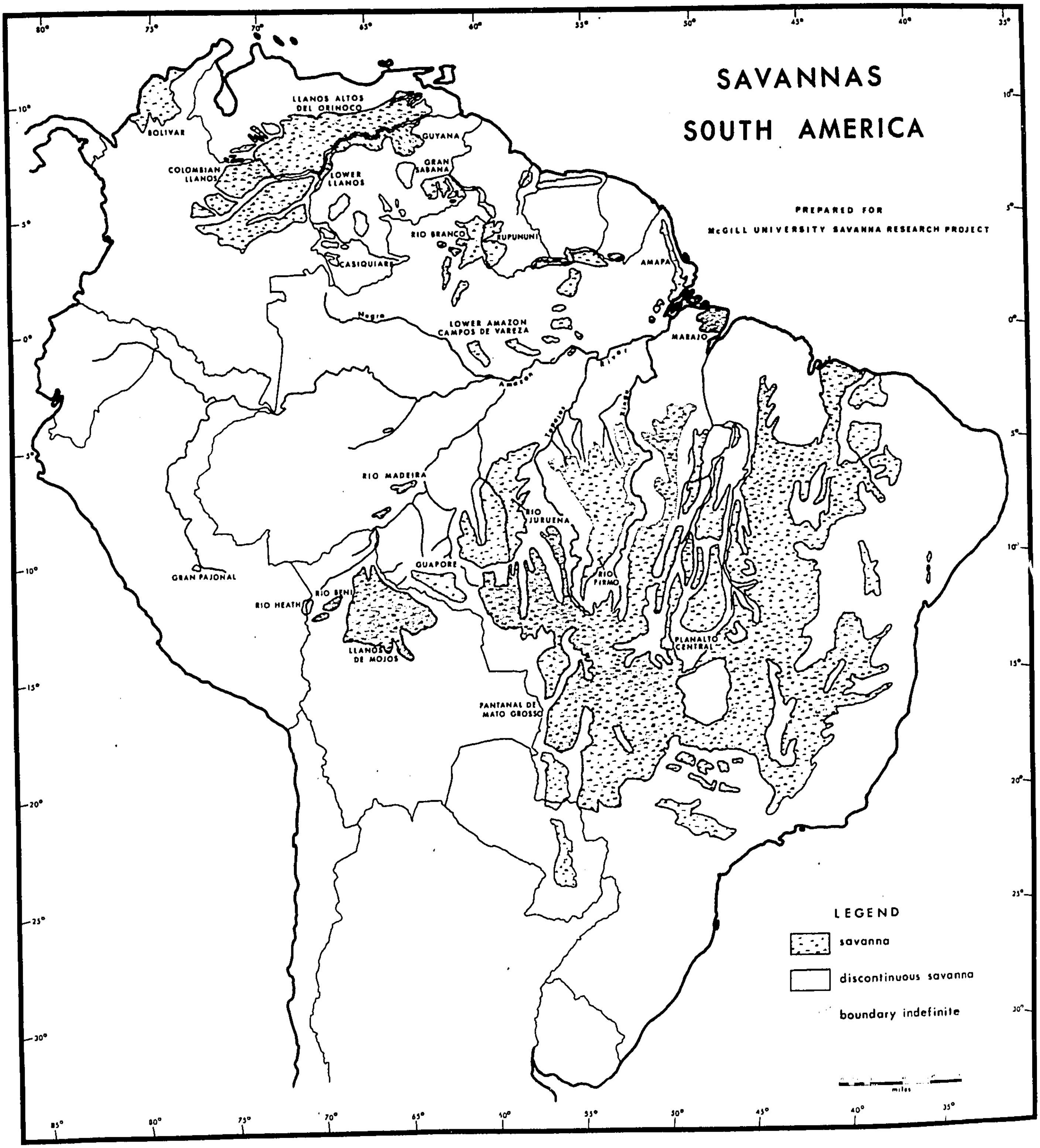

THE TWO AGRICULTURAL SYSTEMS OF THE NEW WORLD
Sauer: Agricultural Origins and Dispersals
Amer. Geog. Soc. Bowman Memorial Lectures Ser. 2, Pl. II
LEGEND
Hearth seed planters
Main lines of dispersal
Hearth tropical planters
Main lines of dispersal
Hearth of polyploid potatoes
Hearth of other Andean root crops
Miles
Projection:— Oblique Conic Conformal
Tepary Bean
Panic Grain
SEED PLANTERS
Seed Culture Dominant
Vegetative Culture Dominant
VEGETATIVE PLANTERS
TRANSPACIFIC CARRIAGE
From W. to E.
Cotton (diploid) Lagenaria gourd
Canavalia beans Coconut Chicken
Plantains Chicha beer Dog eating
Corn-Mother myth
From E. to W.
Sweet potatoes Cucurbitas Cotton (tetraploid)
Grain amaranths
?
Maize Ceiba (Kapok)
Lithographed in U.S.A. by Alumni Offset Inc., N.Y.
Copyright 1952, by the American Geographical Society

FIG. 16


SAVANNAS
SOUTH AMERICA
PREPARED FOR
McGILL UNIVERSITY SAVANNA RESEARCH PROJECT
LLANOS ALTOS DEL ORINOCO
BOLIVAR
GUYANA
GRAN SABANA
COLOMBIAN LLANOS
LOWER LLANOS
RIO BRANCO
RUPUNUNI
CASIQUIARE
AMAPA
Negro
LOWER AMAZON CAMPOS DE VAREZA
MARAJO
Amazon
RIO MADEIRA
RIO JURUENA
RIO PIRMO
GUAPORE
GRAN PAJONAL
RIO BENI
RIO HEATH
LLANOS DE MOJOS
PLANALTO CENTRAL
PANTANAL DE MATO GROSSO
LEGEND
savanna
discontinuous savanna
boundary indefinite
miles

The Maya Region

The Department of El Petén, at the base of the Yucatan Peninsula in Guatemala, today manifests a typical humid tropical landscape. The landscape is predominantly a low plain with many residual hills and numerous lakes, the largest of which is Lake Petén. The vegetation cover of dense tropical rain forest is interrupted only infrequently by low forest, small savannas and "milpa" fields. Mean annual rainfall averages 65-75 inches, with a drier season from November to March, while the temperature range is in the order of about 10° F. maximum with about 86° F. in May and a minimum of 75° F. in January. The Petén Lake region varies in altitude from about 150 feet in the south to 900 feet in the north. Crystalline limestone regions alternate with ridges filled with both calcareous and acidic alluvial deposits. The soils can be described as latosolic with significant calcareous and alluvial influences. An official Guatemalan report on the soils of the country states in regard to the soils of El Petén:

> "Los suelos de los bosques son en su mayor parte fértiles, pero muchos de ellos tienen como factor limitante a su productividad potencial, fuerte pendiente, pedregosidad, poco espesor o mal drenaje. El area de los suelos de los bosques e 89.84% de la superficie del departamento."[11]

The present population density is between 1 to 2 per square mile. This is a remarkable fact considering that, during the first millenium A. D., the Mayan people manifested a culture ranking as one of the high aboriginal cultures of the New World, a civilisation which must have been based on a relatively dense population. Estimates of the population densities during various phases of the Mayan civilisation range as high as 1,000 per square mile (Carter).[12] O. G. Ricketson[13], who attempted to calculate the densities around Uaxactun, to the north of Lake Petén, suggested a population of 48,000 living within 10 miles of the city, which means a density of 470 per square mile. Densities of 100 to 200 per square mile are considered as optimum for cultures depending on a milpa system of agriculture. Regardless of the precise densities, it is obvious that a culture qualifying as a civilisation was supported for many centuries by the Petén environment. We are not necessarily concerned here with the reasons for the collapse of civilisation between the 8th and the 10th centuries A. D., unless, of course, the collapse can be attributed directly or even indirectly to the failure of the soils of the region to support population densities that had prevailed for several centuries.

There is an extensive body of literature (Gourou[14], Cook[15], Hester[16], Means[17], Sapper[18], Morley[19], Kidder[20], Huntington[21], Spinden[22], Cooke[23], and Cowgill[24], and others) that purports to explain the rise, decline and fall of the Mayan civilisation. However, all the hypotheses so far presented are based on an inadequate knowledge of the physical environment, both now and in the past. Gourou reviews and evaluates most of these hypotheses and then comes out in favour of the exhaustion of the soil as perhaps the best explanation and, as this explanation also involves an explanation of how high densities of population were supported, his complete hypothesis is worth considering. Gourou states:

> "Exhaustion of the soil may well be the best explanation. The pre-Columban Mayas practised a system of agriculture identical to the Mayas now in Yucatan. Since the former Mayan Empire was densely peopled, the cultivation on the milpa system without manure, working up the soil, or irrigation necessarily led to excessive shortening of the fallow period, therefore to the utter exhaustion of the land. Milpas had to be made at points more and more distant. We have seen above that the Mayas of Chan Kom are already obliged to do this,

although they are not very numerous. Still more striking is the case of the Indians now living at San Pedro Carcha in Guatemala. They have turned their district into an unproductive savanna and make their milpas 50 miles away in the district of Cajabon whence they carry home the maize on their backs. The former Mayan empire almost inevitably had the same difficulties. The cultivators were obliged to make their milpas farther away but clung to their homes in the old country to which with great trouble they carried part of the harvest. A moment came, however, when it must have seemed impossible to continue the practice. The authorities came to the drastic decision to move the life-centres nearer to the plantation. Hence, the emigration of the Mayas in all directions, because their milpas were situated all round the border of the old centre. It was also the sudden end, without forewarning, which archaeology assigns to Mayan towns; and it explains the spacing out of the dates at which the towns were deserted, for the exhaustion of the soil was not completed at the same time everywhere. Lastly, the creation of new towns in Yucatan just when the old ones disappeared, becomes intelligible."[25]

In support, Gourou claims that the forests of the old Mayan empire are still secondary growth and that the insect life in the humus of the existing forest is less abundant than in the virgin forest. In addition, he also claims that some stretches of laterite are still savanna clad and that the clay fill in various lakes results from acceleration of erosion due to deforestation.[26]

Under what conditions is it possible to utterly exhaust soil? If the nutrient cycle is one that is almost completely dependent upon the decomposition from the litter of the covering vegetation, then the shortening of the fallow will result and there will be fewer and fewer nutrients available. Where there is a negligible reserve of weatherable minerals of value in plant nutrition, as in most of the strongly weathered soil materials of the region, then if woody species will no longer grow to any degree, soils are "exhausted". In many parts of the same region the process of laterization is so far advanced that, on the clearance of the forest, especially if it is completely cleared over an extensive area, laterite will again develop within a few years. This was the case in Iata, Brazil, as described by N. McNeil:[27]

"In Iata...in the heart of the Amazon Basin the Brazilian Government set up an agricultural colony. Earth-moving machinery wrenched a clearing from the forest and crops were planted. From the beginning there were ominous signs of the presence of laterite. Rocks of ironstone stood out on the surface in some places; in others, nodules of the laterite lay just below a thin layer of soil. What had appeared to be a rich soil, with a promising cover of humus, disintegrated after the first or second planting. Under the equatorial sun the iron-rich soil began to bake into brick. In less than 5 years the cleared fields became virtually pavement of rock. Today Iata is a drab, despairing colony that testifies to what a formidable problem laterite presents throughout the tropics."

Gourou is thus correct in implying that unproductive savannas may result from the shortening of the fallow and soil exhaustion. But did these conditions exist in the Petén? To a limited extent, yes, but there are alluvial soils, even though acidic, and by and large there is a greater variety. World Soil Resources Reports - 18 - suggests that the region has potential. How could some of the limitations of these soils have been overcome? Most authorities agree with Gourou that manuring was not a part of the milpa system, as is the case today. Terracing on the lower slopes of limestone hills, of which there is abundant evidence, is one way of building up and, to a certain extent, replenishing fertility. Carter, in Man and the Land,[28] argues that:

"The agriculture had to be efficient, for it had to support not only the people on the land but also great numbers of men at work producing the monumental buildings and works of art, as well as the scholarly and priestly classes who did governmental work. Further, the population figures given above are of the secondary civic centre. The great cities of the Mayan area must have had larger populations and even denser settlement on the land -- all of which indicates that there must have been a much more intensive land use in the Mayan area in the past. An oriental pattern of husbanding is suggested -- all waste materials being returned to the land combined with all possible organic material from the adjacent lands, with a careful

> composting of this material to maintain the fertility of the fields. The question then arises: Once achieved, why should such an agricultural way of life be abandoned?[29]

Catastrophe, suggests Carter, must have struck the Mayas, resulting in a considerable reduction in the population. Under these circumstances, the agricultural methods would shift radically towards a simple land use pattern where the laborious maintenance of land in permanent production would be abandoned for the much easier clearing of a new patch of forest where natural processes had restored the soil fertility during the period that the land was allowed to rest and to grow up to a forest cover.

There is, at the present time, absolutely no evidence of the Mayas having practised an Oriental pattern of husbanding, terracing yes, but not manuring. There is no evidence of such husbandry anywhere near the Maya of the period, nor since, and such techniques do not completely disappear. The only reference to fertilisation so far discovered by the author, is in a very brief and tempting article by a Puerto Rican anthropologist, Adolfo de Hostos. Under the heading of 'Plant Fertilization by Magic in the Taino Area of the Greater Antilles' he states:

> "At the time of Discovery the aborigines of the Greater Antilles had achieved progress in the art of tilling the soil. They were on the eve of discovering rational means for fertilizing the soil, having begun to apply urine to it. Yet they persisted in practising some of their ancient and involved animistic concepts of sympathetic magic in their efforts to make their food plants thrive."[30]

Ursula Cowgill, in Soil Fertility and the Ancient Maya,[31] commenting on the conclusions of C. W. Cooke[32], which were similar to those of Carter's in that he postulates a system of intensive agriculture in which crops were grown consecutively on plots with no fallow, states that:

> "Aside from the gratuitous assumption that slash and burn agriculture is inherently incapable of supporting a population which could produce the observed archaeological remains, the only evidence offered in support of this suggestion came from a pit dug in one of the seasonal swamps near Uaxactun. Here, an underlying layer consisting of equal parts of clay and crystal identified as calcite, was covered by a thick layer of black clay with a lower proportion of crystals, including limestone pebbles up to an inch in diameter. The black colour was found to be due to a small amount of decomposed vegetal matter. Cooke interpreted this as evidence of a period of extensive erosion, and both he and Ricketson have suggested that the collapse of Classic Maya culture is to be understood as due to an over-use of the land, denudation and consequent disastrous erosions."[33]

Cowgill studied modern subsistence in the central Petén. She concluded that modern technology has introduced no important changes other than the replacement of stone tools by steel machetes and axes, and since there was no evidence, as yet, for any climatic changes, data concerning modern subsistence are of considerable validity in inferring the nature and the possibilities of aboriginal subsistence in the region. Specifically her study was concerned with the density of population and the manpower available for non-subsistence techniques, and with the possibility that aborigines could have used more productive methods. She considered it was of particular importance to determine why a field is used for only one or two years before being abandoned and allowed to revert towards forest for several years. She concluded that:

1. In the contemporary Petén, it is possible to sow 4 crops of corn a year, though two of these are catch or emergency crops.

2. Most of the land in the region is usable for corn production.

3. Soil fertility loss, and not weed competition, is the cause of yield decline after a plot of land has been cultivated 2 years in succession. Corn can be planted in the fallow years and the next with reasonable response, but the farmer does not consider the practice efficient.

4. With present agricultural methods, the central Petén is capable of permanently supplying food needs of perhaps 200 people per square mile. Yields of corn are such that one farmer could produce 8,000 lbs. of corn per year, which is twice the needs of a family of about 6. Therefore, half the adult population could be full time non-food producing specialists, supported by the other half of the population. These calculations are based upon the use of the steel tools; more time would be needed for clearing the forest when only stone tools were available, but as the level of production is maintained on the basis of more than about 80 days of labour, more time could readily be found.

5. While data on the number of prehistoric dwellings occupied at any single time are still very incomplete, the size and number of ceremonial centres can be accounted for by a population well below the limits set by slash and burn agriculture. It is, therefore, very unlikely that Classic Mayan Culture declined in this area due to agricultural inadequacies.

In the case of population pressure and demands upon the land being pushed beyond the figures suggested by Cowgill, shortening of the fallow and perhaps an impoverishment or degradation of the forest cover might very well lead to an acceleration of soil erosion. S.F. Cook[34], working in Central Mexico, and A.T. Grove[35], working in Nigeria, have both illustrated how periods of dense population have been characterised by an acceleration of soil erosion. Densities in parts of Nigeria of 300 to 400 per square mile, prior to the use of soil conservation methods and the use of fertilisers, have led both to the cultivation of land on a more or less continual basis and to a serious acceleration of soil erosion.

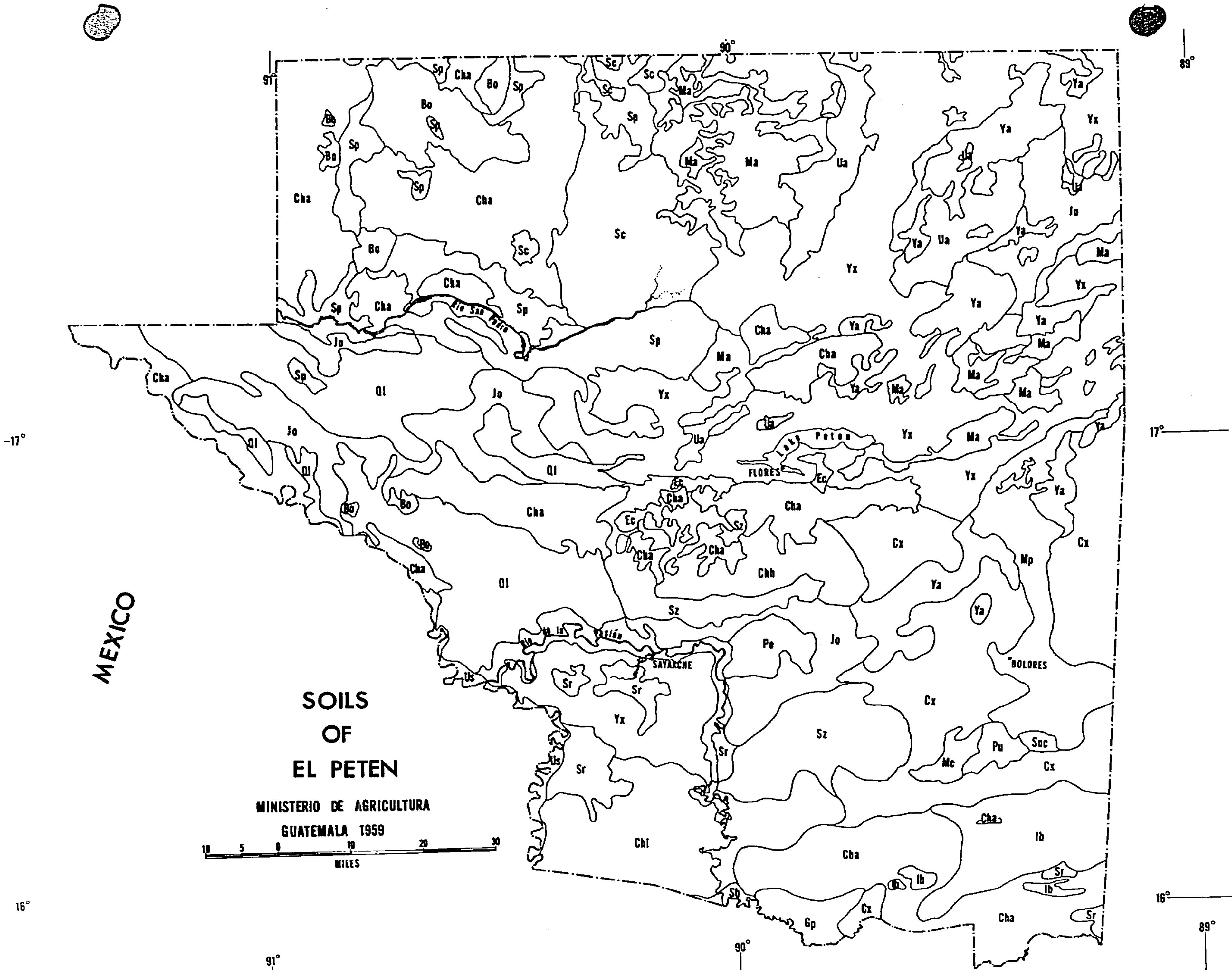

SOILS
OF
EL PETEN
MINISTERIO DE AGRICULTURA
GUATEMALA 1959
MILES
MEXICO
Lake Peten
FLORES
SAYAXCHE
DOLORES
Rio San Pedro
Rio de la Pasión
91°
90°
89°
17°
16°

FIG. 17

LEGEND
SOILS OF EL PETEN

Symbol	Series	% of Area	Drainage	Fertility
Bo	Bolon	2.13	bad	moderate
Cx	Cuxu	8.49	good	high
Cha	Chacalte	9.77	good	high
Chh	Chachaclun	74	good	low
Chl	Chapayal	3.67	slow	moderate
Chq	Chocop	7.33	slow	moderate
Ex	Exkixil	0.23	very slow	low
Gp	Guapaca	1.44	moderate	moderate
Ib	Ixbobo	2.45	moderate	moderate
Jo	Jolja	5.33	good	high
Ma	Macanché	5.11	slow	high
Mc	Machaquila	0.28	very slow	low
Mp	Mopan	2.82	very slow	high
Pe	Petexbatun	0.59	bad	moderate
Pu	Poptun	0.27	good	low
Ql	Quinil	7.41	good	moderate
Sc	Sacluc	3.31	good	high
Sp	Saipuy	5.02	very bad	very low
Sr	Sarstun	2.81	slow	moderate
Sn	Sebol	0.05	moderate	moderate
Sz	Sotz	3.52	good	moderate
Suc	Suchachin	0.09	bad	low
Ua	Uaxactun	3.28	moderate	high
Us	Usumacinta	0.55	slow	high
Ya	Yaloch	6.34	very bad	low
Yx	Yaxa	15.57	good	high

There are one or two points arising out of the above discussion which can now be elaborated upon, thanks in part to the recent soil survey of Guatemala and an excellent review article by Homer Aschmann on the subject of 'The Subsistence Problem in Mesoamerican History'.[36]

Figure 17 and its detailed legend tell a very interesting story. The outstanding lesson to be learned is that of the soils of El Peten, those classified as having 'high' fertility cover 55% of the total area, and the majority of these soils are well drained, but they do have other limitations which have been noted earlier. What is important is that there is presently potential in the soils of El Peten, as probably there has been in the past.

In many respects the following quotations from Aschman speak for themselves. He states:

> "The highest civilizations of the aboriginal North American continent, while exhibiting impressive achievements in other phases of culture, made do with a food production system of a remarkably primitive sort. The complex superstructure of the social and politico-religious organization of large, closely settled populations was capable of placing an overwhelming burden on their narrow base of subsistence technology. There seems to have been no effort to maintain or build up soil fertility by manuring, admittedly a difficult proposition without demesticated grazing animals. Cultivating only with a digging stick a man could farm only a very limited amount of land, perhaps not much more than an acre. High per acre yields were essential if he was to support himself and family.
>
> Only especially favored localities could produce adequate yields on a more or less permanent basis. Some support to the soil was provided by the practice of growing nitrogen fixing legumes in the same field, or even the same hills, with maize, and turning under the plants. But maize is a notoriously heavy feeding crop and on most soils declining yields appear after one or a few years.
>
> ....Indian cultivation in Mesoamerica was and is concentrated to a remarkable extent in hilly upland terrain. One reason for this, of course, is the relative abundance of such surfaces in that part of the world. Burning, the principal method of land clearing, is also distinctly easier both to accomplish and to control on steep

slopes. Finally, the dynamics of tropical soil formation and removal by erosion create a situation in which the soils on slopes are, temporarily at least, likely to be more favorable for farming than are lowland soils.

.....The Indians sought immature soils, alluvial or denudational, for their horticulture. Only the upper, steeper alluvial slopes were attractive since the heavy clays deposited in flatter places are almost impossible to till with a digging stick. Where a denudational surface is cultivated to a moderate extent, the rate of erosion of the surface may be just in balance with the weathering of material from the parent rock underneath so that crops are grown in a continuously renewed and relatively fertile soil. The Indian system of planting in hills, in contrast with plowing, provides fairly good protection against erosion, making this balance easier to maintain. The agricultural worth of these denudational soils is determined primarily by the chemical and mineralogical characteristics of the parent material. Limestone, granite or other acidic rocks, and basic lavas are three widely distributed rock types in the uplands of Mesoamerica, each affording different farming opportunities to the cultivator. The basic lavas are by far the most attractive, and farmed in this fashion they may account for the long maintained high population density in Western and Central Guatemala and in spots on either side of the east-west volcanic chain across the middle of Mexico.

Each upland soil, however, has a limit to the proportion of time it may be kept in cultivation without danger of excessive sheet wash, followed by gullying and complete destruction. With a highly organized society and a growing population shortening the fallow period, insidious sheet erosion, giving no forewarning by declining yields, may suddenly pass the critical limit, and fields be destroyed by gullies in a single season."[37]

Before concluding the above discussion, it is of interest to consider statements made recently by Carl Sauer in The Early Spanish Main in regard to the aboriginal conditions in the Greater Antilles where the physical environment was in some respects similar to that in the Petén. Sauer agrees with Las Casas that population densities were high and that on Puerto Rico, Hispaniola, and Jamaica, there were populations of about 3,000,000, while on Cuba the figure was somewhat less. He considered the agricultural system of the islands most productive and stated:

"The major hazard of weather is from hurricanes which do least damage to root crops; a minor hazard is drought, to which these crops are less sensitive. The white man never fully appreciated the excellent combination of plants that would grow only in conucos. The mixed planting system gave the greatest range of terrain usable without regard to steepness or irregularity of slope. The plants grown were neither demanding nor exhaustive of soil fertility and were relatively indifferent to soil acidity. They needed no special means of storage, had no critical time of harvest and were in production at all seasons.

It would have been a competent agricultural system without yuca, with this great staple it was productive as were few parts of the world. According to Las Casas, who had been a commercial grower, "20 persons working six hours a day for one month will make a planting of such conucos which will provide bread for 300 persons for 2 years." The main labour was in setting out the cuttings and caring for the plants until they were established. The Hieronymite friars in charge of the colony from 1517 to 1518 reported to King Charles that they had set out 800,000 montones of yuca which would feed more than 7,000 Indians for a year. This would amount to provision of bread for more than 3 persons from one acre. Europe knew no food plants of comparable yield until the American Solonum potato was introduced. Conuco planting gave higher returns of food in continuous supply by simplest methods and moderate labour. Seasons and crop plants, being as they are, there was no urgency at any time about work in the fields.

The economy worked because production of the land was in balance with food taken from the water and the bounty of the waters also was great. Fish and shellfish exist in the same kinds and in similar numbers as then but the Manatee and green turtle have disappeared and waterfowl are greatly diminished. Nor does the present population have the water skills of their Indian predecessors."[38]

The Amazon Basin.

The Amazon Basin contains the largest extent of tropical rain forest in the world, thus presumably the largest area of tropical rain forest soils, the physical element of the environment that is under discussion in this chapter. In the voluminous literature on the Amazon, soils, settlement and agricultural potential have been given a great deal of attention,but much of little value or of nonsense has been written.

Djalma Batista, Director of the National Research Institute of Amazonia, stated of the literature,

> "Men of Letters and of Science, travellers and explorers, newspaper men and curious people who travel through the Amazonia or are interested, even at a distance in its problems, have left behind them a lot of work, some of basic value, others of artistic beauty, many of informative nature, and the majority of little or no value. These works constitute however, a documentation that cannot be substituted, and that must be read and appraised by the learned people of our days and of the future."[39]

However, in the past 15 years some extremely valuable substantive data on soils, agricultural systems, settlement patterns and population densities has been produced as well as useful re-assessments of archaeological evidence which has led to valuable hypotheses, though not all the latter are acceptable to the author.

The essence of this material is that there emerges a pattern of more intensive utilisation of parts of the Amazon Basin in the past than hitherto portrayed, of how these patterns developed and the populations involved adapted to diverse ecological settings and of how changes occurred in distribution and downward in numbers prior to and with European contact. It must be made clear immediately that though more is now definitely known about the soils of the Amazon Basin, agricultural systems and settlement, past and present, it is still hazardous to make any claims about the density of populations and settlement of the past or future. There would appear to be little value in discussing all previous descriptions of Amazonian land and soils. It is clear from the body of literature extant that there have been two camps -- the optimists and the pessimists.

In 1853, Alfred Russell Wallace wrote of the Amazon:

"There is no country in the world where people can produce for themselves so many of the necessities and luxuries of life. Indian corn, rice, mandioca, sugar, coffee, cotton, beef, poultry and pork, with oranges, bananas and abundance of other fruits and vegetables, thrive with care. With these articles in abundance, wood, calabashes, cups and pottery of the country, they may live in plenty without a single exotic production and then what advantages there are in a country where there is no stoppage of agricultural operations during the winter, but where crops may be had and poultry be reared all the year round; where the least possible clothing is the most comfortable and where a hundred little necessaries of a cold region are altogether superfluous. With regard to the climate I have said already; and I will repeat, that a man can work as well here as in the hot summer months in England; where if he will only work 3 hours in the morning and 3 in the evening, he will produce more of the necessaries and comforts of life than by 12 hours' daily labour at home."[40]

As recently as 1950, a leading authority on tropical land use, Robert Pendleton, stated:

"In higher latitudes and particularly in the United States, widespread opinion prevails that such humid regions as the enormous Amazon basin, now occupied by luxuriant and apparently limitless tropical high forest, must certainly have rich soils, and hence great potentialities for the production of food, fodder and other agricultural crops....It is true that certain regions such as those recently active volcanoes and those recent alluvial soils and humid equatorial lowlands which are not deeply flooded, do have great crop growing potentialities; they are producing and can continue to produce much from the soil. Nevertheless, on the whole the soils of the humid equatorial regions have distressingly limited possibilities for plant production...this pessimistic attitude is no longer the result of mere opinion, for in a number of widely scattered regions of the humid low latitudes, agricultural scientists have been and still are, seriously at work."[41]

In light of that statement, it is of particular interest to note that in the first of a series of soil reports on the Amazon, produced by F.A.O., titled Soil Investigations conducted in the Lower Amazon Valley, the following conclusions appear:

> "Almost all Amazon soils are low in natural fertility, therefore, the ultimate agricultural value will depend much more on their responses to management, including fertilisation, than to minor differences in natural fertility.
>
> Though the lack of natural fertility in soils should not be regarded with excessive pessimism, the fertility of Amazon soils can be increased by the use of fertilisers and helped by good management. Other factors of crop production, such as adequate moisture, generally good soil structure, and desirable growing temperatures, the Amazon soils have in ample quantities, and the latter factors are those which are the most difficult and expensive to attain where they are lacking."[42]

And elsewhere in the report,

> "The upland soils developing under these conditions (high temperatures, humidity and rainfall) are, as a result, deeply and strongly weathered with the presence of laterite, a common occurrence. They are very low in fertility but generally have a good natural structure and a good tilth, when cultivated. They also absorb water well and runoff under natural cover is a rare occurrence, even with the heaviest intensities of rain."[43]

Another recent and more comprehensive publication, <u>Amazon Soils</u> by W. G. Sombroek, lends strong support to these conclusions. This most recent publication emphasises the relatively high fertility of some of the lowland soils, but points out that the popular impression that all varzea soils are favourable for occupation is erroneous. They vary with the richness of the 'flooding water', the length and depth of flooding, as well of course with the basic chemical qualities of the soils. The upland, or Planicie, soils show promise for large-scale settlement schemes, although the natural fertility of the soils is low. The good drainage of these soils and the 'greater grass timber volumes' are again stressed.[44]

Nevertheless, the Amazon basin is today one of the world's largest areas of very sparse population, with a density of less than half a person per square mile over the region as a whole. And this compares with 7.5 in the Congo basin, the other large contiguous area of tropical rain forest. How can this be explained? The author agrees with Gourou[45] and others who are not prepared to accept an explanation in terms of the problems posed by soils, climate, and dense tropical rain forest. In contrast to the Congo, the Amazon is most accessible. In fact its accessibility may have contributed directly to the lower density of population in the Amazon. Probably in both pre- and certainly in post-Columban times, sedentary population, settled on the banks of the Amazon and its major tributaries, has been prey to warlike invaders, slave traders and the diseases introduced by Europeans.

What are the possibilities of pre-Columban occupance, not only by denser populations but also by higher cultures? In light of recent research findings, it is of interest to quote the oft-quoted statement by Earl Parker Hanson,

> "It would, therefore, appear that a relatively high indigenous civilisation existed along the Amazon four centuries ago, with complex social, political, and economic organisations, division of labour, fixed habitations, advanced knowledge of agriculture, well developed arts, knowledge of textiles and many more people than live along the river banks today. That civilisation was at least high enough to evoke admiration from Spaniards who compared it with contemporary Spain. It had undoubtedly borrowed things from other cultures, since all adjacent cultures grow in part by borrowing from each other, we know that it developed along the Amazon and was not imported bodily from elsewhere in one almighty migration. It had been on the Amazon at least a sufficient number of centuries to have developed an astonishingly advanced medical knowledge, based on plants that were found only along the Amazon. The possibility that Carvajal drew a long bow in describing its externals, seems precluded, not necessarily because he was a friar, and therefore by definition incapable of lying, but because he was healthily accompanied by two shiploads of other men who could later check up on his account....The civilisation that had sprung up along the Amazon simply vanished under the impact of modern colonialism's earliest manifestations."[46]

According to recent published and unpublished findings of D. W. Lathrap, an American anthropologist who has worked extensively in the Amazonian basin, and Sombroek, Hanson's much criticised statement may well come very close to the truth.

Lathrap[47] has concluded that at the time of the first European contact, the Amazon basin showed a considerable range of cultural patterns in terms of size and complexity of social units, complexity of material culture and even basic patterns of subsistence activity. The main stream of the Amazon and the flood plains of its major tributaries sustained large sedentary populations engaged in intensive root crop farming, combined with fishing and the hunting of the aquatic animals and reptiles. In the slightly elevated regions in the flood plains and the major rivers, there was scant population organised into small widely dispersed and mobile social units. These groups typically showed simple and relatively unproductive agricultural systems and relied heavily upon the hunting of terrestrial and arboreal game for their sustenance.

Such simple non-riverine, tropical forest groups, were typically denied access to the flood plain environment by the warlike activities of the riverine group. It was the continual threat of slave-raiding, head-taking and, in some cases, cannibalism, which held the non-riverine groups in the less favourable environment. Such forest-dwelling groups, showing extreme simplicity in most aspects of their culture, are known in most parts of the Amazon basin. There has been a tendency to treat these people as unmodified representatives of a very early and primitive stage of the Tropical Forest Culture, but Lathrap considers there is reason to question this interpretation and to suggest that many, and perhaps all of the simpler and less sedentary groups, are the degraded descendants of peoples who at one time maintained an advanced form of Tropical Forest Culture. Most of the authorities on Tropical Forest Culture have observed that Tropical Forest Culture is less an adaptation to the forest, as such, than to the river region environment within the tropical forest. The deep alluvial soils within the flood plains have a far greater agricultural potential than the laterised, heavily weathered soils in the slightly elevated uplands adjacent to the flood plains. Lathrap quotes the Shipibo Indians as informing him that the deep alluvial soils in certain parts of central Ucayali flood plains will support continuous root crop agriculture for up to 15 to 20 years. Sauer and others have stressed that the tropical forest agricultural pattern is essentially one of carbohydrate production, with the fat and protein requirements of the diet supplied by technologically sophisticated utilisation of the prodigious fish, aquatic mammal, and aquatic reptile resources in the flood plains. 'Evolved Tropical Forest Culture' involved not just developed root crop agriculture, but a developed set of fishing practices, including fish poisoning and effective watercraft. Archaeological evidence suggests that all of these accomplishments appeared early along the rivers within the Amazon basin. The evidence from the Central Ucayali in eastern Peru, an area where Lathrap conducted intensive field work, indicates such cultures dating from 1500 to 2,000 B.C. The elaborate ceramic style, typical of the period, cannot be derived directly from any central Andean styles, Lathrap claims. It does, however, show certain basic similarity at least to the earliest examples of the Tropical Forest Culture known from the Orinoco flood plain of Venezuela, suggesting that both were derived from some common source along the immediate network of rivers. At least three examples of complete ethnic replacement are indicated in the subsequent cultural sequence on the central Ucayali, and two of the intrusive ceramic styles are clearly derived from the central Amazon. The long archaeological sequence on the central Ucayali fully substantiates the picture of cultural development sketched by Steward on the basis of ethnographic distribution alone. As Steward has stated:

> "Culturally the Indians of the Montana belong with the tropical forest peoples. They appear to represent a series of migratory waves, as they spent their force against the barrier of the Andes, where representatives of many widely distributed linguistic families...subsided into comparative isolation."[48]

A series of waves of migration, basically in an upstream direction, is also suggested by the distribution of languages in several of the more fully documented south American linguistic stocks, but most especially Macro-Arawak and Macro-Tupi-Guarani . Lathrap suggests that the proto languages of the two stocks occupied adjacent strips of the central Amazon, between 2,000 and 3,000 B.C., and from there moved outward, mainly in an upstream direction, along all available waterways. The pattern of outward migration, suggested by these converging lines of evidence, could best be explained by intense and continuing population pressures on the flood plain of the central Amazon, the most favourable environment for the support of Tropical Forest Culture. Such continuous expansion by groups moving out to colonise new areas of flood plain progressively pushed weaker groups farther upstream or off the flood plains entirely. This extreme and continuing competition is understandable if one realises that the flood plain environment, the only ecological niche really suitable to Tropical Forest Culture, occupies only about 3% of the total area of the Amazon basin. Considering that these processes were probably continuous from about 2,500 B.C. up to the time of the contact, it is clear that a large number of ethnic groups were forced off the flood plains into less favourable environments. Lathrap concludes that most of the primitive groups inhabiting the tropical forest,away from the major flood plains, can be interpreted as the wreckage of evolved agricultural societies forced into an environment unsuitable to their basic economic pattern. Deprived of the riverine resources, such groups had to rely on hunting the forest game to provide the protein and fat essential to the diet. A more intense orientation to hunting the relatively scarce game available, led to more nomadism, a decline in agricultural productivity and a still greater dependence on wild food. He is convinced that this picture accounts for all of the small groups within the Tupi-Guarani-Arawak-Panoan linguistic stocks and may well apply to other groups.

Table 4 , prepared by Denevan, presents historical and archaeological evidence which the author states is, in the case of historical evidence, somewhat unreliable, and in the case of archaeological evidence, mainly inferential. However, most Amazonian pre-historians now recognise the former existence of a number of socially complex sedentary agricultural societies in the Amazon basin. The discrepancy that occurs between the ethnographic picture of small and simple Tropical Forest Culture communities and the reports of large populations by early explorers and missionaries, in addition to the evidence from pre-Columban archaeological

TABLE 4 (a)

ARCHAEOLOGICAL EVIDENCE

a. Marajoara (Marajo Island) - large mounds; elaborate polychrome ceramics; villages of moderate size and permanent sites; good evidence of social stratification (Meggers and Evans, 1957: 259-424).

b. Rio Napo and Rio Aguarico (eastern Ecuador) - polychrome ceramics in the Marajoara tradition (Meggers and Evans, 1958).

c. Araca, Coari, Guarita (middle Amazon) - polychrome ceramics in the Marajoara tradition (Evans, 1964:438).

d. Aristé (northern Amapa) - polychrome ceramics in the Marajoara tradition (Evans, 1964:438).

e. Caimito (near Yarinacocha, central Ucayali River in Peru) - large settlements and permanence of a century or more; ceramics in the Marajoara tradition (Lathrap and Myers, 1964).

f. Upper Velarde-Hernmarck (Llanos de Mojos) - polychrome ceramics associated with large mounds and causeways (Denevan, 1963:115-119).

g. Lower Velarde-Chimay (Mojos and Rio Alto Beni) - modeled and incised ceramics related to Barrancoid tradition of the lower Orinoco; Velarde Mound associated with causeways (Denevan, 1963: 115-119).

h. Hupa-iya (Yarinacocha) - large settlements and permanence of a century or more; ceramics in the Barrancoid tradition of the Lower Orinoco (Lathrap, 1962).

i. Mangueiras (pre Marajoara on Marajo) - large villages with durations up to 118 years (Meggers and Evans, 1957: 258).

j. Santarém (lower Tapajos and middle Amazon) - elaborate modeled pottery; hundreds of habitation ("black earth") sites, many of which are deep indicating long permanence; incised roads; maize the staple crop? (Nimuendaju, 1952).

TABLE 4 (b)

HISTORICAL EVIDENCE

1. Tapajo - 500 families (at least 2,500 people) in one village in the 1630's (Nimuendaju, 1952:5-6).

2. Apinaye - villages of 500 to 1,400 in 1824 (Lowie, HBSAI, 1,480).

3. Tenetehara - early 20th century villages of over 800 people (Wagley, HBSAI, 3:140).

4. Tupinamba - former villages with 400 to 1,600 people (Métraux, HBSAI, 3:103).

5. Omagua - villages with up to 1,500 people and continuous villages close together in 1651 (Métraux, HBSAI, 3:698).

6. Cocama - incipient class structure; very large and continuous villages in the 16th century (Steward and Faron, 1959:337).

7. Central and Lower Amazon - see Carvajal's account of the Orellana expedition of the 1540's for many reports of dense populations for various tribes including what were probably the Omagua and Cocama (Toribio Medina, 1934).

8. Mojo - villages of 400 houses (at least 2,000 people) reported in 1617; causeways; savanna cultivation? (Métraux, HBSAI, 3:414).

9. Baure - 124 villages and 40,000 people reported in the 1690's; causeways, large palisaded villages with streets and plazas (Denevan, 1963: 144-6).

10. Cayuvava - villages of 1,800 - 2,000 people reported in 1693; savanna cultivation? (Métraux, HBSAI, 3:427).

11. Paressi - causeways; large populations (Métraux, HBSAI, 3:350, 354).

12. Manasi - well developed hereditary classes (Steward and Faron, 1959: 259-61).

13. Xaray - village of 1,000 reported (Métraux, HBSAI, 3:394).

14. Mojos savannas - an estimated 500,000 people in the 16th century (Denevan, 1963:306).

sites, can no doubt be attributed to the early European contact. Most of the historical and archaeological communities under consideration were along the lower and middle courses of the Amazonian rivers, and it was just these riverine communities which were rapidly destroyed or disrupted during the early contact period by epidemic diseases, slave raids and missionisation. Consequently, the tropical forest pattern of culture preserved up to the present has been that of tribes occupying less favourable and less accessible environments where they have retreated in order to avoid white contact.

Some support for Lathrap's views are to be found in Sombroek's publication on the soils of the Amazon.[49] Firstly, as already stated, the basis of a more permanent agriculture does exist in parts of the Amazon lowlands. Secondly, Sombroek states that it is possible to discover several traces of anthropogenic influence on both the forest and the soils. Air photo analysis indicates man's influence upon the forest vegetation over quite extensive areas, especially of the central Amazon lowlands. Pieces of charcoal, in soil profiles at depths of 150 centimeters surrounded by baked clay, indicate extensive burning of the forest. Sombroek concludes that the charcoal was due to man-made fires and that these occurred a long time ago, because the present day planalto forest has one of the highest mean grass timber volumes known for Amazonia.

In addition to the 'charcoal' soil profiles, there are the famous Terra Preta or Terra preta do indio soils. This is an upland soil, with a thick black or dark grey top, containing pieces of artifacts

The author has made it clear that the above interpretation is to him quite acceptable. However, there is a significant group of archaeologists and anthropologists to whom the above would be quite unacceptable, or in part unacceptable. This group has addressed itself to the following type of question. Firstly, under what conditions and what processes did some societies advance to higher levels? What sort of internal or external forces operated to induce the higher level of organization in a cultural system, and what were the characteristics of societies as they passed from one level to another? Secondly, under what conditions does arrest or minimal growth occur? Thirdly, did decline of a cultural system occur at any time or place, and if so, under what conditions? The representatives of this group consider that the Amazonian tropical rain forest environment placed restrictions, to a greater or lesser degree, upon cultural development as well as the size and density of settlement.

Anthony Leeds studied an 'incipient tropical forest slash-and-burn horticultural' group, the Yaruro of the south central Venezuelan Llanos, in order to determine what kind of upper limits were set upon its development by its technology and habitat, or both, and what sort of limiting conditions of incipient tropical forest horticulture might have provided a foundation for evolution to a more developed state. The habitat conditions were found to be as follows: given that the Yaruro had a technology including hunting, gathering, fishing and animal husbandry, and horticulture, all resources were found to be located within a narrow band of about 4 or 5 miles between the Cinaruco and the high sand dunes occurring in the interfluve to the north (See Map 12). Within this space there are three major resource areas distinguishable: (1) the open savannas for and is famed locally for its fertility. Sombroek states that:

> "It can be taken for certain that the patches were occupied by the former Indian population of Amazonia. Those small groups of wild Indians still in existence today, have been driven far away from the means of communication and the population centres."[50]

He is also of the opinion that the present day fertility is solely due to prolonged Indian occupance and that previously the soils were no better than the surrounding areas. Apparently the soil is a type of 'kitchen midden, which has acquired its specific fertility, notably much calcium and phosphorous from dung, household garbage, and the refuse (bones) of hunting and fishing'.[51]

Some support for the ideas of Lathrap and others is perhaps provided by the findings of the McGill University Savanna Research Project which has been operating, since 1961, in the Rio Branco-Rupununi savannas of southern Guyana and the adjacent region of Brazil, the greater part of which lies within the Amazon basin. Palynological evidence suggests a rapid increase in fire-resistant species in the savannas between 2000 and 1500 B.P. Van der Hammen[52] who has produced several pollen diagrams for the region, suggests that the rapid increase and the considerable extent of fire-resistant species could hardly have been produced by an increase in natural fire and, therefore, postulates the arrival of man on the scene, though this occupance was almost certainly not prevalent. Could these people have been amongst the earliest migrants from the middle and lower Amazon regions? They may have been, but from all the existing evidence there have been no relatively permanent occupants until recent times. However, Evans and Meggers[53] do recognise the possibility of earlier, brief periods of occupance.

hunting and gathering, the former involving much greater dispersion of resources than the latter, and consequently, quite different techno-social conditions. Both activities changed locations markedly with the seasons; the rivers and canos are used for water-animal hunting and for fishing. Fishing also displays a seasonal shift between river and cano, whereas river hunting for alligator and turtle become totally impractical in the wet season. (2) The wooded areas, themselves dispersed, include the gallery forests cf smaller streams where flooding is limited, but water and soil abundant, and the montes occurring here in the mid-savanna. These areas provide the Yaruro with garden sites. Away from the streams there are also occasional teeny patches of suitable soil, not close enough to the water table for dry season use, which get enough rain to be used for the planting of seasonal crops for the wet season. Leeds claimed that the particular relationship between a peculiar habitat, such as the one he described above, and the technology operating within it (here, in this case, preponderantly a swidden technology) sets upper limits to territorial socio-economic or cultural expansion and limits to changes in socio-cultural forms.

Leeds estimates that the total resource base covers an area of about 65 square miles and that, within it, there are about 800 acres or 2% which is wooded and which contains all the cultivated land. The cultivated area is further restricted for various reasons and he concludes that a cultivable area of 200 acres, or .5% of the total region, is all that is available. The nature of the wet and dry savanna soils supposedly precludes any possibility of cropping by means of slash-and-burn horticulture or even, to any extent, by modern agricultural means.

The savanna soils are described as sandy and have been leached of all possible content. The forest soils are to be found in gallery montes areas where forest grows thanks to the deposition of the finer particles of (savanna) soils, to the proximity of the water table and to enrichment by litter and humus. A swidden on these forest soils lasts three years and the fallow approximately 10 years. As Leeds claims, it may be said that the Yaruro horticultural practices have been well adapted to the particular soil and water conditions of the habitat on the basis of explicit recognition of these conditions. He further points out that the Yaruro are in no position to change the total ecological balance or to increase the carrying capacity of the land or water for plant or animal species. The portion of land held in reserve for future cultivation must be several times greater than that under cultivation at any given moment -- a proportion varying with such factors as the rate of fertility recovery, the type of weed and grass invasion, the rate of growth of the secondary forest, the rate of mechanical reconstruction of the soil, etc., thus, of the total amount of land potentially available in a given expanse of territory, only a part can be horticulturally exploited at any one time. Where the total potentially arable land in a given expanse is itself only a small proportion of the total area, the amount of land available for cultivation at any one moment is only, of course, minute. This ecological balance in turn limits the human population and socio-economic forms.

What are the possibilities of introductions of plants, livestock and improved techniques such as fertilisation, and what would be their impact? Leeds considers the possibility of some plant growing with success on the dry sandy savanna soils, but he points out that no such plant was available from any surrounding source and still is not. He considers that techniques of fertilisation could probably not have internally evolved, but brought in from other people's, which would have made a significant difference to production. He further suggests:

> "Had it been possible to develop a form of fertiliser under native conditions, the best that might have occurred would be to raise the swidden productivity somewhat, thus raising the population but it is doubtful if it would have significantly changed the forms of surplus, the ecology or social structure."[54]

He suggests that water control would have been impossible because of the streams and rivers drying up completely in summer, but even if the water was available, it is doubtful whether irrigation would have helped the sandy savannas of the region, though water control might well permit a large increase in agricultural productivity in the loamier parts of the Llanos. He ignores the possibility of utilising the soils during the rainy season in the manner in which the Mojo utilised the savannas of northeastern Bolivia some centuries ago, and as did Indians in the northern regions of the Llanos as previously noted.

Under the above conditions, Leeds concludes that the Yaruro society was, for ecological reasons, substantially at an evolutionary dead end. However, in an earlier paragraph, he had referred to the fact that recent exposure to cattle herding was breaking up the fundamental form of their economy. There is little doubt that, without either cattle or a wealth of fauna, in the savannas, the resource base of any group would remain extremely limited. With the development of cattle herding, the savanna environment can be more fully exploited and, in time, the corraling of cattle and the utilisation of their manure, may well initiate the extension of horticulture on to savanna soils.

Robert L. Carneiro has studied the Kuikuru of Central Brazil who occupy a village near the Kuluenu River, a head water tributary of the Xingu (See Map 12). The Kuikuru are

> "a more or less typical Tropical Forest society whose mode of subsistence is slash-and-burn agriculture."[55]

In contrast to Leeds' yaruro, the Kuikuru appear to be operating under conditions which suggest the possibility of growth to considerably higher levels. Within a 4-mile radius of the Kuikuru village, there are some 13,500 acres of usable forest soils. This area of arable land is extremely large in relation to the amount of land under cultivation at any one time as compared with the Yaruro and the rate at which land is abandoned, as well as the time required for an abandoned plot to become re-usable. The Kuikuru have lived in the same location continually for the past 90 years, thus it is obvious that the Kuikuru are not faced with the prospect of having to move their village because of depletion of soil fertility.

In the course of presenting and defending his thesis that the Kuikuru are not restricted in their development, Carneiro presents the following significant points in regard to the relations of man to soils and these will be commented upon in turn.

1. Permanence of settlement. As he states, it is commonly asserted in the literature on swidden agriculture, that because shifting cultivators soon exhaust the surrounding soil, they find it impossible to maintain their villages in the same location for more than a few years. The Kuikuru and neighbouring societies provide abundant evidence to the contrary, and so it is obvious that the mere fact of practising shifting

cultivation does not necessarily prevent a society from maintaining an essentially sedentary community. The villages of the Montana Indian groups are moved quite regularly, but there would appear to be a reasonable explanation for this action. Firstly, these groups are small, with an average population of perhaps only 30 people, and their house type is such that houses can be readily rebuilt, and thus it is probably much easier for these people to relocate the village alongside their new forest clearing. The successive clearing, planting and abandoning of adjacent areas of forest is therefore a factor in bringing about periodic relocation, but to say, without further qualification, that soil exhaustion caused the village to be moved, would obviously be a misleading over-simplification.

It is also possible that the prevalence of warfare and the desire for security from attack may lead to successive relocations of the village, which have no relation to the agricultural cycle. Among tribes with whom hunting still constitutes an important part of subsistence, a depletion of game animals in the vicinity of the village may dictate moving long before other conditions would warrant it. Carneiro concludes:

> "Thus, a variety of factors capable of reflecting settlement patterns must be known in some detail before one can be sure of why a particular society has moved its village. Lacking this information, we are not justified in assuming that the village must have been moved because of soil exhaustion."[56]

2. Villages in the Tropical Forest area are typically rather small in size, averaging, according to Steward (1949)[57], 50 to 150 people. The reason most commonly advanced to explain why communities in this region should be so small is that shifting cultivation does not permit

large concentrations of populations to occur. Meggers, whose work will be considered in a later section of the chapter, has gone so far as to propose the figure of 1,000 as the upper limit of settlement size in the tropical rain forest.[58] However, there is evidence from this century and from the past (See Table 4) of populations of well above 1,000 and Carneiro has calculated that, under the prevailing system of shifting cultivation, the present-day habitat of the Kuikuru could have supported, on a completely sedentary basis, a village of about 2,000 persons.

If it is unreasonable to explain the small village size in terms of shifting cultivation and soil, what other limiting factors operate in the Amazon basin in keeping village size well below 1,000? Carneiro argues that a factor of greater importance than soil has been the ease and frequency of village fissioning for reasons not related to subsistence. The Kuikuru village came into existence as a separate village as the result of a split some 90 years ago. He states:

> "The facility with which this phenomenon occurs suggests that villages may seldom get a chance to increase in population to the point at which they begin to press hard on the carrying capacity of the land. Centrifugal forces that cause villages to break apart seem to reach a critical point well before this happens. What the forces are that lead to village fission falls outside the present discussion. Suffice it to say that many things may give rise to factional disputes within the society and that the larger the community the more frequent the disputes are likely to be."[59]

3. Low food productivity is supposedly a typical characteristic of the horticulture of tropical forest society. However, a comparison of the productivity of tropical forest horticulture based on manioc and/or corn does not bear out this claim. Carneiro and others have recently shown that tropical forest culture is considerably more

productive than the horticulture practised by the Inca and other horticulturists in tropical America, and this is so whether the food productivity of the two societies is compared in terms of food yield per acre or food yield per man hour of labour. Carneiro estimates that the manioc tubers grown by the Kuikuru produced something like 4,000,000 calories per acre per year, though due to loss from rodents, etc., this figure should perhaps be reduced to 2,000,000 calories per year. Even at this lower level, it is still much higher than the figure of 700,000 calories -- an estimate of food productivity in Peru during Inca times. However, this estimate is based upon the production of maize and, if the estimate is based upon potatoes which were the staple food crop of the Highland peasants of Peru in pre-Columban times, the level of food production would be much higher, perhaps 1,500,000 calories. As Carneiro concludes,

> "In view of the foregoing evidence, it would appear that whatever the factors that enabled the central Andes to outstrip the tropical forest in cultural development, greater food productivity per unit of land or per unit of labour was not one of them."[60]

4. The production of a food surplus has long been considered as a prerequisite to the development of an advanced culture characterised by crafts, specialised political controls, elaborate religious complexes, social classes, etc. Meggers and others have attempted to demonstrate that Amazonian cultures could not, through the limitations of their mode of subsistence, produce a surplus of food, thus their failure to evolve beyond the Tropical Forest Culture level. It is true states Carneiro

> "that over the yearly cycle of production, Amazonian cultivators almost never actually produced more food than they need for themselves and their families. Nevertheless, taken by itself, this piece of evidence is inconclusive. It is of critical importance that we

distinguish between the existence of the technological feasibility of surplus food production and the actualisation of such a surplus."[61]

There is little doubt that the Kuikuru are technically capable of producing food well in excess of what they need for their own consumption, but for a variety of reasons -- the lack of economic incentives, political stimulus, etc. -- they do not. There are many documented cases of surplus production of manioc by tropical forest tribes during the last century, as a result of contact with, and the demand of, traders from Amazonian towns, from rubber collecting areas, from railroad construction camps, and the author has first-hand knowledge of the impact of demand on the ranching community upon the horticulture of the Amerindians in southern Guyana, where corn is now grown along with manioc to increase the already high yields of traditional tropical forest horticulture.

5. In discussing the "poverty of soil and the abandonment of plots", Carneiro concludes in favour of the difficulty of coping with weeds rather than in the depletion of soil fertility. He suggests that the abandonment of a plot after a brief period of cultivation can best be understood, not as a necessary consequence of rapid soil depletion, but rather as the most economical way of carrying on subsistence farming under prevailing conditions of technology and environment. Unfortunately in Carneiro's essay on this subject, he does not produce evidence from his study of the Kuikuru, but rather surveys literature on shifting agriculture in other parts of the tropical world and the applicability of conclusions of workers in other parts of the tropical world are not necessarily applicable in the Amazon basin. However, it is the author's own opinion that the rapid growth of weeds and the fact that it may well

take more time to weed an old garden than to clear a new one is a major factor in determining the nature of shifting agriculture. Finally, in trying to account for the higher development of cultures in other regions of the tropical New World, Carneiro concludes that neither soil nor technology have been significant. He states that many areas that supported the Circum-Caribbean level of culture, Puerto Rico, Hispaniola and the Venezuelan coast for example, had essentially the same type of soil as the Amazonian basin and that the agricultural implements that were available were virtually the same. However, it is true that some irrigation and terracing was carried out in the Circum-Caribbean region but only to a very limited extent. Furthermore, terracing and irrigation are more the product of the organisation and direction of labour than they are of mechanical innovation as such. The claim that the soils of Puerto Rico, Hispaniola and the Venezuelan coast are in no way superior to those of the Amazon basin is a claim that would be difficult to substantiate for the simple reason that there are many soils in all three regions that are superior in many respects to the soils of the Amazon basin, with the exception of some of the alluvial soils that occupy limited regions of the Amazon basin.

Meggers and Evans, the other members of this 'group', have attributed to tropical soils, and in particular those of the Amazon Basin, the role of determinant. They revived a full measure of environmental determinism in their conclusion to Archaeological Investigations at the Mouth of the Amazon, in stating that:

> "The Tropical Forest Pattern represents the maximum development of culture that could have been attained in the area where exploitation is limited to slash-and-burn. This limitation is first and foremost an environmental one, which operates in terms of restricting the

> subsistence resources both in quantity and permanence....the cultural development of the Tropical Forest Area cannot be said to have been arrested by the advent of the Europeans as it might have been in other parts of the New World; it had already been arrested by the agricultural deficiencies of the environment in which it existed."[62]

Meggers and Evans were concerned with a culture known as the Marajoara Phase which arrived on the island of Marajo with every indication of possessing a culture of the Circum-Caribbean or Sub-Andean level of development. It had an advanced socio-political organisation characterised by occupational division of labour, social stratification and well-defined leadership. The archaeological record reveals that in the tropical forest environment of Marajo Island, this culture underwent a gradual but persistent decline in which those traits, more advanced than in the Tropical Forest level, were lost. They consider the Marajoara Phase a particularly good case for demonstrating the levelling effect of the tropical forest environment since all other possible causes could be eliminated by comparative evidence.

In that Meggers and Evans considered the quality of soil fundamental to their hypothesis, the soil report (FAO No.1395) referred to earlier will be looked at again. Meggers and Evans have generalised on the basis of the Marajo Island environment, and in this they are hardly justified for the Marajo Island is an essentially savanna environment and, from an agricultural point of view, a poor one at that. It is probably inferior to most of the Amazon forest environment and certainly greatly inferior to the riverine environment of the central and upper Amazon.

Here are three brief descriptions of soils on Marajo Island from the FAO Report. Firstly, a forest and savanna soil,

> "never observed under agricultural use. Extremely low fertility plus generally poorly drained conditions make these soils essentially non-agricultural".[63]

Secondly,

> "never observed under cultivation, very light textures would make this soil both very infertile and droughty and thus severely limiting its agricultural potential".[64]

Thirdly,

> "where observed on Marajo Island these soils have the apparently low nutrient status of most of the soils of the island".[65]

No wonder the Marajoara Phase declined. However, to balance the poor agriculture there was a plentiful food supply to be obtained by hunting, fishing and gathering. In fact, Meggers and Evans acknowledged,

> "possessed of the Indians' knowledge of fish poisons, of the manufacture of traps and weapons, of the habits of the game, and of patience, stealth, and skill, no one would be threatened with starvation. Rather, the island could support a relatively large population, principally because of the excellent fishing conditions found in the combination of large and small streams, lakes, and the Amazon itself."

In this latter respect, the Marajo Island environment was in every way comparable with the riverine environment of the Central and Upper Amazon, but unfortunately it lacked the higher quality soils possessed by the latter environment.

Confronted with the evidence of a Maya civilisation, existing within the tropical forest type environment, Meggers claims that while Maya civilisation may have maintained itself in the Petén, it must have originated in some area other than the tropical loams of Guatemala. Is it not possible that Maya civilisation developed and succeeded for some centuries within the Tropical Forest environment, in contrast to the

Marajoara Phase, for the simple reason that the forest soils of the Petén were that much more fertile and productive than those of Marajo Island?

The Llanos de Mojos.

> "Nay, they are ignorant of the greatest part of America which lies 'twixt Peru and Bresill, although the bounds be knowne of all sides wherein there is diversitie of opinions; some say it is a drowned land, full of Lakes and waterie places; others affirm there are great flourishing kingdomes, imagining there be the Paytiti, the Dorado, and the Caesars, where they say are wonderfull things. I have heard one of our Company say, a man worth of credit, that hee had seene great dwellings there and the waies as much beaten as those between Salamanca and Valladolid..." (José de Acosta, in 1590) (1880:1:171)[66]

It is true there was no apparent El Dorado, but there was, and this is of considerable significance to the present discussion, the kingdom of the grand Moxo (Mojos). This was a region of dense population, large villages and a technology for draining and cultivating savannas -- typical tropical savannas which are not cultivated today and have not been cultivated for several centuries. At some stage in pre-Columban times, there may have been a population of up to half a million, though not dependent entirely on the agriculture of savannas as there were adjacent forested areas. The Mojos appears to have remained, from the European point of view, an unexplored inaccessible land of myth until 1617, when

> "weary Spaniards returned from the North to Santa Cruz della Sierra to report no El Dorado, that Mojos had only swamps and mosquitoes and many savage Indians, and that the Tierra Rica must be further on....after the early explorations Mojos became a mission province and under the administration of the Jesuit order from 1668 to 1767, the native cultures deteriorated and the population was rapidly and drastically reduced by European diseases. The savannas became cattle range and never again were found."[67]

To W. M. Denevan, considerable debt is due for the manner in which he has collected, analysed and synthesised practically all that is known of the Mojos, past and present, in The Aboriginal Cultural Geography of the Llanos de Mojos of Bolivia. As Denevan states in his introduction, the kingdom of Mojos had achieved a remarkably sophisticated society and technology in a hostile, tropical environment, characterised by alternating seasonal flooding and drought, and poor soils. The main purpose of his study was to examine the means by which these peoples dealt with these problems and modified the landscape to accommodate relatively large populations. Even though it is often impossible to say who or when, a great deal can be said about what, where, how, and to some extent, why, in regard to the major features of the occupants of the Mojos.

The Llanos de Mojos, some 70,000 square miles of savanna, occur in the centre of the Beni Basin (see Figure 12) lying between the Andean foothills and the western borders of the Brazilian Highlands. Most of the basin is occupied by fine-grained and consolidated sediments of Quaternary age which overlie typical crystalline basement rock. The basin is drained by tributaries of the Rio Madeira, a major south bank tributary of the Amazon. The nearly flat Llanos rise, from an elevation in the north of about 700 feet, to about 900 feet in the south. The significant physiographic features of the region are firstly curichus, or old meander cut-offs, which contain some water throughout the year, secondly several thousand permanent, shallow lakes with the largest 200 square miles in extent, and with narrow ridge rims and neither inlet nor outlet, thirdly Bajios, or seasonally flooded depressions, which are drained, fourthly patches of ground that stand above annual flood level, that may or may not be forested and which are either shield outcrops, natural levies or man-made mounds, and there are a few isolated hills.

The climate is characterised by a rainfall of between 60 to 72 inches, with a dry season from approximately May to September. The flooding of the region is not always a result of the rainfall, but frequently is due to high rainfalls in the Eastern Andes. The summer season is wet and hot, and the winter dry and warm. The mean annual temperature is about 80°F. with the maximum about 82° (March) and the minimum about 74° (August).

Denevan estimates that, of the 70,000 square miles of the region, about 40,000 are normally covered during maximum flooding, while 50 to 60,000 square miles are covered during exceptional flooding which also extends into forested areas. The depth of flooding may reach 6 feet, but probably averages about 1 to 2 feet.

All that can be stated regarding the soils is that they are poorly drained clay loams, underlain by hard pans and are low in fertility. The best soils are the young alluvial soils (sandy loams, fine sands and loams) that occur under forest on the islas and natural levees. Top soils are generally strongly to slightly acid, except on recently burnt areas where they are neutral to slightly basic. These soils have a higher level of available nitrogen than the savanna soils. The soils of the higher savanna levels are mainly alluvial clay loams and occasionally sandy loams. Clay content increases with depth and there is frequently a clay pan present. The pH is strongly acid in the top soil, but the subsoil is moderately acid to neutral. Loam soils under scrub savanna are very low in nitrogen, low in phosphorus and medium to high in potassium. In the lower grassland savannas, the soils are predominantly clay to clay loams. They are generally very compact and impervious pans of kaolinitic clays, with mottling at shallow depths occurring frequently. These soils are moderately to strongly acid, pH being below 5 on the surface, the nitrogen content being very low, as are phosphorus and calcium, but potassium is medium. In terms of agricultural value, there is no doubt that the best soils are those under the galeria forests and the islas forests, while of the savanna soils those on the higher levels are best.

In this typical lowland seasonally flooded savanna environment of South America, the Mojos built flood-free sites for settlement, communication and cultivation, and had elaborate crafts, methods of farming seasonally flooded grasslands, and relatively dense populations in large villages. The aboriginal villages of the Mojos savannas were characterised by great diversity in size, site, permanency, organisation and protective mechanisms against flooding.

In terms of adaptation to a seasonally flooded environment, the significant characteristics of these villages were firstly, location on natural levees, islas and artificial mounds, and secondly, the use of moats, raised floors and, occasionally in some regions, platforms for houses and man-made mounds of three major types: (i) artificial mounds (3 to 16 meters high and up to 300 meters long), (ii) artificial islas (1 to 2 meters high and 10 to 15 meters long), (iii) house mounds less than 1 meter high and 3 to 7 meters in diameter. These mounds were usually, but not always, built to provide flood-free sites for villages and individual houses.

The Mojos improved communication in several ways. Firstly, canals were dug and maintained adjacent to causeways and between streams and lakes, and river meanders were shortened by artificial cuts through their necks. Secondly, causeways are found throughout the Llanos de Mojos and Denevan estimates that there are at least 1,000 miles of them. He also suggests that it is fairly clear that the aboriginal causeways were built to connect settlements with one another, with areas of cultivation, with ceremonial and burial sites, and with rivers. Causeways occur in conjunction with habitation sites, artificial mounds, canals and drained fields. The basic purpose of the causeways was not for cross-country travel, but for local movement across stretches of low-lying ground subject to flooding. However, some of the causeways, especially the longer and probably more important ones, continue across both high and low ground. The building of raised roads on high ground, where there is no drainage problem, is probably indicative of the importance that causeways came to have for some of the savanna tribes, and is one of the many examples of cultures retaining traits and situations where they are no longer utilitarian.

In an environment, now scorned by the inhabitant for agricultural purposes, Denevan estimates that there is evidence of a total of 100,000 linear drained fields, occupying 15,000 acres, spread unevenly over an area of 30,000 square miles in the Western Beni. He suggests there could well be several hundred thousand fields occupying as many as 50,000 acres. There are four main types of savanna fields that were undoubtedly drained for cultivation: (i) raised fields where the earth was piled up on low rectangular platforms, (ii) narrow ridged fields, (iii) furrow-like fields in which ditches were dug to provide drainage, and (iv) fields consisting of regularly spaced small mounds. Less common are fields ditched in rectangular or gridiron patterns. The different types of fields generally do not occur in the same area.

The largest of the drained fields are the raised fields, or platforms, and they average 30 to 80 feet in width, some being over 1,000 feet in length. Few cover as much as 2 acres. They are ordinarily spaced anywhere from 10 to 20 to several hundred feet apart, and they occur in clusters of up to several hundred, some being in parallel alignment, while others angle off obliquely. In height they range from 6 to 24 inches, which is sufficient to place them above normal flood waters for most of the year.

Ridged fields are found in areas with causeways, artificial islas, large mounds, ditch fields and mound fields. The variety of the shapes and sizes of the ridged fields is considerable. The fields range from 20 to 1,000 feet in length and average 5 to 20 feet in width. The ditches between fields also average 5 to 20 feet in width. The fields are not always straight and there is no apparent orientation in respect to slope or natural drainage features. The object seems to have been to keep the water off the fields, but not to lead the surplus water out of the field for cultivation. The fields occur in groups, which are sometimes surrounded by sinuous ridges that may have functioned as dykes, but there is no clear evidence of water control for irrigation purposes.

The ditched fields are characterised by close furrow-like spacing of the ditches, which give the appearance of ploughed fields. These furrow-like fields are accomplished mainly by closely spaced ditches rather than by raising ridges. They are generally 6 to 12 inches deep and range in length from 25 to 500 feet, averaging about 400 feet. They are from 2 to 4 feet wide and are spaced from 5 to 20 feet.

Fields of small mounds, often referred to as montones, also occur. Most of the mounds are circular, 10 to 20 feet apart, and about 5 feet in diameter, at heights of a few feet. The mounds are evenly spaced in straight, or nearly straight, lines that form orchard-like blocks. The mound fields are generally found in the areas of open grassland farms on the large islas or gallery forests, a location which suggests that they may have been constructed by the people of small villages who were forced, by population pressures, into open grassland subject to deep flooding. Small mounds may have been built for crops instead of large raised fields because of the lack of manpower to build raised fields, while ditched fields were not practical because of deep flooding. Denevan points out quite clearly that there are no eye-witness accounts of the drained fields of Mojos being built or cultivated but that, nevertheless, the only logical explanation of them is that they are artificial features constructed to drain the savannas and to elevate platforms above flat levels for the purpose of cultivation. In defence of this statement Denevan presents the following facts and propositions:

1. Similar features that do have an agricultural function are found elsewhere in the world.[68]

2. Digging sticks, which were probably the only cultivating tool available to the Mojos, were probably adequate for piling up mounds and ridges. Nordenskjold, who is a valuable source on the Mojos and other tribes of the sub-Andean region, refers to digging spades, an implement which was used for grassland cultivation and ridging in the Andes and the Orinoco llanos.[69]

3. Fibre mats and baskets were available and were probably used by the Mojos to move earth.

4. The raising of mounds, platforms and ridges, has several functions besides drainage. Heavy soil is loosened, thereby making it possible for crop roots to penetrate more readily and, at the same time, aeration is greatly improved. The normally thin layer of humus can be concentrated on the mound or ridge and weeds are destroyed at least temporarily. In Mojos, drainage was essential for savanna cultivation since flooding occurs during the growing season and no techniques were developed for irrigation during the non-flooded dry season. Good drainage would also make possible the long preservation of unharvested tubers.

5. The level of fertility would undoubtedly be increased, temporarily, by mounding and ridging. In addition, it has been shown that in parts of the Mojos, fertility of the savanna soils is actually greater in and below the impervious claypan layer due to reduced leaching, and, consequently, the reduction of ridges would both expose and raise to a higher level the superior subsoils, while burying the poorer top soil.

It is not known whether the Mojos tribes had other methods of improving fertility. They certainly had no significant quantities of animal manure available. One factor which has not been mentioned by Denevan, but would appear to the author to be significant, is that of sedimentation during inundation or flooding. In fact, one factor which appears to differentiate these savannas from some others in South America is that they are adjacent to the Andes, and there is little doubt that the sediment load of most of the rivers would be most significant.

There are certain other observations that can be made in regard to the agriculture and the mounding, ridging, etc. All these improvements of the savanna environment must have required a great deal of labour and time. One would expect these raised fields to have been used for longer than the one or two years of the shifting cultivation in the forested areas. Denevan suggests that fields would be readily invaded by savanna grasses and would be abandoned after a year or two for this reason. But again, if there was time and labour sufficient to build the fields, there was surely sufficient for weeding. However, there is no other indication that the agriculture of the savannas was either more permanent or more productive than on forest soils.

Why then did the Mojos farm the savannas? Denevan and others have suggested the following reasons:

1. Stone tools were rare in Mojos and thus it may have been easier to build up fields in the savanna than to clear forest.

2. The pressure of population may have built up to a point where the forest lands were insufficient.

3. Territorial claims may have prevented migration to, and within, forested areas.

4. There is certainly every possibility that ideas and concepts regarding the control of water were diffused from "irrigation" cultures and the Western Andean Pacific lowland regions.

5. Similar amelioration of the savanna environment was conducted in other parts of the tropical world and in South America where, as already stated, it was carried out in Columbian and Venezuelan savannas as well as in Marijo Island (at the mouth of the Amazon).

6. Denevan makes an excellent point in stating that:

> "In the Mojos savannas and islas, edible wild plants and animals are abundant and are more concentrated and easier to obtain than in adjacent forests. Certain plants, animals, fish and birds were major sources of food and, at the same time, provided useful materials for all the aboriginal savanna tribes. Quantity and availability vary considerably as did methods of hunting and gathering. Animal protein was a regular part of the diet; however the pre-Spanish sources were mostly wild animals and fish rather than domesticated animals. Undoubtedly the former large concentration of Indians in the Mojos savannas was partly made possible by the relative abundance of game and fish."[70]

Why did this system of savanna cultivation disappear very rapidly in the 17th century? If the system developed, in the first place, due to pressure of population on available forest soils and perhaps with the assistance of prisoner or slave labour, and if a considerable amount of labour was needed for maintenance, any drastic depletion of the slave supply could have contributed to the collapse of the system. The removal of an essential element in any relatively sophisticated system, such as any agricultural system requiring adaptation to or control of excess water, will result in a fairly rapid collapse of the system. Witness the rapid collapse of irrigation agriculture on the Haitian lowlands, following independence. The supply of labour could have been drastically reduced by loss, warfare and/or the loss of prisoners or slaves, and by disease. Slave trading and resulting tribal displacement were common throughout much of tropical South America in the 17th century. The ravages of disease introduced by Europeans are legend. In addition, the Spanish introduction of metal tools and other implements would have made it easier to clear forests than to build fields.

The usual explanation by climatic change has been produced (PLAFKER). It has been suggested that increased flooding over a number of years would have made use of the savanna fields impossible. There is no doubt of this, and in addition the flooding would probably have reduced the supplies of fish and wildlife. The final result could have been starvation and subsequent population decrease. However, there is no evidence of climatic change.

Denevan concludes his excellent monograph as follows:

> "The evidence has been presented that in the Mojos savannas in the 16th century there were several hundred thousand Indians and large villages with palisades, moats, plazas, streets; there can still be seen at least one thousand miles of causeways, several hundred thousand linear drained fields, and also numerous canals, large mounds, and small mound fields. Clearly aboriginal Mojos is an outstanding example of one aboriginal man's ability to adapt to harsh conditions by modifying those conditions and, too, the fact that 'agricultural potential' is a cultural appraisal. In a savanna environment with seemingly little opportunity for grassland cultivation because of flooding, drought and low fertility, pre-Spanish people achieved a productivity and population density that have not been equalled since."[71]

The evidence clearly indicates that the Mojo modified and to a limited extent controlled their physical and biological environments. They modified and to a certain extent created soils. It is also clear from the small size of some of the mounds which served as habitation sites that the skills and perception involved in the modification and creation of soils were fairly widespread and were not limited to a few 'chiefs'.

CHAPTER 13

PERCEPTION OF SOIL BY THE SHIFTING CULTIVATOR

Various aspects of shifting cultivation and of the perception of soil by the tropical cultivator have already been discussed. The immediate and primary objective of this chapter is to consider, as far as it is possible, the perception of soil by the shifting cultivator in the tropics. Until one knows something of this aspect of the relations between man and soil, it is impossible to state with certainty why the cultivator relocates his field on a regular basis. Incidental to the general discussion but relevant to the main thesis, additional material and discussion is presented on the choice of a forest site for cultivation in preference to the savannas, the significance of the time element or the cultural history of a people in the development of attitudes and environmental perception.

The contribution of the anthropologist to present understanding of the perception of features of the physical environment by the tropical cultivator has already been acknowledged. Conklin's[1] work in this respect is outstanding. Many geographers would question the need, in their own discipline, of an understanding of the perception of the soil by the shifting cultivator, considering that it is perhaps sufficient to know that there is a cultivation-fallow cycle, but that the precise reasons for it are the concern of the anthropologist rather than the geographer. The author is obviously unsympathetic with this viewpoint. If the traditional explanation of shifting cultivation, or swidden agriculture, in terms of the rapid exhaustion of soil fertility is correct, then it must be shown that the tropical cultivator who abandons his field after one, two or three years of cultivation, does so because he is fully aware of the fact that if he cultivates or uses the field for another year, yields will be too low, either to justify the effort of planting the crop or to provide the necessary amount of food.

There are other possible reasons for abandonment. Rapid and dense weed growth may force the abandonment of a field, even though at the same time a replanting might have resulted in low or relatively low yields. To these cultivators the fallow does not mean a period of the 'resting' of the soil or nutrient 'build-up', but rather a time for trees to grow which in time will be both more easily cleared and a source of ash, which may or may not be recognised as necessary for crop growth.

It may be naive to suggest that man living close to the land and directly dependent upon it for his sustenance, will in time acquire familiarity with the physical environment based upon a detailed knowledge and understanding of its many elements and the relations between them, in a way and to a degree not attained by the many more advanced agriculturalists. In the case of the shifting cultivator for example, one wonders whether it can be taken for granted that because he is living close to the land, he will necessarily have a detailed knowledge of it.

Allan, in The African Husbandman states:

"as communities of men changed their way of life from hunting and food-gathering, or herding and shepherding, with increasing dependence on hoe-cultivation, they acquired a working knowledge of the soils they used and a means of recognising and distinguishing them. Without this knowledge, hoe cultivation of the weakest soils which cover much of Africa, would have been too precarious a means of livelihood....Dr. B. F. Thomson of the University of Melbourne says of the Australian aborigines, that they are "expert ecologists and display a knowledge of the economic resources of their country far beyond that possessed by most white men. They have names for each type of country and botanical association and can name every tree and plant. They can also describe the food harvest or the fibre and resin these will yield in season".[2]

Thomas in The Harmless People, a widely read and popular book, further illustrates the same theme in stating that:

"each group knows its own territory very well; although it may be several hundred square miles in area, the people who live there know every bush and stone, every convolution of the ground, and have usually named every place in it where a certain kind of veld food may grow, even if that place is only a few square yards in diameter....the great plains of the Kalahari may seem undiversified but really they are divided into countless little patches, some barren, some fertile, depending probably on the soil."[3]

More specifically Allan states of the shifting cultivator, that he also has an understanding of his environment suited to his needs. He can rate the fertility of a piece of land and its suitability for one or other of his crops by the vegetation which covers it and by the physical characteristics of the soil; and he can assess the 'staying-power' of a soil, the number of seasons for which it can be cropped with satisfactory results, and the number of seasons for which it must be rested before such results can be obtained again. His indicator of initial fertility is the climax vegetation and his index of returning fertility is the succession of vegetational phases that follow cultivation. In many cases, his knowledge is precise and remarkably complete. He has a vocabulary of hundreds of names of trees, grasses, and other plants. He identifies particular vegetation associations by specific terms. This fund of ecological knowledge is the basis of 'shifting' cultivation.[4]

Brookfield and Brown, working among the Chimbu of the New Guinea highlands, have found that these people have a detailed knowledge of different types of rock and soil and an understanding of local differences and climate, and in a broad sense, practise land classification as well as placing differing values on different types of land. The Chimbu have a comprehensive terminology to describe rock and soil types. Their perception of soil is obviously sophisticated as soil is referred to both by colour and texture as well as by horizon. The authors state that:

> "in describing soil the Chimbus do not have one term for a whole soil profile; they describe each horizon by distinct terms. As one soil with three distinct horizons--a topsoil A^{0} with humus, a leached horizon A and a horizon of accumulation B, each horizon of distinct colour and texture--will be described by the Chimbus with three distinct soil terms, though from a distance one term, usually that of the topsoil or immediate subsoil, is applied to the soil as a whole. Often a term used to describe soil is identical with that of the underlying rock, but it is distinguished by the term magan (soil) from kombugu (rockstone)."[5]

Soils are also classed by texture or consistency and very fine distinctions are drawn. They differentiate between deep fertile soils, thin hungry soils, mixed soils as on slopes, and thin, inferior soils.[6]

An indication of the keen appreciation of differences is illustrated by the fact that they have divergent opinions as to the relative qualities of the better soils. Some Chimbu urge that the deep yellow and brown clays are the best, in that they produce the largest sweet potato tubers, stand up well to prolonged cultivation and support heavy crops of bananas and sugar cane without difficulty. They also give high yields of coffee. Others argue that the lighter soils have advantages in very much easier working, in equal ability to sustain prolonged cultivation, in their property of never cracking in drought or becoming sticky in rain, and above all in the quick maturing of crops. Sweet potatoes mature in as little as four months in these soils but take much longer on the clays.[7]

In one of the most penetrating and illuminating studies of shifting cultivators in Africa, Pierre d'Schlippe has shown that the Azande have an immense knowledge of their environment,

> "ranging from the relative fertility of each soil-vegetation type of a complicated ecological mosaic, through the exact timing of every operation in the process of raising each variety of every crop to the utilisation of all sorts of fruits, seeds, leaves, woods, barks and basts, to every kind of foods and utensils. It has been shown that this knowledge is shared and applied by each individual Zande. Individuals naturally differ in the degree to which they have attained this knowledge, in the same way in which one individual may speak his mother tongue better than another. Probably no single individual has ever mastered completely the sum total of collective knowledge. Nevertheless, in the quasi-absence of specialisation, the knowledge of the average individual comes far nearer to the total collective knowledge than is the case in a more advanced society."[8]

In the chapter on Azande ecological concepts, d'Schlippe states that, to study ecological formations by finding out the local terms applied to them, amounts, 'to seeing a habitat through the eyes of its inhabitants'.[9] An Azande botanical dictionary includes over 700 terms for trees, shrubs, climbers, grasses, herbs, and only in exceptional circumstances, due to the dominance of one species, is an ecological term derived from a botanical term. In all other cases, ecological terms are independent notions:

> "they range from bottom to top of the catina; they follow the faces of regeneration from cultivation to climax; they fit into exceptional topographical and geological formations and above all these terms stand for different degrees of types of potential fertility for different crops."[10]

An example of an Azande ecological concept is the term 'pavurudi'. This relates to an area of the most fertile formation which offers the greatest agricultural possibilities and the soils of which are either colluvial, dark brown loam, or yellow to red *in situ* loams, with or without ironstone gravel, loose or re-cemented. However, the Azande see it as the whole slope between the valley and the 'breakaway' zone shield, or the third step of the catina. The climax of this step seems to be forest, a transitional formation from rain or gallery forest, to deciduous woodland or tropophilous forest. When this climax is intact, it is called 'bire-pavurudi' (forest along side the stream). Even if it had been degraded by cultivation, it still carried the name of pavurudi as long as trees and shrubs which are not fire-resistant are there to indicate a stage of regeneration which ultimately will reach the climax.[11]

Although d'Schlippe makes reference to soils considered by the Azande as'soft place' or 'soft soil', which correspond to several ecological formations which have one thing in common, that is a deep, dark soil without stones or gravel, there is little indication as to whether the Azande perceive the soil directly, as do the Chimbu of New Guinea and the Hanunoo of the Philippines. However, the Azande do perceive the characteristic of soil fertility. As d'Schlippe states:

> "the Azande are perfectly conscious of this decline of soil fertility. They may express it by saying that the 'fatness' of the land has disappeared, that the land has become sterile, that it has become old, that it is wasted or eaten up, that it has become hard, that it has become red or that the earth has turned into sand. Their reflections on crops may be that they are sick, or stunted, or that they fail (to fail = to be absent or empty)."[12]

Harold C. Conklin in Hanunoo Agriculture: A report on an Integral System of Shifting Cultivation in the Philippines[13] displays the remarkable knowledge and understanding that the Hanunoo have of their environment. When confronted by a work of this thoroughness and excellence, one is forced to ask the question, must we compare the perception of the environment on the part of all other shifting cultivators with that of the Hanunoo? Do the Hanunoo appear to be much more perceptive because of the thoroughness and skill of Conklin's anthropological and ecological research? Or, are we confronted with the most perceptive of all shifting cultivators? The Hanunoo's knowledge and perception of soil as described by Conklin can be summarised in the following way:

1. In distinguishing general and specific soil types they use eight criteria: moisture content, sand content, rock content, general texture, firmness, structure in dry season, stickiness in wet season and colour.

2. They differentiate between non-sandy soils in a temporarily muddy state and in a permanently muddy state, and they also recognise fine silty gravel or quicksand.
3. Four degrees of soil firmness are recognised: excessively hard, firm, loose, including tallis formation, and very loose, with rill formation.
4. The following specific types of soil are recognised primarily on the basis of a combination of sand content and seasonal changes in texture and colour: grey to dark brown clay, light coloured sandy clay, light coloured sandy loam (with higher sand and lower clay content than the former), sand, red lateritic soil, and four specific types of clay named after the locations where they are found.
5. The latter six are excluded from consideration as swidden sites by the Hanunoo because the sand and red lateritic soil will not support grain crops and the four specific clay types exist in very restricted areas.
6. The light coloured sandy clay and light coloured sandy loam are considered the best soils for grains and bananas, while the grey to dark brown clay is considered the best for root crops, beans, other legumes and sugar cane.

Conklin states that the relative fertility rating which the Hanunoo associate with these categories seems to agree rather well with the soil analysis information which he obtained, especially with conditions resulting from different pH values and for varying calcium, manganese, magnesium, phosphorus, potassium, and nitrate content.[14]

However, like the Azande, the Hanunoo consider the plant life about them as the most complex variable in their natural environment and as Conklin states:

> "Ethno-ecological categorisation is correspondingly elaborate, more so in fact than is the case in reference to all other components of the natural environment combined. In evaluating a new swidden site in terms of its economic potential, the Hanunoo farmer relies heavily on the state of the vegetational cover The value of a particular fallow, for example, is judged not in years but by the type of vegetation. This, in turn, often reflects other important ecological conditions such as the intrinsic and temporary soil fertility built up by the regenerating vegetation."[15]

Leeds[16], in discussing the Yaruro, who are located in a mixed savanna/forest environment in the Llanos of Venezuela between the Apure and the Amazonian rain forest to the south, states that:

> "slope and climatic gradations are paralleled...by orderly series of soil and vegetation types. As one moves steadily nearer the mountains, soils change from muds, as at San Fernando, to muddy and sandy loams at Guachara, to sands and sandy loams in the Central Cinaruco and increasingly to sands and pebbly areas. These micro-ecological differences appear to determine micro-cultural differences among various groups of Yaruro as one goes westward, for example, in the specific content of the cosmology."

There is no indication that the Yaruro are aware in any way of this ecological influence upon their culture and the differentiation in their culture within the southern Llanos. However, they do appear to have some perception of soil and of its influence upon their agriculture as indicated in Leeds' statement that:

> "the carrying capacity of the land for horticultural food plants has with the given technology, a fairly fixed upper limit. That such limitations exist for their horticulture is recognised by the Yaruro themselves to some extent. First, they recognise that, given the types of soils extant in their habitat, only certain kinds of crops can be used in certain places. A knowledge in this regard seems to be quite accurate and, of course, determines where a garden will be prepared at any time according to projected needs, existing resources, and past exploitation. Again, they know that a swidden lasts three years, a fact not only confirmed by the evidence of conditions in recently abandoned patches, but also by the results of soil analysis."[17]

Unfortunately it is impossible to judge completely and accurately whether or not the Yaruro are as sophisticated as the Chimbu or the Hanunoo, but from the information that is available, there seems little likelihood that the Yaruro are as perceptive of their physical environment though, again, it may be, that Leeds did not investigate this aspect of their culture as thoroughly as Brown, Brookfield, d'Schlippe and Conklin did their respective groups of shifting cultivators. However, it does appear likely that the Yaruro, like many Amerindian groups living close to the forest/savanna boundary around the periphery of the Amazonian basin, may well have been relatively recent arrivals on the scene and may, perhaps, have only become full agriculturalists in the last century or two.

AMERINDIAN AGRICULTURE

Three groups of Amerindians inhabit the Rupununi District of Guyana. The Wapishana number approximately 5,000 and are an Arawak-speaking group of people, while the Macusi, numbering approximately 3,000, are a Carib-speaking group, as are the Waiwai, a much smaller group, numbering only 500. The Wapishana and the Macusi villages are located on the Rupununi savannas primarily within 10 miles of the edge of the forest which they cultivate to a depth of about a mile. The Waiwai are located deep within the forest to the south at about 1^{o} 30' N. (See Figure18, Photos 34 & 35)

These three groups are of special interest in this study of the knowledge of, attitude to, and perception of <u>soil</u> because there is considerable evidence to support the belief that the Macusi and Wapishana may only have become full-agriculturists within the two or three centuries, while the Waiwai may not have reached this stage until even more recently. The agriculture of the Macusi and Wapishana has been observed by the author on a regular basis since 1958, partly with the aid of an excellent air photo coverage in both 1952 and 1962. Knowledge of the agricultural activities of the Waiwai has been gained from the literature, especially the outstanding volumes by a group of Danish anthropologists; by discussion with the missionaries working with the Waiwai, while at their base at Lethem, Rupununi District, and as a result of a special investigation

FIG. 18

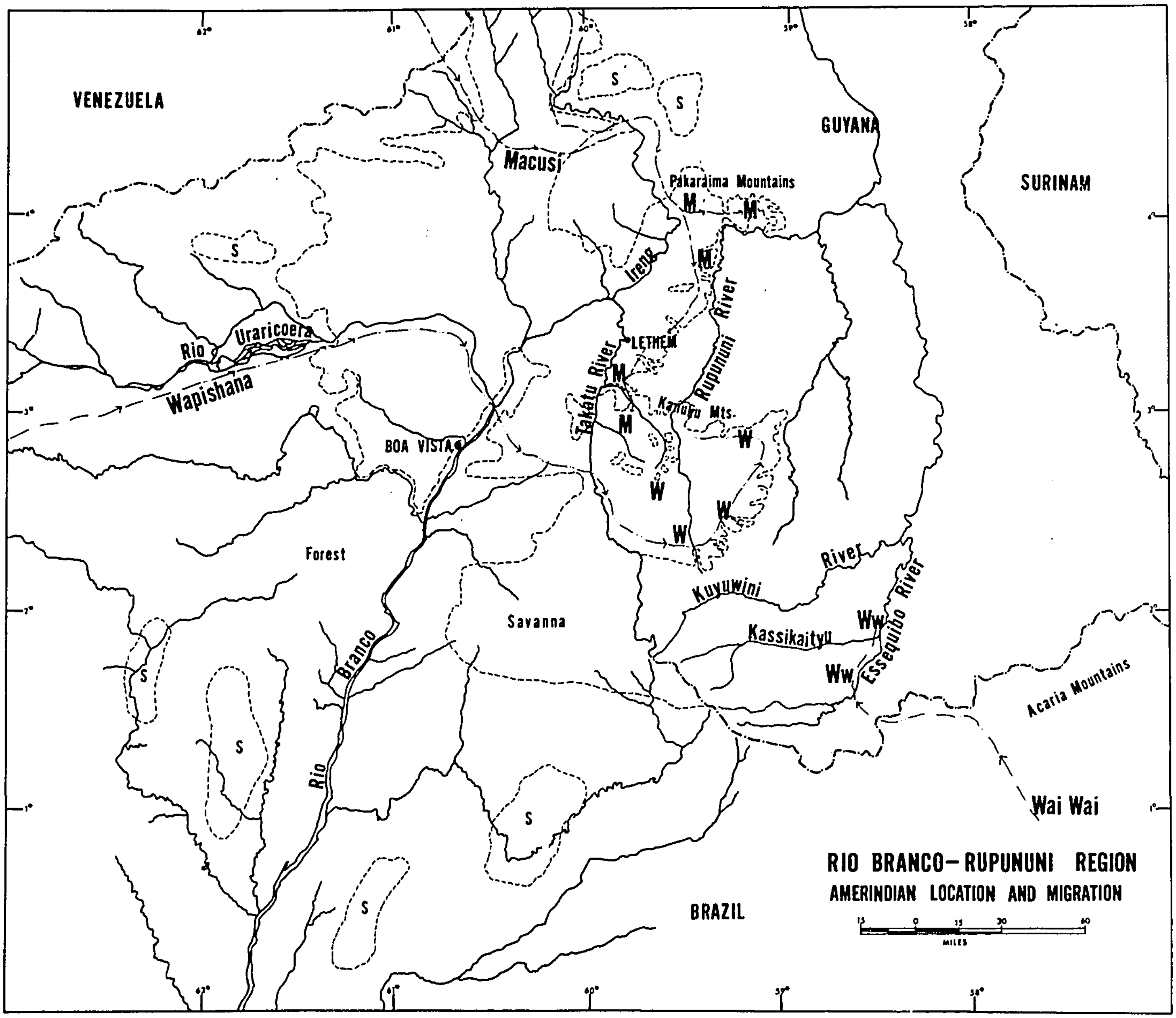

VENEZUELA
GUYANA
SURINAM
Macusi
Pakaraima Mountains
M
M
M
Ireng
River
Rupununi
LETHEM
Takutu River
M
Kanuku Mts.
M
W
W
W
W
Rio
Uraricoera
Wapishana
BOA VISTA
Forest
Savanna
Rio
Branco
Kuyuwini
River
Kassikaityu
Ww
Ww
Essequibo River
Acaria Mountains
Wai Wai
S
BRAZIL
RIO BRANCO—RUPUNUNI REGION
AMERINDIAN LOCATION AND MIGRATION
MILES

PHOTO 34

Waiwai, Guyana

PHOTO 35

Wapishana -- On the Rupununi River below Sand Creek.

conducted more recently by R. Dagon. The knowledge that a particular group of Amerindians has only recently developed full-agriculture is useful in that the development of the art can be observed, that is if acculturation due to contact with the non-Amerindian element of the population does not halt or hinder the progress of agriculture. If it is legitimate to consider the agriculture of the Hanunoo and the Chimbu, among the swidden agriculturalists of the tropics as relatively sophisticated, especially their understanding and perception of soil, then the agriculture of the Macusi, the Wapishana and the Waiwai can be considered as relatively primitive, though dynamic and possibly progressing towards the Hanunoo level of sophistication. Long-term observations of the process of change and development in respect to knowledge of and perception of soil should be most rewarding to the social scientist. Rewarding though it may be, the pursuit of such an objective poses many problems, the most significant of which have already been discussed in Chapter 4.

As also stated earlier, no precise and acceptable methodology for determining the nature and degree of perception of an element of the environment as specific as soil, has yet been developed and tested to the satisfaction of all interested social scientists, though Conklin has surely gone further in this direction than anybody else.

In the published works on the Amerindians of southern Guyana by Roth, Gillin, and Meggers and Evans, and in the thesis by Rivière, there is negligible attention to ethno-ecological characteristics of Amerindian culture. The information that is available has been gained from notes by Dummett, Salisbury and Dagon, and the author's own field observations, and will now be presented within the following framework:

1. The space element--the locational geography and the natural environment.

2. The time element--the cultural history of these tribes.

3. Cultural dimensions--social, technological, and ethno-ecological.

Geographical location and natural environment.

The Rupununi District lies to the south of 5° N. and between the Essequibo River and Brazil. The savannas are restricted to the west and southwest corner of the District and are divided into the northern and southern savannas by the Kanuku Mts. which rise abruptly, from the savanna surface in the west, and from a forested surface in the east, to an average elevation of approximately 3,000 feet. The two areas combined total approximately 5,000 square miles, though they are in fact merely an appendage of a much larger savanna landscape totaling some 21,000 square miles, which lies astride the political boundary separating Guyana from Brazil, and will be referred to for the purpose of convenience as, the Rio Branco-Rupununi savannas. The Rio Branco section--by far the larger of the two--lies within the Territorio do Roraimo, one of the federal territories of the state of Amazona, Brazil, and which in physical and biological descriptions of the Amazon is frequently referred to as, the Alto Rio Branco. This savanna landscape, with its surrounding tropical rain forest is one of many located within and around the periphery of the Amazonian basin,

PHOTO 36

Savanna/Forest Boundary -- View North towards the Pakaraima Mts.

PHOTO 37

Savanna -- Ground view

PHOTO 38

The Landscape of the Shifting Cultivator -- Foot of Kanuku Mts.

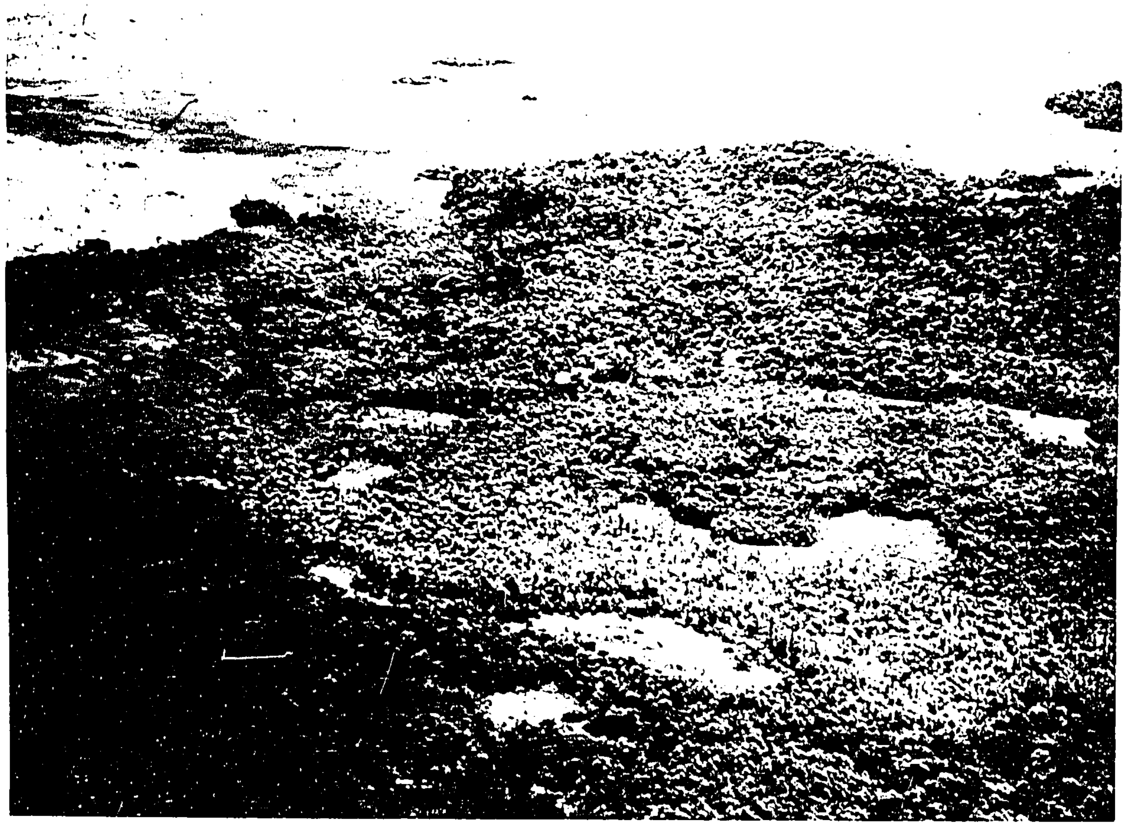


PHOTO 39

Ranch Headquarters -- With gardens based upon coralling

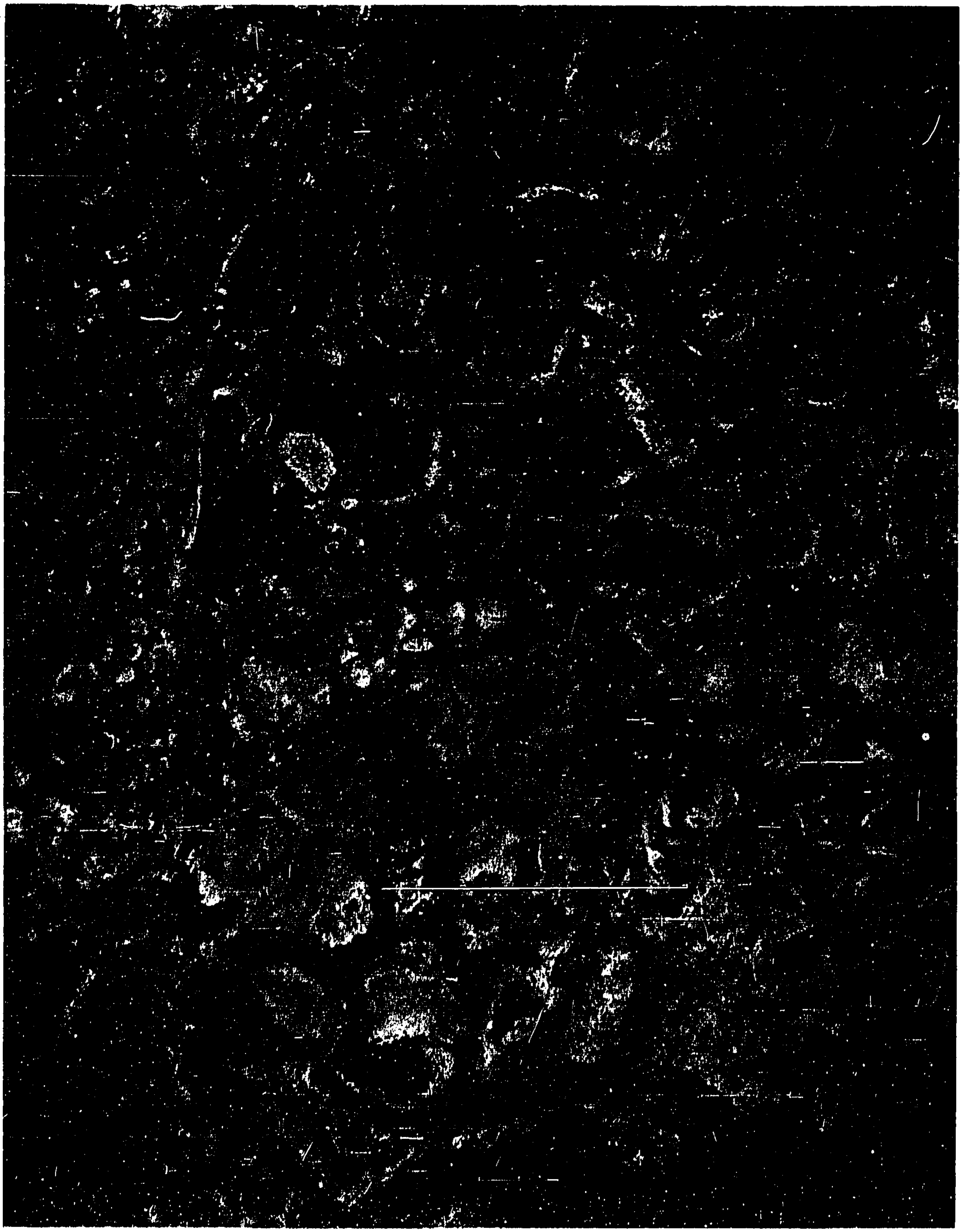
which are beginning to appear more frequently and accurately on maps of the region. Today the region is reached from Georgetown by air, while in the past transportation was primarily via the Essequibo and Rupununi Rivers from the coast of Guyana, or via the Amazon, the Rio Branco and the Takutu, from Brazil. The routeway provided by the Essequibo, its tributary the Rupununi, the low 320 foot divide within the northern Rupununi, the Ireng, the Takutu and the Rio Branco, provide the lowest pass through the whole of the Guiana Highlands, from the Amazonian Basin to the Atlantic Ocean. The divide between drainage to the Guyana coast and into the Amazon is so low and flat, that at times, at the height of the rainy season, the waters of the two drainage basins actually coalesce. Within the Amazonian drainage basin, the 1500 miles from the mouth of the Amazon to this divide can be travelled by boat with the exception of one series of falls and rapids below Boa Vista. A series of illustrations of the landscapes and characteristics of the landscapes described above and in the ensuing paragraphs is to be found in Photos 36, 37, 38, and 39.

The Ric Branco-Rupununi landscape lies at a general level of 300 to 500 feet above sea level, and rises somewhat towards the marginal watersheds. Much of the landscape is characterised by an undulating plain of monotonous appearance, within which isolated peaks and low ridges occasionally rise to view above the riparian forest along meandering rivers and streams. Encircling this plain, though occurring discontinuously, is an area of more elevated terrain, between 500 and 700 feet above sea level, composed of undulating gravel ridges, largely of lateritic origin, lateritic plateau remnants, long gentle sheet wash slopes, and, more particularly in the southeast, the remnants of granitic ridges. The landscape as a whole is enclosed by a series of mountain ranges and elevated surfaces which rise 1,500 to 4,000 feet on their flanks and are arranged in such a way as to produce a basin-like relief with the southern rim of the basin lower and less continuous. The physiographic margin is interrupted by the two broad drainage outlets to the north the Rupununi River and to the southwest, the broad alluvial valley of the Rio Branco. Structurally the Rio Branco-Rupununi savannas belong to the Guiana Shield, an ancient pre-Cambrian mass that forms the nucleus of the northeastern part of South America.

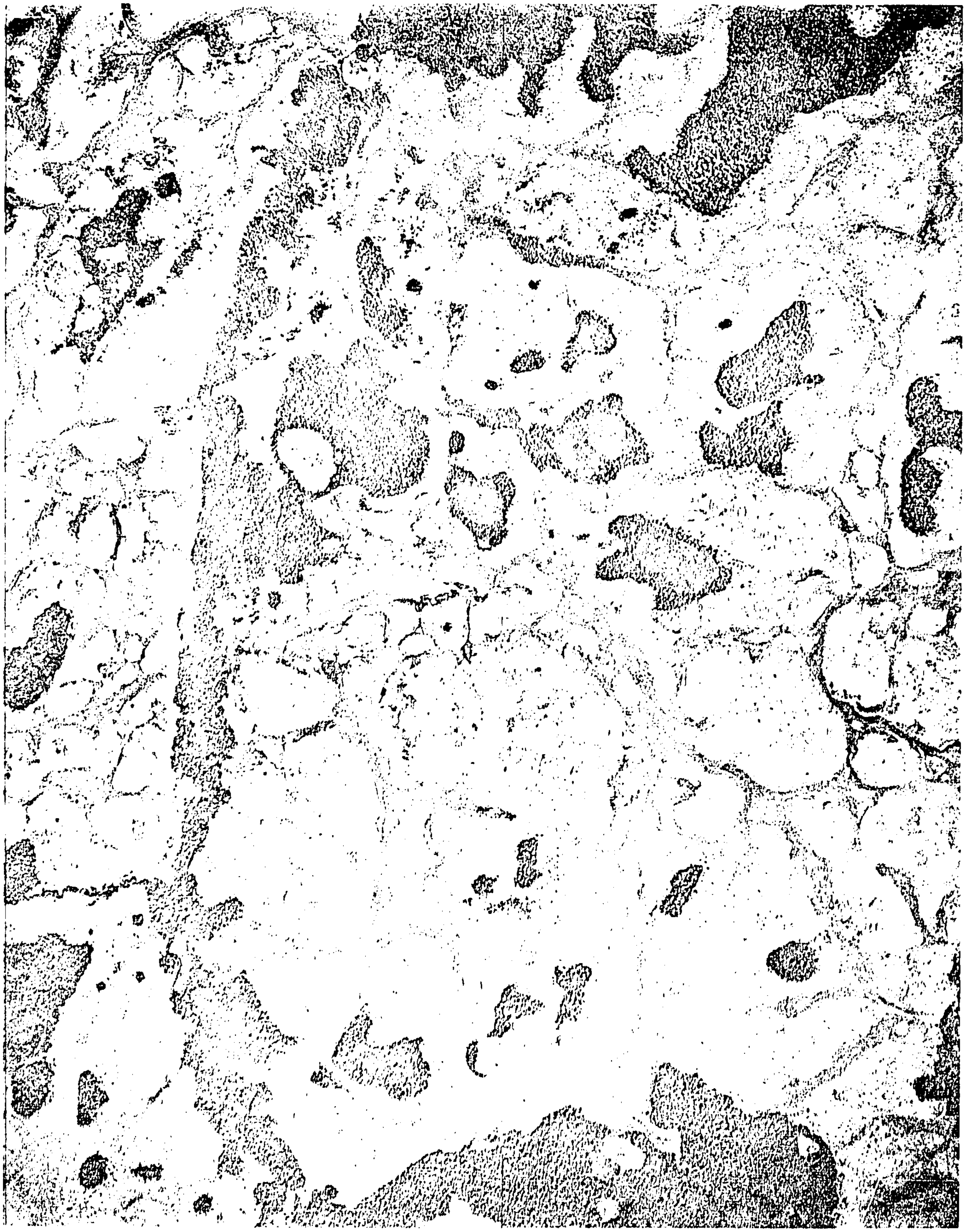
Flying southwest from Georgetown across the forested areas of the coastal lowland and then the Pakaraima Mts, which to the north of the Rupununi average 4,000 to 5,000 feet in elevation, descent is sudden and most dramatic; the dark green of the rain forest and the steep slopes of the Pakaraimas give way with striking abruptness to the dominantly grassy savanna cover of the flat to undulating plain. The broad sweep of the savanna is broken only by the riparian forest along the drainage channels, isolated bush islands and the fringing palms of the swampy depressions. To the east of the Rupununi River at the foot of the Kanuku Mts., and to the far south, the rain forest takes over again with a suddenness that is difficult to explain in purely climatic, pedological or edaphic terms. Man, his fire, and grazing animals have no doubt been the accompaniment

PHOTO 40

The Bush Island Landscape



BRITISH GUIANA OCT. 1952 6" 15,000 ft FILM Nº6



BRITISH GUIANA OCT 1952 6" 15,000 ft. FILM Nº16 of the plain and have helped to restrict the forest largely to the mountain slopes.

The forest surrounding the savanna landscape is, in part, typical Amazonian rain forest, and in part, forest that has been described variously as dry-evergreen, deciduous, monsoon, semi-deciduous or montane forest. Within the savanna landscape, various vegetation types can be distinguished; riparian or galeria forest, bush islands, Ité swamps, marshes, aquatic vegetation, muri scrub, and savanna. The savanna varies from sedge-dominant to grass-dominant and areas where woody species form a canopy of almost 50%.

A dominant feature of the Rupununi landscape is of course the climate, which is typically humid tropical, though characterised by a distinctive dry season which varies in length from four to seven months. It is much longer in the heart of the northern Rupununi than it is in the southeast of the southern savannas. The annual total fall varies from 50 to 80 inches with the lower total being typical of locations in the lee of both the Pakaraima and Kanuku Mts. while the higher totals are typical of locations to the south and southwest. The rainy season extends from approximately the end of April to September. The combination of the concentration of rainfall in the rainy season, approximately 80% or more falling in the period April to September, and the senile nature of much of the lowland landscape, results in severe restrictions being placed upon groundwater drainage, both in the savanna and in much of the surrounding lowland forest. This means that extensive flooding and waterlogging occur in all lowlying areas. In more elevated areas conditions are less extreme, but even here, ground water levels frequently rise close to the surface. With the slackening of rainfall, however, towards the end of the rainy season, much of the surface flood water rapidly disperses and is accompanied by regional lowering of river levels. An increased ground-water gradient is thus established and ground-water drainage is accelerated. This process is greatly facilitated by the appearance of porous and gravel sub-strata, both in the low-lying fluvial, lacustrine trough and in the more elevated areas to the south and east. In a few places where ground-water drainage is impeded by heavy textured horizons, ponds and lakes may persist for several months but there is at this time (the dry season) no general profile impediment and ground-water levels fall fairly rapidly with the lowering of the rivers. Thus, in addition to the climatic seasonality, it is apparent that the hydrological imbalance across the watershed region contributes to this seasonal contrast of the savanna and surrounding forest landscape. (See Photos 41 and 42)

In a consideration of the soil factor in the physical and biological environment of the Rio Branco-Rupununi region, it is essential that soils over the entire region be considered, not only those in the present zone of shifting cultivation. The bulk of the parent material of the soils of the region has been derived from the granitic and gneissic rocks of the crystalline pre-Cambrian mass of the Guiana Shield that surrounds the

PHOTO 41

Rainy Season Inundation -- On the Rio Branco

PHOTO 42

Amerindian Settlement -- Close to the savanna/forest boundary (Shea)

BRITISH GUIANA OCT 1952 6" 15,000 ft / FILM No16

BRITISH GUIANA OCT 1952 6" 15,000 ft. FILM Nº16 greater part of the region under discussion. The Rio Branco, the northern Rupununi and the southern Rupununi are lowland regions within the Guiana Shield and are presently basins of accumulation, although today, the greater part of the savanna surface of the southern Rupununi is in the process of degradation. The southern Rupununi is underlain primarily by crystalline basement rocks which rise above the present erosion surface in the form of inselberg-like expressions to heights from a few hundred feet to several thousand feet, while the northern Rupununi savannas are underlain by sediments derived almost entirely from the surrounding shield rocks. Basement and sediments alike yield very poor soils and profiles are extremely leached and intensively weathered. Development of clay in the subsoil is slight and moisture retention properties are low. In general it can be said of nearly all the savanna soils, as well as most of the forest soils, that they are acid and extremely low in natural fertility and organic matter, in nutrient and in water holding capacity. Three principal groups of soils are to be found. On the more elevated and undulating terrain, regardless of the nature of the vegetation, free draining soils with weakly-developed latosolic characteristics occur. Elsewhere in the lower and flatter areas, under either forest or savanna cover, ground water laterite and low humic glei soils appear. The freely drained soils display a pronounced red/yellow colouration and they frequently have a high sand or gravel content, although slight clay accumulation has taken place at the lower profile. By contrast the hydromorphic soils have a higher

PHOTO 43

Laterite

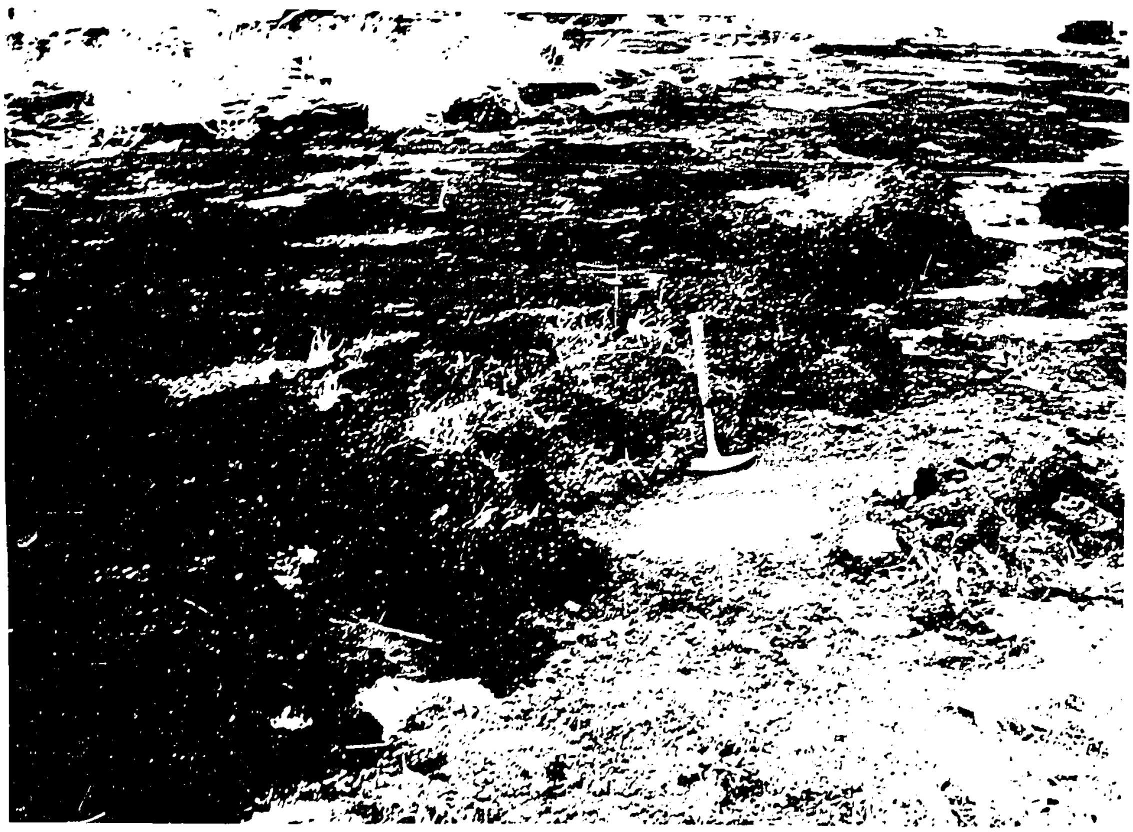


PHOTO 44

Poor Rupununi Cattle -- Reflecting poor nutrition on the poorest savanna

silt and clay content and show moderate structural development in their lower horizons. They are seasonally saturated or flooded and display strong gleying and mottling content, although slight clay accumulation has taken place at the lower profile. In many sites the translation of iron has led to the formation of water table fluctuation although no iron pan has developed. Photos 43 , and 44 illustrate a number of the above soils and their characteristics.

The general characteristics described above, especially the characteristics that can be considered as disadvantageous from the point of view of plant growth, are more typical of the mature or zonal soils, these being the soils that occupy the greater part of the savanna-covered and forested areas. From an agricultural point of view, it can be stated immediately and without any reservations whatsoever, that without improvement by man, the grasses growing upon these soils are largely unpalatable and lacking in nutrition while the soils themselves are by and large only the medium by which plants are supported, in which moisture is stored temporarily and through which plant nutrients, resulting from the burning of grasses or forest growth, pass rapidly and directly to the subsoil, thus being lost to plant growth, or almost directly to the root systems of cultivated plants or regenerating grasses and forest species. Fortunately for man, there are some better soils, the immature or azonal soils which, however, are very limited in extent. These soils result from active weathering and degradation on the slopes of many of the residual features,

TABLE 5

NOTES ON THE BETTER SOILS OF THE RUPUNUNI DISTRICT

(This information was extracted from The Rupununi Savannas by, R. F. Loxton, G. K. Rutherford, J. Spector, T. A. Jones, British Guiana Soil and Land-Use Surveys No. 2, The Regional Research Centre, The Imperial College of Tropical Agriculture, Trinidad, B.W.I., 1958.)

Well Drained Soils of the Pediments

1. Wichabai Series (approximate extent 12 square miles): This occurs on the north face of the Tup-tup-ialli Mountain and is formed over a basic intrusion in the intermediate porphyritic (alkali) granite of the injection complex. The soil is famous in the district for its productivity but is of limited extent on a fairly steep pediment. The soil has very favourable structural characters but it erodes easily and bakes on isolation. The pediment bottom has a typical "slump" appearance suggesting that under certain moisture conditions landslides might prove a nuisance value to agricultural activities.

Well Drained Soils of the Undulating Uplands

2. St. Ignatius Series (approximate extent 57 square miles): This series is differentiated from its close associate Lethem Series by the occurrence of outcropping ironstone pavement or the presence of ironstone gravel either at the surface or to a depth of less than 3 feet in the soil profile. A large portion of St. Ignatius Livestock Research Station is situated on this soil, and similarly many bush islands on the open savannas. It was also found under fringing forest at the foot of the Kanuku Mountains. Amerindians apparently do not practise bush fallow on such sites yet excellent cassava was observed growing on these concretionary gravels in one instance. There is a fair supply of plant nutrients found in these gravels but agriculturally this series will prove a problem soil.

3. Sawariwau Series (approximate extent 57 square miles): Unlike the soils further north associated with or derived from lateritic detritus, Sawariwau Series displays a noticeable increase in clay with depth. The physical characteristics of the soil profiles are favourable and generally they provide conditions more conducive to plant growth than their northern counterparts. The Rupununi Development Company recognise the areas occupied by this soil series as some of their best grazing localities where cattle remain healthy and pasture seems more nutritive than in most other places.

(cont'd) Moderately Well Drained Soils of Gentle Colluvial Slopes

4. Kumu Series (approximate extent 11½ square miles): This is characteristically developed near Moko-moko Village on gently rolling topography in the vicinity of incised rivers and creeks, and in contrast to the adjoining Lethem-Burru Association there are no rock outcrops and "baixas" are less well developed. Some good citrus was seen on this soil, and a reasonable stand of tobacco was observed which had been planted after a period of corralling. The soil is however acidic with weak horizon development, and is low in nutrients.

5. Alluvial soils (approximate extent 75 square miles): Although of appreciable total extent, alluvial soils form only an insignificant part of the general soil pattern. Present day flood plains are not extensive and the alluvials are confined to comparatively thin riverine strips, which are heavily inundated during peak flood periods. Several pits were dug in this area and as expected profiles were very variable. The example given cannot be regarded as representative but is typical of much of the area. Soil reaction is alkaline and the clay mineral is probably a mixed illite/montmorillonite type.

ranging from the lesser inselberg-like impressions in the southern Rupununi, in both the savanna and the forest areas, to the slopes of the Kanuku, Pakaraima and Maraudi Mts., also deposition of this material at the bottom of the slopes, or in certain cases, on the rock pediments resulting from the retreat of slope of the residual feature. In addition, there are alluvial deposits to be found where rivers issue from the Kanuku Mts., especially in the northwest of that mountain area, as well as discontinuously along the river flats and terraces on which grow the riparian forests of the major river valleys. The agricultural value of these denudational and alluvial soils is determined by the chemical and mineralogical characteristics of the parent material and the youth of these soils, which means that time has not taken its toll as with the more mature forest and savanna soils, and by the structure of these soils which makes them easier to cultivate by relatively primitive agricultural tools. Table 5 with annotation, provides a more detailed analysis of the agricultural qualities of these soils.

Restricting attention for now to the Rupununi District, a relatively simple pattern of population distribution appears. Almost 95% of the population of approximately 9,000 is Amerindian and of this proportion, the greater part is located within ten villages which are within ten miles of the savanna/forest boundary. The rest of the Amerindian population is located within the forest, and close to the bush islands in both the northern and the southern savannas. The remaining small element of the population which is composed primarily of ranchers, some coastal settlers, school teachers, and government administrators, is dispersed throughout the savannas and at the major administrative centre of Lethem. The dominant feature of Amerindian population distribution is that it is peripheral to the savanna landscape. (See Figure 19).

As already stated, a high proportion of the Amerindian population is located within ten miles of the forest edge, in fact more than 80% is located within three miles of the forest edge and within this peripheral zone the density of population rises to almost four per square mile, though the figure in the southern savannas where the greater part of the Amerindian population is concentrated, is higher.

The Time Element.

The perspective of time enables an understanding that comes from an appreciation of the development process. In attempting to determine the nature of the perception of soil by the Amerindian, the investigator is not blessed as yet with the luxury of the time period that is often available in studies in other environments or cultures. There is literature--by Rouse[18], Gillin[19], Farabee[20], Evans and Meggers[21], Lathrap[22], Bauve[23], Schomburgk[24], Yde[25], and Rivière[26]--in which fortunately all the authors give some attention to the time depth of the cultures concerned. It is not the intention of the author to become too deeply involved in all the controversies present in these writings, but rather to summarise the findings that are pertinent and, since Evans and Meggers and Rivière have already summarised the findings and views of the others, considerable

FIG. 19 (a)

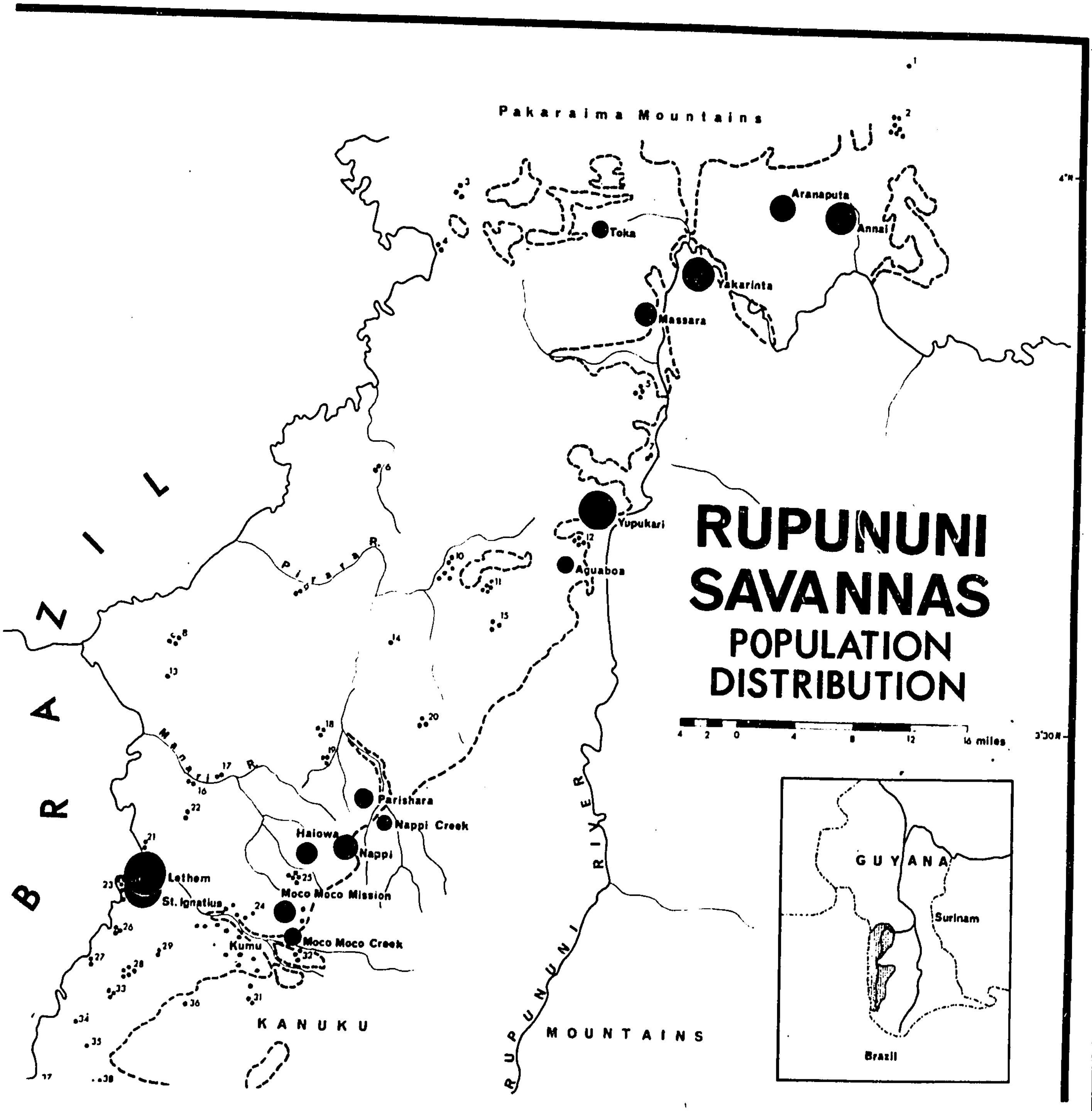
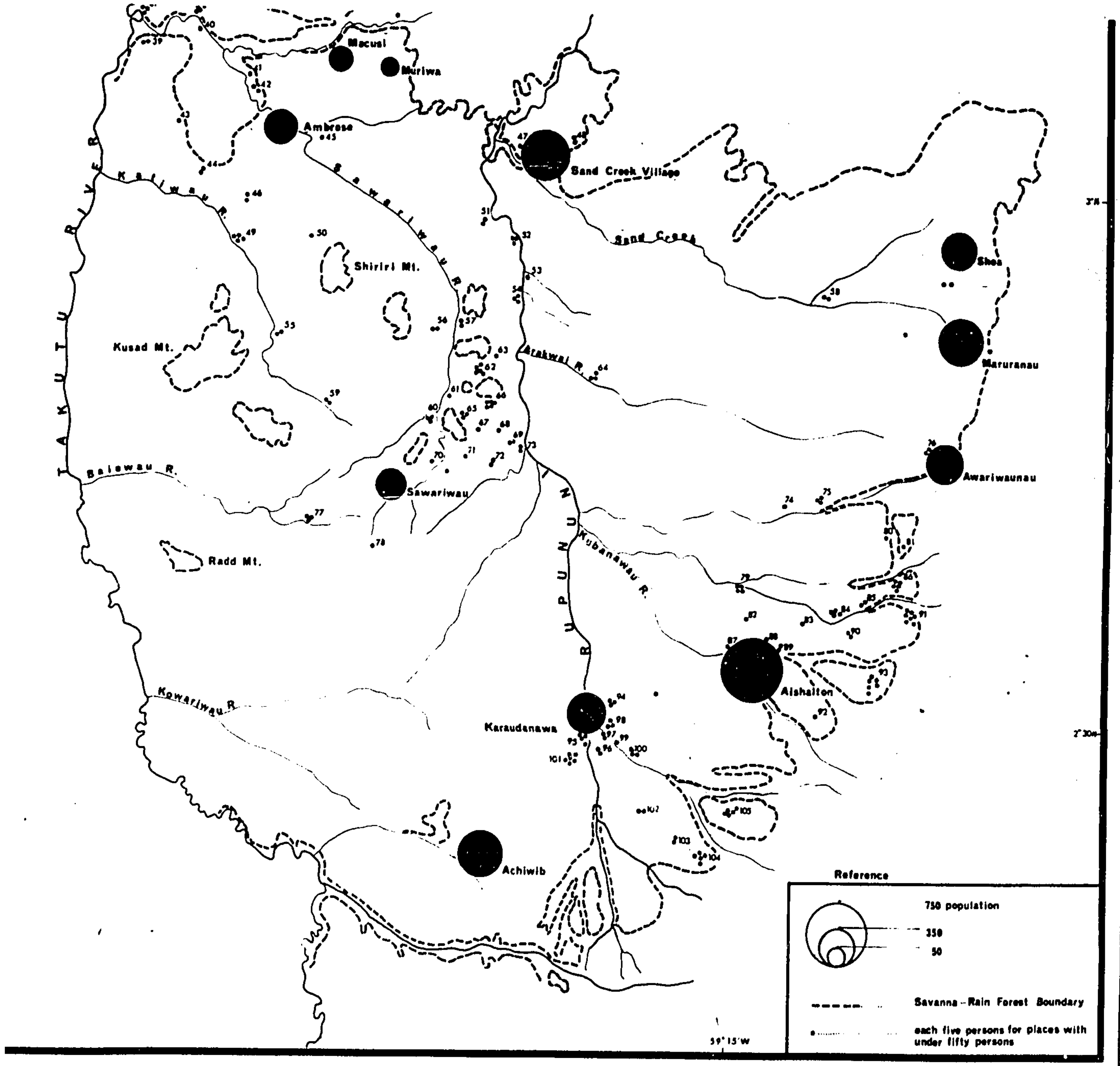

RUPUNUNI
SAVANNAS
POPULATION
DISTRIBUTION
Pakaraima Mountains
Aranaputa
Annai
Toka
Yakarinta
Massara
Yupukari
Aguaboa
BRAZIL
Pirara R.
Manari R.
Parishara
Nappi Creek
Halowa
Nappi
Lethem
St. Ignatius
Moco Moco Mission
Moco Moco Creek
Kumu
KANUKU
MOUNTAINS
RUPUNUNI RIVER
16 miles
GUYANA
Surinam
Brazil

FIG. 19 (b)



Macusi
Muriwa
Ambrose
Sand Creek Village
Sand Creek
Shea
Maruranau
Awariwaunau
Aishalton
Karaudanawa
Achiwib
Sawariwau
Shiriri Mt.
Kusad Mt.
Radd Mt.
Kaliwau R.
Sawariwau R.
Arakwai R.
Balewau R.
Kubanawau R.
Kowariwau R.
TAKUTU RIVER
RUPUNUNI
59°15'W
Reference
750 population
350
50
Savanna - Rain Forest Boundary
each five persons for places with under fifty persons

reliance will be placed upon their conclusions. The author did, however, consult all their references.

The immediate objective in ~~their~~ surveying the cultural history of the Amerindians of the Rupununi is to provide answers to the following questions:

1. When did the Macusi, Wapishana and Waiwai establish their present location and distribution pattern?
2. In moving to their present location and in establishing their present distribution pattern, did they move from one major type of environment into another? And, in the case of the Macusi and Wapishana, did they move into a savanna environment from a forest environment?
3. What were their movements prior to their migration to the Rupununi District? What were the reasons for migration?
4. For how long have each of these Amerindian groups practised agriculture?
5. Has there been any major change in their sources of food and in the relative significance of fishing, collecting, hunting and agriculture as the major source of food in recent centuries?
6. What have been the staple crops of their agriculture and for how long have cassava and corn been staples?
7. What has been the nature of European contact and especially its impact upon Amerindian agriculture?

There is general agreement between Evans and Meggers, Rivière, Gillán, Farabee, and Schomburgk, that all three groups arrived in their present locations in relatively recent times. Evans and Meggers, previously quoted in reference to archaeological work on Marajo Island at the mouth of the Amazon, and who conducted archaeological investigations in the Rupununi in 1952-53, have conducted the only thorough, although not exhaustive, study of the pre-history of the area. Their conclusions can be summarised as follows:[27]

(i) Archaeologically the arrival of the Macusi and the Wapishana is recognised as the Rupununi Phase, and as such, did not appear in Guyana until the 18th century. The Waiwai probably did not cross into Guyana until the present century. In the cultural sequence they are known as the Waiwai Phase. The latter and the Rupununi Phase were preceded by the Taruma Phase. The Taruma Phase is significant in that it preceded both the Rupununi and the Waiwai Phases in the move from either the south or southwest. Its postulated migration from the Lower Rio Negro is dated historically as later than 1670 AD. Ethnographically, the Taruma was virtually identical with the Waiwai and traded with them for at least a century prior to their extinction about 1925. Meggers and Evans consider the Taruma "a typical representative of the Guiana variant of the Tropical Forest pattern".

(ii) The Rupununi Phase moved from south to north. All the sites in the lower half of the sequence are south of the Kanuku Mts. and all the sites in the upper half of the sequence are north of the Kanuku Mts.

> "This site distribution is explainable only in terms of a shift in geographical location of the culture from south to north through time. The dates derived from European trade materials place the two earlier sites in the north savanna as 1819 to 1850 and 1780 to 1830, suggesting that this shift took place between 1800 and 1850.

The majority of the historical records tend to support a recent intrusion of the Wapishana into the southern Rupununi with consequent displacement of the Macushi to the north."[28]

(iii) As far as movement from one environment to another is concerned, Evans and Meggers suggested that the Rupununi Phase could be equated with the Macusi and Wapishana Indians who are known to have occupied some of the later sites in the sequence. The sampling of sites represented in their Rupununi Savanna Survey led them to the conclusion that the entry of these groups on to the savanna was relatively recent. Evidence indicated that the date of intrusion was most unlikely to be earlier than the end of the 18th century. Use of the savanna for hunting at an earlier time is probable, but the choice of the savanna for residence is clearly opposed to European phenomena dictated by the economic advantages of proximity to European settlements. They claim that the Rupununi Phase in all its features is distinct from all other archaeological phases identified in Guyana, and that historical evidence indicates that the Wapishana and Macusi once inhabited the Rio Branco savannas, though their appearance in the Rio Branco probably does not greatly antedate their arrival in Guyana.

(iv) From whence did they come? Evans and Meggers recognise that ethnographically the Rupununi is sub-divided into two tribes with linguistic affiliation to two different language families, suggesting quite different origins, though culturally the Caraban-speaking Macusi and the Arawakan-speaking Wapishana do not differ greatly, at least in archaeological aspects. The archaeological sequence, which extends into the 20th century, presents a uniform picture in settlement pattern, burial practices, pottery types, etc. However, they have considered Schomburgk's theory regarding the origin of the Macusi, which is, that the Macusi came from the Orinoco, on the basis of resemblances between Macusi words and those referred to by Raleigh in his description of tribes along that river. They conclude that verification or rejection of this hypothesis will have to await further archaeological work in the interior of Venezuela. They have nothing to say on the supposed Rio Negro origin of the Wapishana. However, there is little doubt that Evans and Meggers see the peoples involved in the Taruma, Waiwai and Rupununi Phases as having a forest origin.

(v) Another major conclusion of the authors is highly relevant to the questions raised above. They state that:

> "The cultural sequence in British Guiana has bearing on a number of theories and assumptions of general significance. Like the region at the mouth of the Amazon, this area acted as a recipient rather than an originator of culture traits and complexes. The late post-Columban appearance substantiates the hypothesis that the Guyanas functioned as a refuge area rather than a fountain head of Tropical Forest cultural development, as once postulated. The antiquity of settlement by Tropical Forest groups is greatest at both margins of the area--the mouth of the Orinoco and the mouth of the Amazon--implying primarily migrations and/or confusion down these two major rivers from the West. Spread along the coast of the Guyanas appears to have been incredibly slow, and towards the interior practically nil. In fact, it is an open question whether the Rupununi savanna or the upper Essequibo would have yet been invaded by Tropical Forest culture, had the original balance not been upset by the arrival of Europeans."[29]

(vi) The Taruma, Waiwai and Rupununi Phase peoples have all practised slash and burn agriculture as far back as archaeological evidence goes. The authors comment on variation in the size of fields and in the crops grown, but there is no attempt to discuss the origins of the agriculture of these people. What they do say in regard to agriculture is as follows:

"If population composition, accessibility to centres of civilisation, and economic conditions are all variables between the aboriginal and the modern situation, none of them can be used to explain the fact that the Guianas then and now have remained underdeveloped in comparison to other parts of South America. The explanation must lie in some condition constant through time and directly related to exploitation of the region by man. The most obvious factor is the environment, and since agriculture is generally acknowledged to be the foundation of cultural development, the agricultural potential of the environment would seem to be particularly significant. It has been argued that the combination of temperature and rainfall characteristics in the tropical lowlands of South America is unfavourable to intensive agricultural exploitation. In the case of British Guiana it has been charged further, (Evans 1939), that the soils found in most parts of the colony are of low initial fertility, making intensive exploitation even more difficult. These data strongly suggest that the environment is crucial in explaining the secondary role of the Guianas throughout their occupation by man.... In pre-European times, the Guianas occupied a position similar to the one they hold today. They were far removed from the centers of New World civilisation and basic inventions and discoveries reached them not only centuries, but millenia, after their introduction to the Western coast of the continent. Once agriculture replaced hunting and wild food gathering, the foundation was laid for the kind of development that brought dense populations and elaborate socio-political systems elsewhere. In the Guianas, however, the primitive pattern of small, semi-permanent villages and simple, kinship-based societies was never superseded."[30]

In summary, according to Meggers and Evans, the Macusi and the Wapishana did not appear in the Rupununi region until the 18th century and the Waiwai probably did not enter Guyana until the 20th century. The Macusi and Wapishana probably occupied the Rio Branco first, having moved into this region from the south and west or northwest. Both had a forest origin and both practised agriculture at least from the mid-18th century. Migration appears to have resulted from initial European contact.

Rivière in his ethnographic survey of the Indians of the Divide region concluded, in regard to the origin of the Macusi, that there is no indisputable historical evidence of where the Macusi came from and when, but that certain cultural and linguistic affinities support the historical indication of a more northern origin. In addition, he states that:

> "There is a reasonably strong case for supposing a distribution peripheral to the savannas and possibly exclusively to the north, prior to the drift to the east .... There is no lack of reference to the Macusi living at the foot of Pakaraima range and in those mountains. It is not until Schomburgk's time that there is any actual record of them on the open savanna and in the Kanuku mountains."

As far as the Wapishana are concerned, Rivière concluded that there is no irrefutable ethnographic evidence of the movements of the Wapishana prior to the mid-18th century. However, what evidence is available suggests a possible source of origin on the Rio Negro to the east and for sub-groups on the Rio Negro to the south. The historical evidence also supports his conclusion that the Wapishana were most certainly living on the southern Rupununi savannas, in greater or lesser numbers from 1810 onwards however, if it was necessary to state a date for the initial Wapishana migration to the south-east (that is from the Rio Branco) it would be going against what evidence there is to suggest one outside the last decade of the 18th century. It seems highly probable that the Wapishana were in fact a smaller part of a large group of Arawak-speaking Indians, who migrated northward from the Rio Negro, up the Rio Branco, finally moving across what is now a political boundary into the southern savannas, towards the end of the 18th century.[31]

And finally he concludes that archaeology demonstrates that the interior of Guyana was neither a source of culture nor a cross-roads of migratory movements. With the possible exception of an early pre-ceramic people, the region was uninhabited until quite recently, probably no more than 200 years ago for the upper Essequibo and rather less for the savanna regions of the Rupununi. At this time an Amerindian population had moved into the region from a generally westerly direction. There was no contact with the coastal cultures.

Bauve and Schomburgk, both contributed to the provision of, what would appear to be a fairly complete and accurate picture of the development of the Wapishana distribution pattern during the 19th century, and that pattern would seem to be very little different from the contemporary pattern with but two exceptions. Today there are very few Wapishana in the northern Rupununi and the villages close to the savanna/forest boundary are more highly centralised. Rivière supports a forest environment at least for the Macusi and, in support of his viewpoint, he suggested that the 'horticulture' on which Macusi economy was based was never geared to cope with savanna soils, and the proximity of forest to the mountain side was a necessity for their 'slash-and-burn' farming.[32]

In spite of some relatively recent and interesting material on Waiwai agriculture, contributed by Yde and Fock, it is questionable whether much of the published material is of great importance to this discussion. There is little doubt that the Waiwai migrated to the north from a Brazilian location within the last century, that the most recent phase of the migration was stimulated primarily by missionary activities, and that they have remained within a riverine forest environment. As to how long the Waiwai have practised agriculture, the only evidence is archaeological and that is so recent that it is of little value. However, in regard to any change in the relative significance of fishing, collecting, hunting and agriculture as sources of food, Yde in his discussion of 'protected weeds' and semi-cultivated plants, introduces some interesting possibilities. Yde states that:

> "The clearings with the cultivated fields are found in the immediate surroundings of the villages. A walk through the fields does not fail to make one realise that the Waiwai utilised a large number of

> cultivated plants. These are such plants which are planted and grown deliberately, but also such which invade the clearings naturally and are allowed to grow up because the Waiwai by experience have recognised their useful properties and therefore do not weed them away. In other words, the fields contain cultivated plants and 'protected weeds', or semi-cultivated plants as this category may aptly be called."[33]

One possible interpretation of the considerable significance of the semi-cultivated plants is that this characteristic is indicative of a development towards full agriculture. This conclusion is based upon the premise that the development of agriculture passed through a phase during which man relied upon 'protected weeds' for food of plant origin. It may be possible that the Waiwai have retained this appreciation of the value of the 'protected weed' from an earlier pre-agricultural phase in which food was obtained by hunting, fishing and collecting only. This point is made because, under these circumstances, perception of soil would not be particularly sophisticated, if recognised at all, as a factor in plant growth.

Niels Fock, a member with Yde of the Danish Ethnographical Expedition to British Guiana and Brazil in 1954-55, in a major work on the Waiwai has also contributed ideas on the development and contemporary nature of Waiwai agriculture. In his chapter on Myths and Legends--The Creation Myth, he states that:

> "The combination of myth and history with the Wai-Wai thus seems to agree with current theories based on studies of acculturation, The Creation Myth reflecting a development, from a purely hunter and collector culture via the use of cassava with kraua, to a more advanced agricultural culture with, amongst other things, cotton."[34]

The introduction to the volume contains a statement which is also relevant, both to the immediate discussion and the general thesis. Fock states that:

"The occupational life and technical plane of the Wai-Wai is restricted in its development as a result of their natural and cultural environment. The tropical rain forest limits husbandry to a primitive slash-and-burn agriculture, and the wish for certain communications still further restricts its effectiveness. The primitive husbandry of the Wai-Wai gives no surplus production, which may be traditionally motivated by the wish to maintain hunting as a relatively predominant occupation. In the meantime production is responsible for the fact that there is little specialisation and also, to some extent, for the lack of class division. A determinative angle does not, however, seem to be acceptable to illustrate the inter-relationship between nature, occupation and community, as primitive views of Nature modify these relations. In the Wai-Wai consciousness, Nature is not apprehended determinatively as an occupational basis, nor is it realised that occupation is a factor limiting community development. On the other hand, the Wai-Wai regard natural environment as consisting of active -- to some extent arbitrary -- powers and forces, whose activities can sometimes be limited or promoted in order to ensure an harmonious existence, both materially and spiritually. The absence of the sun must be impeded by a sun-cult; rain must be driven away be rain-magic. Floods, governed by the Anaconda people, are feared. Threats to the crops must be dispelled, and rain summoned by magic. Thus it is as much the Wai-Wai understanding of Nature as Nature itself that affects cultural development. In this way the religious ideas, therefore, become the basis stamping the occupational and social institutions."[35]

From opinions already expressed by the author, his reaction to the above views can well be anticipated. Firstly, the tropical rain forest does not limit husbandry to shifting cultivation. It is limited in part by the ecology of the tropical rain forest, but also in large measure by both the Waiwai's limited understanding of 'Nature', as Fock accepts, and the lack of communications that might result both in the introduction of new techniques and crops, and a market for any surplus. Nearly all the significant ethnographic literature on the Amerindians includes references to their cultivated plants but rarely to their date of introduction into Amerindian agriculture. The spread of cultivated plants and their introduction into different cultures can be useful in developing a time scale. The introduction of a crop that requires techniques of cultivation and makes demands upon fertility, different from those of the existing crops, may well give rise to the modification of a change in attitudes to and perception of soil.

The 'ethnographic evidence' of Evans and Meggers, relating to the Macusi and the Wapishana[36], contains a typical reference to the subsistence crops of these tribes. They acknowledge bitter manioc as the main crop, and maize, sweet potatoes, sugar cane, sweet manioc, pineapples, pumpkins, tobacco, peppers, bananas, plantains, cashew and papaya as 'also planted'. They acknowledge Farabee[37] as the source of this information.

Three crops would appear to be significant in this discussion: bitter manioc, sweet manioc, and maize. The cultivation of bitter manioc is universal to the Guiana - Amazon region, but farine making was absent from the Waiwai economy until the missionaries introduced it about 1957-58.[38]

Sweet manioc was also absent until that time and, according to Rivière, there is no reference in the literature to its presence in the Rupununi District until Farabee's 1918 reference[39]. The relatively recent arrival on the scene of a crop, so ubiquitous elsewhere in the Amazonian rain forest region, lends support to the idea of the Rupununi District as something of a 'refuge'.and of retarded agricultural development. Additional support is provided by the absence of maize from Waiwai agriculture to this day, and its apparent recent introduction to Macusi and Wapishana agriculture. The first reference to maize is Farabee 1918, but it could easily have been introduced earlier in the century. However, none of the 19th century travellers noted its presence. Gillin notes maize as one of the 'aboriginal' cultivated plants of the 'Tribes of the Guiana'.[40]

Cultural Dimensions -- social, technological and ethno-ecological,

As far as it has been possible, the Amerindians of the Rupununi District have been located both in relation to their natural environment and the time scale of cultural development of the Amazon - Guiana region. The social, technological and etno-ecological factors of their cultural dimensions are now to be discussed, in so far as they are pertinent to soils.

Particular attention shall be given to the role of soils, in the location, migration, settlement pattern, and agricultural practices of the Amerindians.

Firstly, on the basis of the history of the Amerindians that has already been outlined, what evidence is there that the search for agricultural land and especially fertile soils played any part in decisions related to the migrations undertaken by the Macusi, Wapishana, and Waiwai?

On the basis of the quotations and other statements attributed to Evans and Meggers, Rivière, Farabee, Roth, Lathrap, Schomburgk, and all other historical evidence, the Macusi and Wapishana would appear to have moved under pressure, both of indigenous warfare and European influence, and as Evans and Meggers have suggested, the Rio Branco/Rupununi region would appear to have been a cultural refuge. Once on the move there were undoubtedly alternatives available to them. When they reached the Rio Branco/Rupununi savannas for example, where there is 1,000 miles of savanna/forest boundary, for what reason did they finally settle where they appear to have been for the last century or two, and not evenly around the entire savanna/forest boundary?

What evidence is there of soil, or of suitable agricultural land, having been a significant locational factor? Other questions pertinent to the perception of soil are as follows:

(i) Once the village site was determined, at least partially on the basis of the availability of agricultural land, how did the Amerindians, and how do they presently, select the sites and limits of their fields?

(ii) Is there any relationship between methods of cutting and burning and modification and/or improvement of soil conditions?

(iii) Once the land has been cleared, cultivated, drained, etc., is the ash from the forest employed in any particular way?

(iv) Is there any planting pattern? Is there any pattern related to any feature of the soil?

(v) Is there any planting schedule that is related to the demands of crops, for example, the planting of corn ahead of manioc, because of its greater demands on available nutrients?

(vi) From the time of planting, is there any activity, such as cultivation, and weeding, which is indicative of an appreciation of the benefits to the soil of such activity?

(vii) And perhaps, the most vital question of all, what evidence is there of appreciation by the Amerindians of a reduction or exhaustion of soil fertility as a prelude to the selection and preparation of a new field?

Gillin, in his chapter on tribes of the Guianas, expresses the view that:

> "Guiana settlements tend to be impermanent because of the exhaustion of the soil, inter-tribal wars, the exigencies of trade, and customs demanding the abandonment or destruction of dwellings upon

> the death of their owner or residents. In forested country, the settlement is usually located at some distance from a navigable river bank, often as protection".[41]

He also notes that "in this region of many rivers, fishing, is of first importance to almost all tribes", a fact which is no longer true of many Amerindian tribes. Nevertheless, there is no doubt that all these factors and others also, must be considered in attempting to explain both the selection of site and the overall distribution pattern of settlement. From all the evidence that is available and which has been summarised so ably by Rivière, the forest/savanna boundary close to a major river was the ideal site for Amerindian settlement. A boundary location provided the hunter, collector, and cultivator with the best of two environments, for though some of the forest trees that were in great demand might be located a considerable distance from the boundary, the forest provided the possibility of agriculture on the basis of both a closed nutrient cycle and a greater sufficiency of moisture, while the savanna offered open village sites and a different fauna and flora. In the light of Gillin's statement regarding fishing, the value of the river location is obvious. With a premium on these site characteristics, most settlements tended to be peripheral within the Rio Branco/Rupununi, with the exceptions provided by riverine sites where the riverine forest zone is, or has been, wide enough to serve for agricultural purposes. Agricultural activities and savanna fires would appear to have greatly reduced the extent and the quality of riverine forest during the last century.

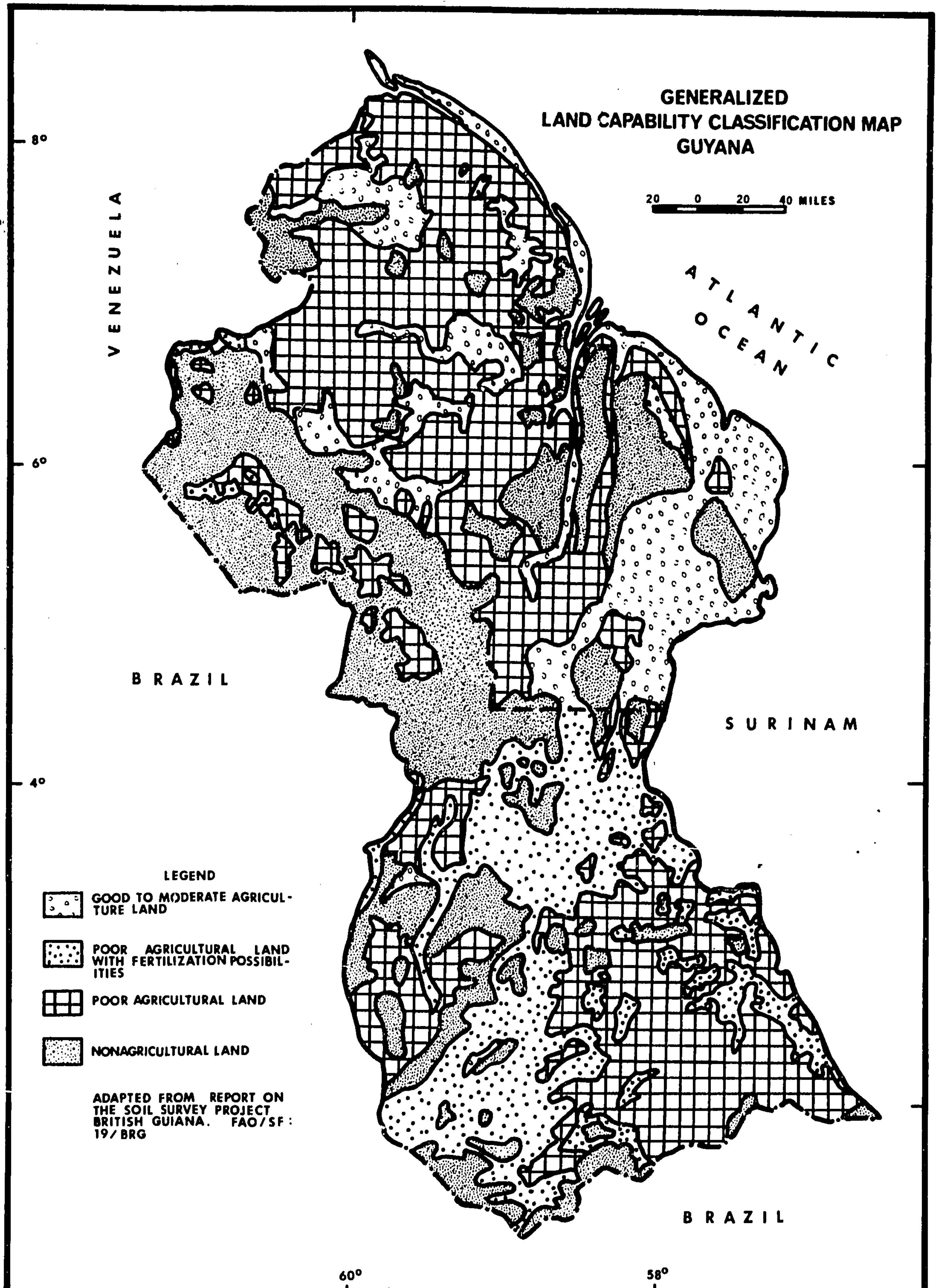
The attraction of such sites was proven when the Portuguese failed in their attempt to settle Rio Branco Amerindians in permanent villages on the banks of the Rio Branco.[42] The Portuguese made this attempt in 1777 in order to provide a ready labour supply and to facilitate the conversion of the Amerindians to Christianity. They initially succeeded in settling over 1,000 Amerindians in five villages. However, within a few years the Indians revolted and only one village, the most southerly and probably the village on the most desirable site, survived. Later attempts were also unsuccessful. These attempts may well have precipitated or hastened the eastward migrations of both the Wapishana and the Macusi. The political boundary hence became a factor in the distributional pattern.

From the time the Wapishana and Macusi crossed the Takutu and the Ireng, the densest concentrations appear to have been on what, at least today, is considered as the best agricultural land. An outstanding exception would be the concentration of Macusi along the southern foot of the Pakaraima Mts., where both soil fertility and soil moisture are relatively unfavourable except in the vicinity of Annai. One compensating factor was probably the greater ease of clearing and burning the slopes of the Pakaraimas.[43] Again, it is impossible to state to what extent the Indians were conscious of the agricultural qualities of the land they occupied along the northwestern fringe of the Kanuku Mts. Other favourable site factors were also present: the savanna/forest boundary, excellent hunting in both forest and savanna, good fishing, trading opportunities, and access to well protected sites in the heart of the Kanuku Mts. In the history of Amerindian occupance of these sites, there may in fact be evidence of the complete lack of appreciation or perception of variation in soil quality.

These soils, the distribution of which is shown on Figure , are considered equal in quality to the best Guyana coastal soils and yet all evidence indicates that fields were rarely, if ever, used for more than two or three years at a time. Only in the last decade has the fallow period been reduced in some areas to as short a period as from 10 to 15 years. During this period settlers from coastal regions have demonstrated that agriculture on these soils can be practised on a permanent basis. Most authors describing agriculture in the 19th century, refer to the typical slash and burn or shifting cultivation of the Indians, but there are no specific statements regarding the cultivation/fallow ratio. Schomburgk describes abqndoned fields and states in explanation of the abandonment:

> "We found ourselves apparently in an abandoned provision field, now run wild, upon which a ruined house still remained. Its former owner, Pureka, was one of the men who accompanied me. Upon this neglected piece of ground, the Musa sapientium had reached a height of 40 feet and a trunk in diameter of 14 inches. The average height of the sugar cane amounted to between 15 and 18 feet. In this respect the richness of the soil here surpassed anything I had ever seen before: the latter consisted of a mixture of humus, loam and sand. The occurrence of a painful death had induced the former proprietor to abandon his house and the rich fields surrounding it....though the Indian is anything but intimately attached to the soil he happens to occupy, and where perhaps he was born, quite a trifling cause often induces him to pack up his hunting-kit as well as all his other belongings and seek some other place of residence, but so long as the fruits of his field are not harvested, he will only shift his quarters if the circumstances seem to be very urgent. It must accordingly have been some such cogent reason that induced the Indians to abandon their fields, then in so flourishing a condition and take their departure."[44]

It is very clear from all the evidence available that throughout the Rio Branco/Rupununi region, the Amerindian cultivator has traditionally maintained a field for two years and occasionally for two and a half to three years regardless of the quality of the soil. It is also clear that


GENERALIZED
LAND CAPABILITY CLASSIFICATION MAP
GUYANA
20 0 20 40 MILES
8°
6°
4°
60°
58°
VENEZUELA
ATLANTIC
OCEAN
BRAZIL
SURINAM
BRAZIL
LEGEND
GOOD TO MODERATE AGRICULTURE LAND
POOR AGRICULTURAL LAND WITH FERTILIZATION POSSIBILITIES
POOR AGRICULTURAL LAND
NONAGRICULTURAL LAND
ADAPTED FROM REPORT ON THE SOIL SURVEY PROJECT BRITISH GUIANA. FAO/SF: 19/BRG

certain soils on the fringe of the Kanuku Mts. could well have been used on a relatively permanent basis, whereas the soils in the southeast could not. There are no significant differences between Macusi and Wapishana agriculture so that the failure of the former to exploit their soils fully cannot be explained in these terms. Either weed growth was so overpowering that a second planting could not be considered, or else the Amerindian was so bound by tradition developed in regions to the west, where soils were incapable of supporting more than one, or two crops at the most, that perception of improved growing conditions was impossible.

Site Selection.

In any consideration of the selection of the site and limits of a field, little assistance is provided by the literature except that pertaining to the Waiwai. In analysing the situation now and in the past, Conklin's guide to the investigation of 'site selection' will be used.[45] Conklin has suggested that the following are factors that should be considered by the investigator and may be considered by the shifting cultivator:

1. Land is considered uncultivable because of

 - poor drainage
 - limiting surface conditions (rocky, sandy, or eroded terrain)
 - limiting vegetation (some grasslands)
 - religious taboos (sacred groves, cemeteries, etc.)
 - other systems of land usage

2. Variables considered within cultivable areas

 - distance from one's present field and settlement site (including those other than one's own)
 - topography (slope, depressions, etc.)
 - exposure to sun and wind
 - soil conditions
 - patterned vegetation
 - ownership and previous use of land

- anticipated labour requirements
- external considerations (government restrictions, crop quotas, etc.)
- planning

In attempting to go through the field site selection process with numerous Amerindians, the author repeatedly found that their initial concern was for the land that was uncultivable -- "that area is no good, it is too wet" or "it's flat" or "there are too many streams to cross to get to it".

Turning now to the variables within the cultivable area, according to Conklin, firstly, 'distance from one's own existing swidden and settlement site'. There is a minimum distance, that is to the edge of the forest, that must be covered, and within the Rupununi these distances range from two to twenty miles. The greater this distance, the less distance the Amerindian will wish to cover within the forest in moving to his field. Distance is measured, not only in miles, but also in quality; difficult rivers and steep slopes increase 'distance', especially for the women who must carry produce from the field to the village. There is little doubt that the factor of 'distance' is vital in field site selection. Distance influences several factors -- the effective time spent at the field, whether or not a temporary move to the field will be made for preparation, planting and harvesting periods, the safety and degree of protection of crops and the amount of produce that can be transported to points of consumption or sale.

The other limiting factors listed by Conklin are not significant in the Rupununi. Sacred groves have not been heard of and, as the Amerindian practises cremation, a cemetery will not be a significant land use. All Amerindians practise agriculture in forested areas on Amerindian

- anticipated labour requirements
- external considerations (government restrictions, crop quotas, etc.)
- planning

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The other limiting factors listed by Conklin are not significant in the Rupununi. Sacred groves have not been heard of and, as the Amerindian practises cremation, a cemetery will not be a significant land use. All Amerindians practise agriculture in forested areas on Amerindian reservations where there are no other forms of land usage. Two types of vegetation are avoided, ité palms because they invariably indicate poor drainage, and the occasional small savanna within the forest. 'Limiting surface conditions' usually take the form of surface laterite or a thick layer of lateritic gravel, pure sand, or a sharp change in slope in the form of a small bluff. In addition, there is a biotic factor -- the presence of Acoushi ants, their known, suspected, or predicted presence will rule out any possibility of that area being cleared.

The considerable increase in distances between villages and fields, resulting from the nucleation of settlements, has undoubtedly influenced the relative significance of field site factors. Amerindians would appear to spend less time in the field now than in the past, but of this there is no proof. If this assumption is correct, then less care can be given to weeds than previously. The degree to which temporary residence, at or close to the field, is resorted to as a means of overcoming some of the disadvantages of the great distances, will depend upon a variety of factors, one of which is the availability of water. Water sometimes has to be carried from the village well to the site of temporary residence. Another result of nucleation would appear to be the greater concentration of fields and hence, the shortening of the fallow in order to minimise the distance factor.

Ideally, fields should be well protected from cattle by a thick fringe of forest between the savanna and the field. When distance from village to field increases, the Amerindian cannot afford the luxury of too much protection. One of the advantages attributed to cassava as a staple crop is that it can remain in the ground for a period of up to six

PHOTO 45

Waiwai Village

months from maturity without deterioration, a factor of the greatest importance with a group which has no means of storage. However, this benefit is nullified if the distance from the field to the village is so great as to discourage the Amerindian woman from visiting the field regularly.

In field site selection, the distance from the present field is significant in that the Amerindian woman who goes to the field to plant, prefers not to have to travel too great a distance to the old field in order to harvest cassava. In some areas, the new field is merely an extension of the existing field, as in Waiwai agriculture and, to a certain extent, in other areas around the Rupununi. Reference has already been made to the consideration of land as uncultivable because of poor drainage. In the cultivable areas, drainage is again a very significant factor. Ordinarily, too much soil moisture and especially inundation of cassava roots, for even a few days, will cause damage, so it is of vital importance to know the behaviour of the water table, and thus to reconnoitre for a site initially, at least, during the rainy season. A sloping field, with a lower flat area which may be inundated for a short period, may not be excluded because eddoe thrive under such conditions and if the inundation is regular and for known periods, bananas and yams may even be grown on these sites.

Steep slopes, of the degree that are used in the Pakaraimas, are avoided in the Kanuku Mountain region and are seldom encountered in the south. Exposure to sun and wind does not appear to be a significant locational factor, at least it has never been mentioned by Amerindians. The only way in which wind is considered is that, given the choice of having to locate a field within a bush island, the leeward side would be preferred, as a fringe of forest to the windward side is desirable as a protection against the severest of the savanna fires.

Do Amerindians classify, or at least differentiate between, vegetation types in their environment and for what purpose? They clearly differentiate between savanna and forest for a great many reasons. As far as agriculture is concerned, they rarely consider the possibility of using the savanna. One Macusi village is known to have cultivated an area cleared of dense savanna woodland, and with reasonable results, but the cost of fencing such an area is usually considerable. No detailed study of Amerindian vegetation terminology has been conducted, but the author is aware that the Amerindian differentiates between -

1. Virgin, dense lowland rain forest, both well-drained and liable to inundation.
2. Virgin, dense montane type rain forest.
3. The above forest types regenerating from fire (plot cultivation).
4. Forest with specific trees, such as the Brazil nut tree or balata tree.
5. Various stages of regeneration in abandoned fields.

From the time that a field is so overgrown by weeds that it can no longer be cultivated, to the stage, somewhere between 10 and 20 years, when regenerating forest is no longer too dense to be cleared, Amerindians recognise stages of growth by the disappearance of certain species in the sub-climaxes or secondary succession, but they are not really interested until the forest has reached a stage suitable for re-clearing. (See Photos 46, 47).

Does the average Amerindian understand the ecological relationships involved in the vegetation types he recognises? Does he appreciate that, when he selects and prepares a field in the forest that has regenerated

PHOTO 46

A 'field' -- Note the dimensions of the surrounding trees

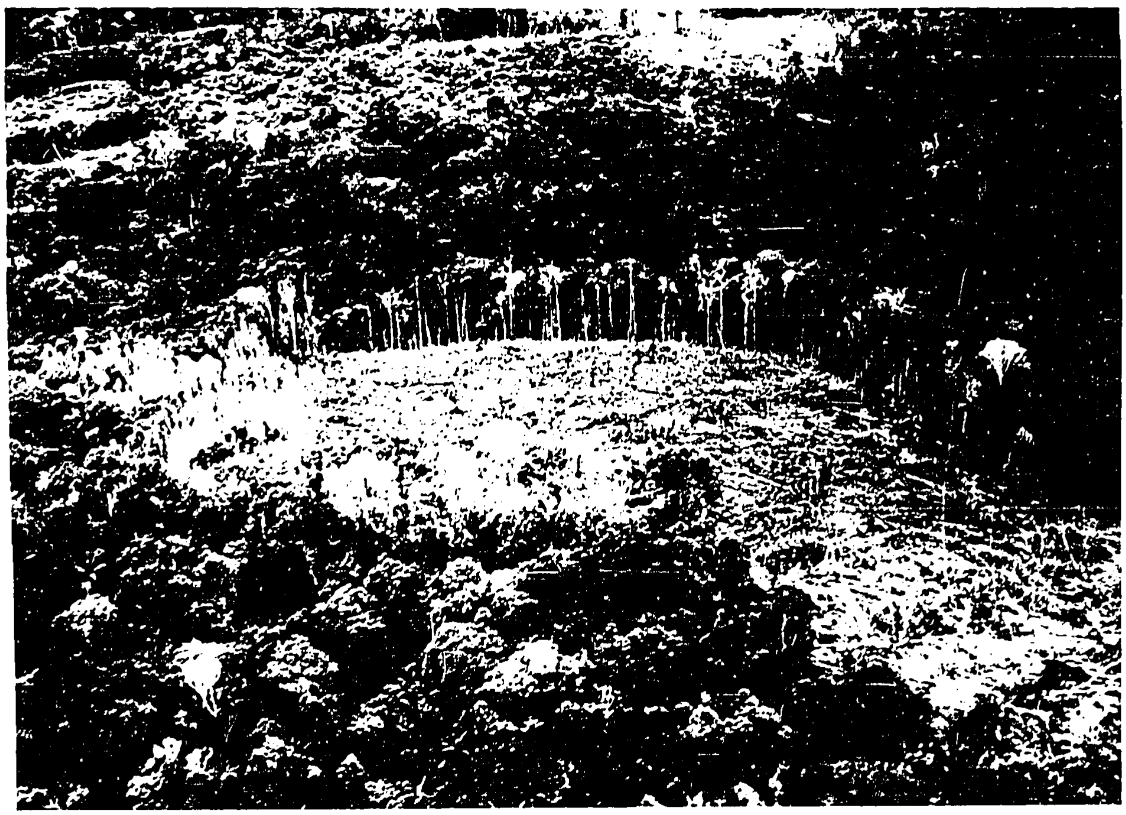

PHOTO 47

The preparation of a field

for 15 or 20 years, the soils will have been improved or rejuvenated? If he perceives soil as anything apart from within "land", he will probably perceive the physical condition of soil and especially its ability to retain moisture. There is no evidence that he has any perception of soil fertility as such. His ecological concepts may involve an appreciation of relations between moisture, soil texture, slope and vegetation or crop. Amerindians frequently refer to 'hot' and 'cold' soils. White or yellow sandy soils are 'hot' and they dry out. Some red latesols are described as 'cool' and 'wet', which means they have good moisture retention. The appreciation by some Amerindians that a field in virgin forest would produce good crops does not necessarily mean that they appreciate the benefits of virgin soils, it may simply mean and probably does mean, that new fields will produce more ash which is recognised as good for crops.

Thus in site selection it is soil texture and drainage, slope and amount of ash likely to be produced, rather than soil fertility, that appear to be of significance.

As regards the perception of soil by the Waiwai and the significance of soil as a factor in site selection, Fock makes an interesting observation. He states:

> "Occupational life is dominated by slash-and-burn agriculture with bitter manioc as the most important culture plant. Sweet manioc is not found as at the upper Rio Negro, nor is maize. This gives the agriculture a particularly light character as no special harvest season is required and storage is unnecessary. Agriculture can thus be said to be adjusted to man's chief occupations, hunting and fishing, as it does not demand any radical change of mentality in regard to the stability of work. Farming also takes place on lighter soil than, for example, with the earlier and recent neighbours, the Taruma and Mouyena, who primarily cultivated patches of dark soil that were not so quickly exhausted. In consequence, the Wai-Wai were less domiciled than their two neighbouring tribes."[46]

Before analysing the above statement, the following quotation from Evans and Meggers should be considered.

> "Analysis of the site descriptions and the site seriation, brings out several characteristics of the Taruma Phase pattern. The majority of the village sites are surrounded by large field clearings, the exceptions being cases where the hilltop was too small to permit cultivation. The excessive size of some form of clearings suggests that the Taruma followed the same practice as the present-day Wai-Wai, progressively extending the fields. Where the land area is sufficient, the Wai-Wai field is first cleared next to the new house. When a field begins to decline, the adjacent area is planted. It is only after suitable land in the immediate vicinity has been exhausted that a more distant location is found. This stage may be accompanied by the moving of the village if the distance is great enough. That the Taruma followed a similar practice is suggested by the fact that field clearings with habitation refuse tended to be larger than those not associated with villages. Only one independent field clearing reached 200 by 100 meters whereas nine of those adjacent to villages were as large as this or larger, and only four were smaller."[47]

There is no evidence, other than circumstantial, for the conclusion that Fock comes to in regard to the relations between soil and length of settlement. There is no evidence of the Taruma or Mouyena utilising a field for any longer period than do the Macusi, Wapishana or Waiwai today or in the past. There is also no evidence of the Waiwai waiting for yields to decline.

Is ownership or previous use of land significant in site selection, among the Amerindians? In any study of social organisation, rights of property are significant and must be given detailed and systematic attention. Of the three tribes considered in this study, only the Waiwai have been given a degree of attention that would allow any reasonably definitive statements on rights of property, especially as regards the use of land. However, it can be stated with reasonable certainty that the Wapishana and Macusi cultivators have freedom of choice in locating their fields, with the exception that, in those areas where pressure on available land has increased, the farms tend to be an extension of existing fields, and it is not too likely that the Amerindian would cut a field immediately adjacent to that of another unless he is a member of the extended family. This is also probably true of an Amerindian cultivator in a small bush island in the savanna, such as in the Sawariwau area. If a farmer has cultivated in a one bush island for five years to a decade, it is unlikely that another farmer would locate a farm in the one remaining patch of forest in that bush island that is suitable for clearing. The author expected to find that Amerindians, especially the sedentary Wapishana and Macusi, would over a period of years, watch the development of a patch of forest in anticipation of making a farm on that site. Not one Amerindian questioned acknowledged such anticipation. Most claimed that they never gave any thought to a new field until the weeds were too much for them in their existing field. However, a number of Amerindians among the Wapishana and Macusi mentioned the discovery of their field during hunting activities in which they had been engaged while taking time off from activities in their existing field.

One thing that can be stated with some certainty is that the cultivator of a field has no prior claim to that land when the farm is again ready for cultivation. Thus, in site selection, whether or not the above is an accurate representation of the situation regarding the rights of property among the Wapishana and Macusi, it would appear that ownership is not a significant factor. The situation among the Waiwai is somewhat different. With the exception of the recent nucleation at Kanashen, Waiwai settlements have traditionally been migratory. Villages have averaged 25 individuals in size and move every 3 to 6 years.[48] Once they establish a field they tend to extend the field outward like the Taruma did before them. According to Evans and Meggers,

> "when a house is built, a slash-and-burn field is cleared behind it and planted. Each following year, the clearing is enlarged for new planting and this continues until the suitable land in the vicinity is exhausted. At this time a new field is cleared on the high spot. If this is more than about an hour's travel away by dugout, the village is usually moved to that location. Otherwise if the old house is in sufficiently good condition, the people will at least remain until the old field ceases to produce. When the field is not by the house, it frequently contains a small lean-to for temporary shelter. When the garden immediately adjacent to the house is beginning to die out, a small area is frequently re-cleared and a second planting of manioc is set out. This practice is not extended to the entire field..."[49]

Within a Waiwai village, the head, or Yayalitomo, owns the clearing even though it was the result of common effort. It is subsequently divided into family plots of about 2 acres which each family plants and thus acquires the right of use. All produce of the field becomes theirs, except when the field is deserted, then any products become joint property. Amongst the Wapishana and Macusi any produce of a field, once abandoned, becomes common property. Once the decision is made to migrate, a site some distance from other villages is sought so as not to have to compete in hunting and fishing activities with another village. It is a matter of competition, rather than conflict, because field and hunting territorial rights are always common property.

The other variables considered by Conklin, 'anticipated labour requirements', 'external considerations' and 'planning' are rarely significant among the Wapishana, Macusi, and Waiwai.

The author fully appreciates that other factors may have been overlooked through ignorance of Amerindian culture and language, but it is unlikely that any of these would be of considerable significance.

Turning now to technical aspects of Amerindian agriculture, what other indication is there, if any, of the Amerindian perception of soil? Selection of site and delimitation of the field is followed by clearing and burning. The major question to ask at this stage of the agricultural operation is whether all Amerindians appreciate the significance of ash to the yield of their crops. This is a difficult question to answer. Firstly, what does ash mean? The following data illustrates very clearly what ash means as far as available nutrients are concerned. In one recently cleared field (Aishalton, March 1964), Soil Sample A was taken, and in the same soil type in an adjacent field with one year old manioc, Soil Sample B was taken.

Available Nutrients in lbs. per acre	N	P	K	Ng	pH
A.	24	818	1,000	200	7.9
B.	18	74	178	10	6.3

The growing manioc would not of course have been responsible for the entire depletion of the available nutrients as chemical and mechanical leaching would have taken their toil. Soil Sample A was taken in a field in which there was a particularly plentiful and well distributed cover of ash. The normal clearing would produce less. However, this example serves to illustrate the physical reality, but how much of this does the Amerindian perceive? One wonders if he perceives much at all, when logs and large branches are observed being piled up around a field to form a fence. But the Amerindian might well argue with you, that it is better to protect a moderate crop from marauding cattle, than to see a good crop eaten and trampled down.

The treatment of ash by the cultivator varies a great deal, however, the author has discovered no reference to ash in the descriptions of Waiwai agriculture. In fact, none of the literature on the Amerindian cultivator, though there are references to the piling up of branches in order to gain a better burn. But this ordinarily means a better burn for the purpose of a cleaner field. The author has observed both direct manipulation of ash and planting according to the distribution of ash. Bananas, pineapples, shrubs yielding fish poison and to a lesser extent such specialties as pumpkins, melons, okra, tobacco, pepper and herbs, are planted in concentrations of ash. The concentrations may be natural (see Photo 48) where a line of ash results from the burning of an old log that had fallen long before the clearing and burning of the field, or it may result from the scraping of ash into low ridges or mounds. The author has also been told by Amerindians that they prefer a field in a new or 'virgin' forest because it would produce a lot of ash which would "make crops grow better". Can this reply be considered as evidence of Amerindian appreciation of the role of ash in the closed plant nutrient cycle?

Apart from the distribution of ash, are there other factors pertaining to soil which are considered by the Amerindian in planting his crops? Reference has already been made to the differences between 'cool' and 'hot' soils. The Amerindian clearly recognises that the soil that is too 'cool' will produce too much growth above ground in the cassava plant and too little root. He recognises a sandy soil as a 'hot' soil and as preferable for cotton, whereas bananas, plantains, and sugar cane yield best, in the 'cooler' soils of depressions. Sweet potatoes do best on slopes. As stated previously, there appears to be recognition here of the role of both soil moisture and temperature.

PHOTO 48

Ash. A heavy concentration of ash, resulting from the fall of a large tree, runs from the lower right to the top left corner of the photo.

Dummett has stated that the habit of planting corn first in the succession of corn-cassava-cassava is a clear indication of the appreciation by the Amerindians that corn is a more nutrient-demanding plant than cassava.[50] The author disagrees for the following reasons: firstly, it could be purely a matter of convenience that corn is planted first, in that it ripens in approximately 5 months, and at this stage weed control is not a problem. If corn was planted as the cassava crop was harvested, weed control would probably be an insurmountable problem. Secondly, corn must be planted towards the end of the dry season in order to grow and mature during the rainy season and the early phase of the dry season. Cassava is harvested in stages, but corn cannot be planted in stages. Thirdly, corn is a relatively recent arrival on the scene and has never been a staple crop in this region. It is the rancher who in recent decades has demanded supplemental feed for his cattle in the form of corn, who has largely been responsible for raising corn to the level of a major crop, though it has not yet replaced cassava as a staple. In the southern Rupununi, the Rupununi Development Company has, for the past two or three decades, encouraged Amerindians to grow more corn and to plant it ahead of cassava. It was obviously in the best interests of the Company and judging from the rapid increase in corn production, the Amerindian considered it in his best interests too.

For the cultivation of both cassava and corn, mounds are made. The explanation for the mounding is very simple. Towards the end of the dry season when the corn and the first of the cassava are planted and after the corn is harvested well into the dry season, soils tend to be dry and are difficult to cultivate. As a consequence, the Amerindian cultivator scrapes all the loose soil, including ash, into a mound in order to provide sufficient depth and support for corn and cassava. In most cases then, it is a matter of sufficient soil to cover the seeds and to support the cuttings as in the case of cassava. Only where ash is scraped into mounds or ridges is there evidence of an appreciation, by the cultivator, of some special quality of the material he is moulding.

CHAPTER 14

CONCLUSION

Many questions were raised in the introduction and many more have been raised in the course of presentation. Some questions were answered, some could not be. Several hypotheses or points of view on the nature of man/land relationships were presented and discussed. This conclusion will not consist of a compilation of conclusions already clearly stated. The primary objective will be to present the author's viewpoint on the existing man/land relationship hypotheses, especially as they relate to the use and role of soils.

Cognitive behaviourism would appear to offer the very best opportunity for appreciating the true place of soils in the relations between man and his environment. The restrictions and problems inherent in the recently revived environmental determinism should be clear. It is obvious from the latest treatise on the soils of the Amazon that the physical environment of the region is not a determining, static thing but one constantly changing and offering a great variety of possibilities. One of the most significant variables creating the possibilities, is man's perception of his environment. It is plain that concepts and perceptions both inspire and limit human efforts to adapt to and/or modify environment.

It is all very well to state and hold this viewpoint but to what extent is it possible to determine with any certainty the concepts and perceptions of each individual or group, either culture or national.

It has been shown that very few geographers in analysing agricultural and rural settlement patterns, past and present have concerned themselves with attitudes to and perception of soil. With some it was not so much a matter of disregard, but rather the difficulty of determining attitudes and perceptions, especially in the past. However, must the geographer concern himself directly with this type of research or can he rely upon the sociologist, anthropologist, especially the ethnoecologist, and perhaps the psychologist. It is the conclusion of the author that the geographer should become directly concerned, or he will lose by default to the ethnoecologist, who is vigorously learning as much about the physical environment as many geographers have learned in the course of their training and experience. A sound geographical training does result in a reasonable appreciation of the physical realities of the environment, and this appreciation is as vital in a study of man/land relationships as the ability to discover the concepts and perceptions of a group of people. The two must be married and preferably within geography.

The convergence of interests between geographers and social and cultural anthropologists over a wide field of common ground in their studies in tropical regions in recent years suggests the possibility of such a marriage.

The author is fully aware of the fact that a large body of geographers still hold to the viewpoint that the geographer's concern should be for the land and man's use of it rather than primarily with people. Trying to understand what people are thinking and what their perception of the environment is at a given time in a given place, should be fundamental to any human geographical research. The problem is not, should we be concerned, but rather, how do we get on with the job?

In looking to the future, we must not for a moment overlook the benefits to be gained from looking into the past, as Lathrap and Denevan and others have been doing. With an increasing availability of soil maps and data from tropical areas as illustrated in Chapter 12, and with the cooperation of the palynologist, the geographer working in tropical areas should be able to recreate past landscapes, an exercise which could be of the greatest value in studies in cultural geography. Investigating concepts, perceptions, ideas, biasses, etc., of the past, could be as valuable as studying them today.

However, in emphasising man, it must be made clear that though man will play a major role in determining the nature of the process of settlement, it must not be forgotten that in the development of any pattern in the landscape, a great variety of spatial and temporal conditions, besides the immediate needs of man, contribute decisively in determining the fate and shape of the land.

It has been shown that the knowledge of, attitudes to, and perception of, tropical soils during the 18th and 19th centuries, involved a variety of misconceptions which were, in part, a result of 'previous experience' in mid-latitude environments. The fact that some of these misconceptions have survived to the present day, is purely a result of modern soil science having so far failed either to survey the entire tropical land surface area or to communicate all its findings about the nature of tropical soils, to those who have made or must make decisions related to settlement and the use of soils.

The findings of the thesis in regard to the sub-division of land are not conclusive, but strong evidence has been presented of the benefits to be gained from a system of land division which takes into account variation in the spatial distribution of the components of the physical environment. In terms of administrative convenience at the national, regional and local level, a strong argument can be presented for a symmetrical or 'geometric' survey system, but it seems clear that in the settlement of new lands some allowance must be made for these variations certainly at the local, and preferably at the regional level too.

A P P E N D I X

SOME CHARACTERISTICS OF TROPICAL SOILS

1. Compared with soils of the temperate regions, most soils of the Humid Tropics are low in nutrient elements. Outstanding exceptions are those that are enriched (a) through the incorporation of fresh mineral material, as natural erosion lowers the surface, (b) through additions of nutrient-rich volcanic ash and other dust to the surface, or (c) by deposits of nutrient-rich alluvium along some recent flood plains and coastal plains.
2. In the Humid Tropics where rainfall is abundant all or part of the year, the soils are subject to strong leaching. Under these conditions, most of the plant nutrients that are not actually tied up in the vegetation itself are subject to removal by leaching. Since woody plants, and especially large forest trees, mobilise greater amounts of nutrients, per hectare, than new grasses, and since the grasses are very likely to be burnt annually, the soils under forest are generally more productive than those under savanna under comparable conditions. Once the nutrients are incorporated within the tissues of the trees, they are maintained within the cycle of the soil to the trees and gradually back to the soil again. Since the demand for nutrients by crop plants is greater and different from the demands of wild plants, one can tell little about the potential of the soil simply from observation of the vegetation.
3. In temperate regions one is accustomed to thinking of grasses as benefiting soils and of trees being less beneficial. Generally the reverse is true of the tropics. In the drier tropics one may be able to develop good natural fallows where leaching is less severe. Recent studies have shown possibilities of developing new combinations of

improved grasses and legumes for soil improvement under humid conditions. Under shifting cultivation, the natural growth is cut and burnt preparatory to cropping. Cultivation and growing of crops stops short of severe exhaustion of fertility or deterioration of soil structure. Where this is done the natural vegetation regenerates well and rapidly, but if the crop cycle is unduly lengthened there is the danger of poor grasses returning rather than woody plants, and the soil fertility deteriorates even further. In extreme cases, Imperata cylindrica and other grasses difficult to eradicate, may take over.

4. The potential of tropical soils cannot necessarily be judged by the results obtained by uninformed indigenous cultivators who lack the skills and facilities of modern technology. Highly productive arable soils can be developed from some of those natural soils which yield only a very poor harvest if simple clearing, tillage and seeding are the only practices used. It is to be remembered that many people writing and thinking about tropical soils today, still do not realise the very great potential these soils could represent in the light of modern research. This applies especially to the rainy tropics where water is abundant and frost is absent and the natural soils are strongly leached.

5. The great variety of soils occurring within the humid tropical regions have been classified as latosols, grumosols, red-yellow podzolic soils, andosols and alluvial soils.

   Latosols cover very large areas in the humid tropics. They have a deep and freely drained profile. The clay fraction is mainly composed of kaolinite sesquioxides and quartz. Cation-exchange capacity and base saturation are low and soil acidity is usually high. Organic matter is frequently low on cultivated soils but at higher elevations it may be high. A common characteristic of these soils is a high phosphate fixation. Latosols are low in plant nutrients but physically are very suitable for plant growth. They are normally well aerated and the tilth is good. The surface soil usually has a favourable texture, structure, and depth. Soil crusting is less common than in some soils of temperate regions, mainly because of the nature of the clay fraction and lack of silt. These soils do not puddle readily nor are hard clods formed on drying. The subsoil usually has a porous structure and a friable consistency, which provides a favourable physical medium for root development.

As drainage is free, gravity water is easily lost and soils reach field capacity shortly after the rains. Latosols can therefore be cultivated very soon after the heavy rains. Latosols are generally more resistant to soil erosion mainly because of their physical conditions than many other tropical soils.

Red-yellow podzolic soils also cover extensive areas of the humid tropics. They differ in many respects from latosols. Plant nutrients are also low in these soils but the activity of the clays is greater than that in most latosols. Base-exchange capacity is somewhat higher than in the latosols and usually increases with depth. In most of the red-yellow podzolic soils, there is less phosphate fixation than in the latosols. Physically they are not as favourable for plant growth. These soils are very susceptible to erosion. The latter is especially harmful and it frequently takes the form of gullying. If erosion only removes part of the surface horizon, it has little permanent effect on productivity.

The grumosols or black tropical soils have quite different features. These heavy clay and deeply cracking soils normally form a self-mulching granular structure at the surface when drying. Grumosols are neutral to alkaline and are relatively low in organic matter. When moistened, the clay swells as the soil becomes sticky, plastic and almost impervious. Low productivity is mainly due to these physical features. The soils are generally rich in lime, have a fairly high magnesium content and a low phosphoric acid content and are poor in nitrogen. They are highly susceptible to erosion - sheet and gully erosion as well as creek erosion. The cracks causing saturation of the subsoil are the principle causes of erosion.

The Andosols are characterised by a relatively thick black to very dark brown surface horizon, rich in organic matter, overlying a dark yellowish brown subsoil. They are medium to coarse textured, have crumb structure in the surface layer and a low bulk density, and are porous and very friable. Allophane clay is a characteristic of the andosols. The fertility of these soils is a function of the composition of the parent material and in most places this is easily weatherable andesitic volcanic ash, although they may be formed from rhyolite.

The fertility of alluvial soils is directly related to the sources of parent material so that some alluvial soils are well supplied with plant nutrients and others are not. But most of the areas of alluvial soils along large streams are as a general rule of mixed origin and moderately well equipped with plant nutrients. The main management problem of such soils is water control, including protection from flooding in the dry season. The alluvial soils may vary widely in texture, both vertically and horizontally. The clay soils are apt to be difficult to drain and to till.

6. Many studies have shown that with increasing rainfall, and decreasing temperature, soil organic matter tends to increase. Rainfall controls the kind and density of vegetation. The temperature, on the other hand, mainly affects the rate of decomposition of plant residue either directly by accelerating the processes of oxidation or through its influence on the micro-biological activity. Proper management of tropical soils should aim at maintaining organic matter and structure in soils recently brought into cultivation and increasing the organic matter and improving the soil structure in the old cultivated soils. By such measures, improvement of soil productivity and fertility on a sustained basis can be attained.
7. Animal manures and composts have proved beneficial in the tropics. They are not only a source of organic matter but also of plant nutrient elements, including the micro-nutrient chemicals. High responses to animal manure and compost have been reported for a variety of crops and a number of tropical countries.
8. Deficiencies of soil micro-nutrient elements can be expected to be quite widespread in the tropics where soils have been strongly leached. How widespread in the tropics these deficiencies are and which micro-nutrients are predominantly lacking is difficult to ascertain at our present stage of knowledge. It should also be mentioned that the acid conditions prevailing in most of the tropical soils may encourage toxic amounts of some micro-nutrient elements such as manganese and deficiencies of others, such as molyodenum.
9. Phosphate fixation in tropical soils is to a large extent due to the

formation of insoluble compounds of iron and aluminium. On soils rich in sesqui-oxides, it is therefore difficult for the plants to obtain phosphorus from insoluble phosphorus compounds. Recent studies in Brazil have shown a very rapid transformation of super phosphate to an unavailable form in Terra Roxa, a latosol derived from basalt and very high in iron and sesqui-oxides. Marked plant responses to the application of phosphate fertilisers have been obtained in many tropical soils. In East Africa dressings of phosphates have shown long-lasting effects.

10. With many soils monoculture of tillage crops is regarded as a dangerous practice. There may be serious risks of building up soil-borne diseases, pests, and of soil erosion, or of soil structure. Many soils in the tropics will not endure continuous cultivation and exposure to the sun. Some become structureless while others bake into hard masses. In either case, they can be restored only by a long period under grass, shrubs or trees, depending on climate and local soil. It is in the tropics, however, especially on young soils from alluvium, volcanic ash and rock, that monoculture is most prevalent, with rice and sugarcane as most important examples.

11. Many rivers in the tropics originate from deeply weathered areas and their deposits consist mainly of quartz and other resistant minerals. Since many alluvial soils in the tropics contain particles which have been through one or more cycles of deposition and erosion, resistant minerals dominate and the natural fertility of the sediments is low. Where rivers originate in recent volcanic areas, mineral composition may be favourable

and natural fertility high. In other cases, the material may be very poor because the parent material consists of deeply weathered rocks on old land surfaces. Reworked marine sediments may have acquired a totally different nature compared with the original sediments and are normally enriched in their mineral composition. The natural fertility of alluvial soils in the tropics varies much more than in temperate areas and often it is low.

12. In regard to the potentialities of tropical alluvial soils, it can be demonstrated that though they offer many problems to soil scientists, engineers and land use planners, they may well form a major agricultural resource. In many places it has been shown that estate agriculture with a full application of science and technology, can produce immense amounts of food and other agricultural products in tropical plains, at an economical cost price. The difficulty in accomplishing results with these methods is that they are unavailable to destitute and uneducated local populations. The main difficulties in tropical lowlands are not connected with soil problems, they are largely connected with unsolved social problems.

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1. For a great deal of the factual information about organic soils I am indebted to Mr. J. J. Jasmin, for a long period, Director of the Sub-station at Ste. Clothilde, but presently President, Terres Noires Ltée, Sherrington, P. Q.

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