THE PHYSICAL ENVIRONMENT OF CENTRAL MALAWI

WITH SPECIAL REFERENCE TO SOILS AND AGRICULTURE

BY

PETER BROWN, B.A., D.T.A.

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At scale 1 : 1,300,000 approx

PREFACE

IT IS ONLY in relatively recent years that soil and ecological surveys have become accepted as a necessary preliminary to agricultural development. Even in Britain and the United States, surveys of this nature have still reached only their early stages. In Nyasaland the first attempt at soil survey was made in 1938 by A. J. W. Hornby and others, and this was a preliminary account of the soils which could not pretend to much detailed investigation. No work on this subject could be done during the war, but various lines have been followed up since then. The principal work was done by G. Jackson, who was able to carry out investigations in all parts of the country. This work was done principally on an ecological basis supplemented by some work on the soils, using the methods developed in Northern Rhodesia by C. G. Trapnell. In addition to this a number of local surveys were made which had the object of planning for resettlement and development schemes. Many thousands of soil analyses have also been made, either for advisory purposes or in connexion with fertilizer experiments which have been laid out all over the country.

In these ways, knowledge of a number of local soils and of their agricultural properties has been acquired without any framework to which this could be related and by means of which it could be extended. The need was therefore felt for a survey which would have as its object the assessment of the total agricultural resources of the country and the mapping of the distribution of these resources. This would provide a basis for cropping programmes, farm planning and other aspects of agricultural development, both on a national and on a local scale. It would also put on permanent record the local knowledge of the district officers and provide a co-ordinating framework for research and experimental work.

Nyasaland is entirely dependent on agriculture for its resources and if these are to be increased and developed there is no doubt of the need for a broad approach to these problems. A narrowly based investigation which is confined to problems that are purely local in importance frequently tends to beget other problems and, in the long run, greatly increases the amount of research work required.

The authors, in their introduction to this survey, say they intend it not only as a guide for agricultural development, but also as a scientific account of the area. The proof that these two aims need not be incompatible is shown by a study of the text, and it will be seen that both these objectives have been successfully achieved. Unless an investigation of this nature is undertaken with the consideration of all the environmental features, there can be no sound basis for proper agricultural planning.

This is the second part of a survey which is intended to cover the whole of Nyasaland in three parts. Part I, covering northern Nyasaland, has already been published, and work has been started on the collection and presentation of data that will form Part III, southern Nyasaland. This involves the study and collation of a mass of information obtained in the past, which is checked and amplified by frequent surveys and extensive journeys in the field.

There have been many attempts to find mineral wealth in Nyasaland, and though a number of valuable minerals have been found, so far there have been good economic reasons why these could not be developed. So far as can be seen, the future prosperity of Nyasaland depends on developing its agricultural resources to the maximum. Unless this can be done, there is no possibility of a substantial increase in the standard of living. There is reason to believe that the farmers of Nyasaland have never been so interested in development as they are today. It is, therefore, most important that such development should be planned to make the best possible use of the financial resources of the country so that they shall be developed to the full and not be wasted.

I believe that this makes an important contribution to these objectives.

S. T. HOYLE, O.B.E.,
Chief Agricultural Research Officer.

ACKNOWLEDGEMENTS

THIS SURVEY could not have been produced without the assistance and co-operation of a large number of people. The authors would like to express their thanks to all of these.

In the Nyasaland Department of Agriculture, particular mention should be made, firstly of the staff of the soil survey section. All the maps and diagrams in this memoir, with the exception of the coloured map of natural regions and areas, have been drawn by Mr. R. B. Mwangala. The many stages involved in the transfer of detail from air photographs to maps have been carried out by Mr. Mangwala with the assistance of Mr. S. Sichali and Mr. E. B. Gunda. Mr. Sichali has also assisted in the collection and identification of plant specimens. All mechanical soil analyses and pH determinations have been made by Mr. G. M. Mandala. All of the above have assisted with the, at times arduous, work of field soil survey. Secondly, thanks are due to Mr. R. A. Wood and the staff of the soil analysis laboratory of Chitedze Agricultural Research Station, for numerous soil analyses. Thirdly, the assistance of all members of the Nyasaland Department of Agriculture in Central Province has been invaluable, both in carrying out agronomic experiments and in making arrangements for field soil survey; special mention should be made of field discussions with Mr. C. Stephens in Kasungu District. Fourthly, the authors would like to express particular thanks to Mr. S. T. Hoyle, O.B.E., and Mr. H. B. Ambrose for their continuous support of the survey and for guidance in its course.

Assistance has been received from many other government departments. Petrographic descriptions of rock specimens have been supplied by Mr. K. Bloomfield of the Nyasaland Department of Geological Survey. Members of the Branch of Botany and Plant Pathology, Federal Ministry of Agriculture, kindly identified plant specimens. Climatic statistics were supplied by the Federal Meteorological Department. The Department of Overseas Surveys undertook the printing of the map of natural regions and areas. Assistance has also been received from the Nyasaland Departments of Forestry and Water Development.

Mrs. D. M. Young has devoted much time to checking the manuscript, and is responsible for clarifying the meaning of many originally obscure sentences.

The agronomic experimental work was carried out under the direction of P. Brown, who has edited the bulletin and is responsible for chapter VI and the aronomy sections of chapter IX. The field soil survey and air photograph interpretation was done by A. Young, who is responsible for chapters I - V, VII, VIII, and the series descriptions in chapter IX.

INTRODUCTION

THIS SURVEY has the same two aims as the survey of northern Nyasaland previously published*. Firstly, it is hoped that it will be of assistance in the planning of agricultural development. Secondly, it is intended as a contribution to regional geography.

The first part of the bulletin gives a systematic account of each of the factors which contribute to the physical environment of central Nyasaland. This is intended to provide a factual basis for agricultural planning on a national scale, and to serve as a framework to which local projects may be related. The second part summarizes existing knowledge of the soil series and of their potentialities for agricultural utilization. It is designed to be of assistance in agricultural developments on a local scale, for example on village co-operative schemes or individual farms.

The plan of the bulletin is similar to that adopted for northern Nyasaland, but with two differences of emphasis. Firstly, relatively more space has been devoted to agriculture. This is in accord with the much greater agricultural productivity, both actual and potential, of central Nyasaland. It is aided by the fact that considerably more agronomic data are available than was the case for northern Nyasaland. Secondly, greater emphasis has been placed upon the natural region; the systematic accounts of environmental factors given in chapters I - IV have been reduced in length, and are essentially explanations and amplifications of the maps which accompany them; conversely, the regional summaries given in chapter V are more comprehensive than in the bulletin on northern Nyasaland. This change is intended to place greater emphasis on the geographical approach, in which the environment is viewed as a unified entity, resulting from the mutual interaction of its component factors.

The survey covers that part of Nyasaland lying between latitudes 12° and 15° south, and west of longitude 34°30′ east. This comprises the Kota Kota, Lilongwe and Dedza sheets of the topographic map on a scale of 1 : 250,000, produced by the Federal Department of Surveys, Salisbury. It is therefore largely coincident with the Central Province of Nyasaland, but excludes Ncheu District and a small part of Dedza District, and includes parts of the Mzimba and Nkata Bay districts of Northern Province.

ARRANGEMENT OF THE BULLETIN

Part One contains systematic accounts of the geology, geomorphology, climate, vegetation, and soils of central Nyasaland. For reasons of space, these accounts have been made essentially descriptive, only the main casual inter-relationships being indicated. Particular attention has been given to those aspects of the factors under consideration which are of particular relevance to agriculture. This part of the survey is summarized in the **Map of Natural Regions and Areas**, on a scale of 1 : 500,000 (**in pocket at back cover**). The main divisions of the physical landscape are termed **natural regions**, and are numbered. The numbering is consecutive with that used in northern Nyasaland, and natural regions 1–15 and 18 do not occur in the area covered by the present bulletin. Subdivisions of the natural regions are termed **natural areas**, and are indicated by letters. The natural regions and areas shown on the map are referred to in the text by their numbers and letters, e.g. the Lilongwe Plain (28), the Nathenje area (28d).

*A. Young and P. Brown, 1962. *The physical environment of northern Nyasaland, with special reference to soils and agriculture.* Government Printer, Zomba, 108 pp. This will be referred to as the bulletin on northern Nyasaland.

Part Two commences with a summary of the present agriculture, the agricultural potential, and certain general factors in the agronomy. It then gives descriptions of the **soil series** that have been identified, together with accounts of the agronomy associated with each of these. In a reconnaissance survey it is not possible to produce a map showing the detailed distribution of soil series, consequently the method that has been adopted is as follows. For each natural area, the soil series that are known or believed to occur within it are listed in the key to the map of natural regions and areas. Chapter VIII contains a key, by means of which the series to which an observed soil profile belongs can be determined. Chapter IX contains descriptions of each series, together with accounts of the agronomy associated with them. These accounts refer not only to the soils themselves, but also to the other environmental conditions under which they occur. The use of Part Two in connexion with local agricultural projects is described further on pp. 25-26 and 39-40.

METHOD OF SURVEY

As in the survey of northern Nyasaland, the present work is based on data of four types: field soil survey, accompanied by observations of other features of the landscape; laboratory analyses of soils; stereoscopic examination and interpretation of air photographs; and agronomic experimental work on sites distributed throughout the area surveyed. The methods of survey have been described in more detail in the bulletin on northern Nyasaland. Quantitatively, the central Nyasaland survey is the product of 308 soil profile descriptions; mile by mile notes on factors of the visible landscape along some 2,000 miles of road and track; 476 textural analyses and 240 full chemical analyses of soils; the interpretation of 2,800 air photographs; and analysis of the results of some 80 replicated agronomic field trials in the districts backed by about 120 single replicate observations on farmers' gardens.

The provisional nature of an extensive survey of this kind must be emphasized. Detailed local soil surveys, on a scale of at least 1 : 50,000, are now widely recognized to be a desirable preliminary to agricultural development. As these are carried out, so the present survey will become superseded in local areas.

Part One

The Physical Environment

CHAPTER I

Geology and Geomorphology

GEOLOGY

NO DETAILED geological mapping has been carried out in central Nyasaland, with the exception of mineral investigations by prospecting companies. Consequently, available knowledge is dependent upon reconnaissance observations. These have been summarized by Cooper[1] and Bloomfield[2], and the following account is based largely on the latter source. The most recent map is the geological sheet of the Federal Atlas of Rhodesia and Nyasaland, on a scale of 1 : 2,500,000.

More than 90 per cent of central Nyasaland is Cambrian age; the few available age determinations suggest a late pre-Cambrian date, possibly, extending into early Cambrian. These rocks strike dominantly between north-north-west and north-north-east, these directions being frequently expressed in the orientation of ridges and elongated hills (e.g. Dzenza Hills, Dedza District and Ngara and Bunda hills, south of Lilongwe District). The Chimaliro Ridge (22a) possesses an east-north-east strike. Over the areas of plains the strike direction is frequently apparent only in isolated hills, but in certain dissected areas it strongly influences the orientation of ridges and valleys. This is markedly the case in two hill areas above the Kota Kota scarp (parts of area 24d), in the Chimaliro Ridge (22a), and in parts of the Dzalanyama Range (31a).

Petrologically the Basement Complex consists of medium to high grade metamorphic rocks, predominantly gneisses. Hornblende-biotite-gneisses are the most widespread type. Certain red soils of Lilongwe and Dedza districts have been proved from borehole evidence to be underlain by hornblende rich gneisses[3]; the extent of this and similar soils suggests the existence of an area of rocks of this type, with less acid composition than over the remainder of the Province, in adjacent parts of Lilongwe, Dowa, and Dedza districts (*see* p. 22). Other common rock types are pyroxene-gneisses and granulites, muscovite-schists and gneisses, quartzo feldspathic granulites and gneisses, and pelitic gneisses and schists[2]. At Dedza Mountain and an area to the west and north-west of it, perthosite-gneisses and other gneisses of acid composition predominate.

The Fort Manning Hills are underlain by rocks of the Mafingi System, a subdivision of the Basement Complex, the type area of which is the Mafingi Hills of northern Nyasaland. Many hills in the Fort Manning region, including Nchinji Ridge (26b), are formed of quartz schists.

A number of relatively small igneous intrusions occur, for the most part forming hills. These include Kasungu Mountain (perthitic syenogabbro), Ngara Hill of north-west Dowa District (syenitic), and Senga Hill (granitic).

In respect of soil formation, the most important property of metamorphic and igneous rocks is their relative proportions of quartz, feldspars and ferro-magnesian minerals. Rocks of acid composition are those in which free quartz is present, associated with a low proportion of ferro-magnesian minerals; these are pale in colour, and tend to produce ferallitic soils (*see* chapter IV), or thin, stony soils. Rocks of basic composition contain a high proportion of ferro-magnesian minerals; they are dark or black in colour, and tend to produce ferruginous soils. It is probable that rock composition is of considerable importance in determining soil type in central Nyasaland, owing to the relatively small range of topographic and climatic variation over much of the province. A clear example of this was observed four miles east of Mkanda Village, Fort Manning District, on the Upper Bua Plain. Below three adjacent hills there are pediments of similar form and slope, approximately 2°; the central of these is covered by a sandy, ferallitic soil, whilst the two other pediments carry a dark red, ferruginous soil, of considerably higher fertility. The former hill is formed of biotite-granite (acid), whilst the two latter are of basic to ultrabasic igneous rocks (gabbro or pyroxenite).

A serious difficulty arises in relating soils to parent rock in plains of the tropics, in that the rocks are rarely accessible. Any hill, tor, or low outcrop, projecting above the surface of the plain is almost certainly formed of a rock type more resistant to weathering than the surrounding rocks, from which the soil has been derived, and the same is likely to be the case with stones or boulders found within the soil profile. The true parent material can be observed only in boreholes, or in the beds of rivers incised below the plain where these are present.

Patches of sediments, possibly of Cretaceous age, are believed to occur to the west of the plains which border the Lake Nyasa shore, but neither the extent nor age of these has been determined.

In addition to Basement Complex rocks, the second main soil parent material is alluvial deposits, occupying possibly 10 per cent. of the area of central Nyasaland. These occur mainly along the Lake Nyasa shore. On the Salima Lake Shore Plain they form a broad and continuous zone, that of natural areas 30a to 30d and marshes enclosed within these. On the Kota Kota and Nkata Bay Lake Shore Lowlands they occur in patches (areas 21e, 25c, 25d and marshes), the largest of which is Bana Swamp. These deposits were deposited mainly by rivers in flood, and consist of bedded sands and clays. Fine sand is usually predominant over coarse, and the silt fraction in derived soils is often relatively high (10–15 per cent.), compared to that found in soils derived from Basement Complex rocks. Muscovite (white mica) flakes are frequently common.

In addition to the lake shore deposits, valley floors in plains areas are occupied by clays, and valley floor margins and valley heads by coarse sandy deposits of colluvial and alluvial origin.

Close to the Lake Nyasa shore, coarse sands deposited by lacustrine processes occur as narrow belts. Sandy raised beach deposits, probably of Quarternary or late Tertiary age, occur at altitudes of 1,700–1,800 ft. in the Kota Kota Lake Shore Lowlands (area 25b.).

GEOMORPHOLOGY

Map I shows the five major relief units into which central Nyasaland may be divided. These are distinguished on the basis of altitude and predominant land forms. They consist of three areas of plains and plateaux, at altitudes of 5,500–7,000 ft., 3,400–4,000 ft. and 1,550–2,000 ft., respectively, separated by two areas of hilly and dissected land. The landforms, or detailed topographic forms are shown on map II. The primary classification of landforms is in terms of predominant angles of slope, giving four main divisions. Plains of depositional origin are nearly level (0°–1°). Erosional plains have slope angles predominantly less than 5°; they may be divided into almost level, or very gently undulating, plains, with slopes not normally exceeding 2°, and gently undulating plains with 2°–5° slopes occurring on valley sides. Pediments occur below all hills rising above the erosional plains; these are gentle slopes, normally 2°–3°, sloping away from the hill-foot. In two areas (16g, 26a) they are sufficiently extensive to be mapped as the predominant landforms. The high altitude dissected plateaux are more steeply sloping, with slopes of up to 10° common. The third main division is dissected areas with moderate slopes (5°–15°) predominant; the majority of these possess moderate relief*. The fourth division covers all areas with steep slopes (15°–35°), including both isolated hills and extensive areas of steep dissection; the relief is normally high, but may also be moderate.

The major relief units and the landforms both influence agricultural utilization of the land. In addition to the effect of the slope of the ground surface on cultivation techniques and soil conservation requirements, indirect influences include the effect of slope on soil formation and that of altitude on climate; vegetation is influenced by a complex of these factors. A comparison of maps I–VI shows that the major relief units form a framework to which is related the distribution of landforms, soils, vegetation and, to a lesser extent, climate also; map VII indicates a similar relationship with agricultural potential. The geomorphology of each of these five units is described below. Emphasis is placed upon the descriptive aspects, since it is the form of the land surface, and not the origins of this form, which affect other environmental factors and agriculture. The associations between relief units and environment will be discussed in the first part of chapter V.

1. **The High Plateaux.** These consist of isolated plateaux at altitudes of 5,500–7,000 ft., with rocky hills rising above the plateau surfaces. These are probably remnants of a former extensive plain which, by analogy with similar remnants in southern Nyasaland[4], is believed to have been formed in end-Jurassic or early Cretaceous times. They are represented only by the southern extension of the High Vipya Plateau (19b) and by remnants on the crests of Dedza and Chongoni mountains (parts of 32d). Gentle and moderate

*__Relief__ is used in this bulletin in the sense of range of relief, or height difference between valley floors and adjacent interfluve crests in an area. The terms used are as follows: low relief: less than 100 ft.: moderate relief: 100-400 ft.; high relief: more than 400 ft.

slopes predominate. The summits of Dedza Mountain (7,212 ft.) and Kwanadama Hill (*c.* 7,500 ft.) on the Vipya are the highest points in central Nyasaland. Mlunduni Mountain, in area 32a, has a long, relatively level crest at approximately 6,500 ft., but this consists of a narrow rocky ridge, with no plateau remnants.

2. **High Altitude Hill Zones.** These comprise hill areas rising above 4,000 ft. They occur mainly as a belt along the eastern margin of the Mid-Tertiary Surface (*see* below), separating this from the Rift Valley. The only major break in the continuity of this belt is north-east of Lilongwe, where the Chimutu - Lumbadzi area (28g), of lower altitude, occurs in its place. The presence of higher land above the Rift Valley margin, falling in altitude away from the latter, is a common feature in all three provinces of Nyasaland, and has been reported in other parts of the African Rift Valley. It is probably caused by upward tilting of this marginal land, associated with the downward movement of the Rift Valley floor.

Three other areas fall within this unit, the Chimaliro Ridge (22a), Nchinji Ridge (26b) and associated hills of west Fort Manning District, and the Dzalanyama Range (31a). The Fort Manning Hills occur on the Mafingi System, in which resistant quartzitic rocks are common, and it is possible that this may be the case for the two other areas also.

Two distinctive landform types occur in the high altitude hill zones, characterized by steep and moderate slopes, respectively. Hill areas with stony soils occupy the Chimaliro Hills (22a), hills above the Kota Kota Scarp Zone (24d), Nchinji Ridge (26b), Nchisi Hill (29e), the Dzalanyama Range (31a), and hills above the Dedza Scarp Zone (32e). These contrast with areas of moderate slopes, mainly of considerable agricultural value, comprising parts of the Dowa Hills (areas 29a, b) and Dedza Hills (areas 32a–c). These areas are characterized by wide valleys with broad convexities on the interfluves. The convexities, on which the slopes increase progressively to 10° or 15°, occupy the majority of the land surface; the inner parts of valleys have slopes of up to 25°, but these occupy relatively small areas. The Mwera Hill (29b) and Dedza-Bembeke (32a) areas both lie at 4,800–5,200 ft.

3. **The Mid-Tertiary Surface.** This is an extensive, continuous plain covering more than half the area of central Nyasaland. It lies mainly at 3,400–4,400 ft., rising very gently to the west and south-west. It forms part of the most extensive erosion surface developed in southern Africa, which is considered to have been formed in the Miocene or Pliocene period.

Over an area between and north of the Rusa and Upper Bua rivers the plain is undissected, with very gentle slopes. Over large areas no slope is apparent, either in the field or on air photographs, although measurement will reveal that the greater parts of the ground surface is inclined at approximately $\frac{1}{2}$°. Valleys have maximum slopes of $1\frac{1}{2}$°–2°, and broad, marshy floors. The Bua and Ruša flow amid continuous level marshy flood-plains, of $\frac{1}{2}$–1 mile width. Areas of impeded drainage are extensive. This undissected plain, covering areas 23d and 27b, is associated with soils of very low fertility. A similar relationship was observed in northern Nyasaland where the Luwewe Plain, undissected and with very gentle slopes, carries poorer soils than the gently undulating parts of the South Rukuru Valley.

The greater part of the Mid-Tertiary Surface in central Nyasaland has gentle slopes. The Dwangwa, Lower Bua, Lilongwe and Linthipe rivers flow in broad valleys cut somewhat below the general level of the plain, and a few of their major tributaries have similar valleys; these have slopes of up to 7° and relatively narrow floors. A large majority of the tributaries have valleys with maximum slopes of 2°–4°, and broad, concave valley floors; frequently there is no incised river-bed, water-flow taking place by seepage through the marsh grassland which occupies the valley floors. Almost level areas, sloping at $\frac{1}{2}$° and less, are present on interfluve crests; the proportion of the ground surface occupied by these varies considerably over different parts of the plain, but rarely exceeds 30 per cent.

With respect to agriculture, this part of the plain combines the advantage of gentle slopes with adequate drainage. It occupies the Kasungu Plain, excluding area 23d, the Lilongwe Plain, with the exception of the Chimutu-Lumbadzi area (28g), and the Tembwe area (27a); the pediments of the Fort Manning Hills (26a) may also be included.

A part of the Upper South Rukuru Valley (area 16d) lies within the area covered by the central Nyasaland maps. This lies at 4,000–4,600 ft., falling to the north, and has gentle slopes. It is described in more detail in the northern Nyasaland bulletin.

4. **The Rift Valley Scarp Zone.** This forms a continuous north-south belt, 2–15 miles in width, of dissected country at altitudes of 2,000–4,000 ft. Well defined scarps, with relatively little dissection, occur only on the eastern margin of the East Vipya Scarp Zone, and in the Dedza Scarp Zone. The greater part of the Kota Kota Scarp Zone consists of a broad belt of deeply dissected country with steep slopes. The less dissected scarps are associated with relatively recent faulting. The main rivers draining from the Mid-Tertiary Surface enter deep and steep gorge sections in crossing this zone.

Below the main scarp in the Dedza Scarp Zone lies an area of scarp foothills (33b). The eastern margin of these, where they adjoin the alluvial plain of the lake shore, is formed by a low, almost undissected scarp, with a series of straight sections, the latter having angular intersections. These were produced by recent faulting, probably of later age than any other tectonic features of central Nyasaland.

The predominance of steep slopes and stony soils renders the Rift Valley Scarp Zone of little value for agriculture. It is a potential source of natural forest products, and includes an extensive game reserve.

5. **The Lake Shore Plain.** Along the shore of Lake Nyasa is a belt of country at altitudes between that of the lake surface, 1,550 ft., and approximately 2,200 ft. There are two distinct sections, plains formed on alluvial deposits, and undulating lowlands developed on Basement Complex rocks.

An alluvial plain is extensively and continuously developed only in the south; it attains a maximum width of 16 miles at Salima, narrowing to the north and south. In the Kota Kota Lake Shore Lowlands it consists of a series of isolated patches, considerably less extensive, the largest of which are west of Chia Lagoon and at the mouths of the Dwangwa and Bua rivers. The surface is almost level, with an overall eastward slope of less than $\frac{1}{2}°$. There are no valleys, the river-beds lying between banks at the level of this plain or raised slightly above it as low, indistinct levees. During periods of flood the flow exceeds the capacity of the river-beds, and parts of the plain become flooded; the river load is deposited, building up the surface. This process has been the principal means by which the plain has been formed; as a result of this the sediments are characterized by frequent depositional bedding, with beds varying from a few inches to several feet thick. In some parts of the plain the process of intermittent deposition is still continuing.

A second means is associated with the action of lacustrine depositional processes. Both the prevalent and dominant winds on Lake Nyasa are from the south-east, and therefore movement of sand along the shore is northwards. Sand spits extend northwards, the two largest at the present day being Sungu Spit at Kota Kota and Kachulu Point north-east of Salima; sand-bars are also frequently formed parallel to the shore. These constructional features produce sheltered areas on their landward sides, which ultimately become infilled to form marshes. Bana Swamp, the large marsh at the mouth of the Dwanga River, consists in its north-eastern part of an extensive complex of successively formed sand spits with enclosed lagoons and marshes; to the south of this lies firstly a uniform area of alluvial clays, and secondly the present flood-plain of the Dwangwa, which includes sandy alluvial deposits.

Lying mainly to the west of this plain is a belt of undulating lowlands, or scarp foothills, with a width of 8–10 miles (areas 24b, 30g and part of 33b). These lie mainly at altitudes of 1,800–2,200 ft., with only a few hills rising above this height. The uniformity of crest level suggests that this belt was originally a plain, sloping gently toward Lake Nyasa. A subsequent fall in the level of the lake surface, now 1,550 ft., has caused the dissection of this plain. The resulting landscape consists of undulating topography with low or lowish relief and moderate or gentle slopes; the relief is higher and the slopes steeper in the Kota Kota area (24b) than in the Salima area (30g). The Kota Kota lake shore ridge (25a) also forms part of this belt, being terminated on its western side by a low scarp, to the west of which lies a north-south depression, probably of fault origin, and containing Chia Lagoon and a line of marshes and small lakes.

The alluvial plain includes areas of highly fertile soils with intensive agriculture and also extensive areas at present uncultivated but of potential value. Certain of the marsh areas are used for rice growing. Apart from the Mwansambo (29c) and Chitala (30f) areas, poor soils predominate in the undulating belt; little agricultural use has so far been made of the majority of this belt, partly owing to the proximity of considerably more fertile alluvial soils.

COMPARISON OF NORTHERN AND CENTRAL PROVINCES

The same five major relief units are present in central as in northern Nyasaland. The greater agricultural potential of the former is due, more than to any other single factor, to the difference in their relative extent. The contrasts are more clearly seen if the comparison is made in respect of the administrative provinces of Nyasaland, rather than taking the 12° south latitude line as the boundary. Regions 17–22, shown in the map accompanying the present bulletin, lie wholly or largely in Northern Province; regions 23–33, with the exception of small areas near the northern margin, are in Central Province.

The High Plateaux are considerably more extensive in the north, Central Province having no large plateaux comparable with the Nyika and Vipya. Both of the latter include areas of gently undulating topography, unaffected by recent dissection, but such areas are absent in Central Province.

The High Altitude Hill Zones occupy a similar proportion of both provinces, but the relative importance of the two main landform types differs. Hill areas with steep slopes predominate in the north, whereas areas of moderate slope are more extensive in Central Province. Agriculturally this contrast is increased by the presence of poor and often stony soils on many of the moderately undulating areas of the north, for example in the Central Mzimba Hills (17), in contrast to the rich soils of the Dowa and Dedza hills of Central Province.

The Mid-Tertiary Surface occupies a considerably greater relative and actual extent in Central Province, where it forms a single continuous plain. In Northern Province it is broken by higher intervening country into three areas, the Fort Hill Plain, the plains west of the Nyika, and the plains of the South Rukuru - Kasitu river system. The altitude of the greater part of these is somewhat higher in Northern Province, more than half the total area lying above 4,000 ft. Both provinces include areas in which slopes do not exceed 2°, and gently undulating areas.

The Rift Valley Scarp Zone is of comparable extent in both provinces, and the same subdivision into scarps and broad, deeply dissected belts is present. The Lake Shore Scarp Zone on the north is similar to the Dedza Scarp Zone, although only in the former case does the scarp foot form the Lake Nyasa shore. A similar scarp occurs west of the southern end of the Nkata Bay Lake Shore Lowlands, its foot touching the lake shore for a distance of one mile. The Karonga Scarp Zone and the East Vipya Hills of Northern Province are of similar topography and extent to the Kota Kota Scarp Zone and its continuation southwards through the Dowa Hills region.

There are substantial resemblances between the two provinces in respect of the extent of the Lake Shore Plain and the landforms developed on it. The Karonga and Salima Lake Shore Plains both contain extensive level alluvial areas, and both have an undulating belt, or scarp foothill zone, lying to the west. In this case the area of soils of high fertility is greater in Northern Province. The Nkata Bay and Kota Kota Lake Shore Lowlands both contain undulating and dissected country of moderate relief at altitudes below 2,200 ft.

DRAINAGE

The river system of central Nyasaland has a basic pattern of great simplicity, made up of two main groups of rivers. The drainage of the Mid-Tertiary Surface has a dendritic pattern with a general north-eastward direction; the streams join to form four major rivers, the Dwangwa, Bua, Lilongwe and Linthipe, which together carry the entire drainage of the surface. These continue across the Rift Valley Scarp Zone in a north-easterly direction, and discharge into Lake Nyasa; the Lilongwe and Linthipe unite west of Salima, and at the present day this combined river flows south-east across the alluvial section of the Lake Shore Plain. The valley-forms of these rivers contain contrasting sections. The smaller tributaries have shallow and gently sloping valleys, frequently without incised beds. The main rivers on the Mid-Tertiary Surface flow in broad valleys of gentle to moderate slope, the depth of which increases eastwards. Across the Rift Valley Scarp Zone these rivers enter very deep and steep sided gorge sections. In this zone they drain belts of only limited north-south width. The gradient of the Bua averages less than 2 ft./mile across the Mid-Tertiary Surface and more than 7 ft./mile after leaving it, becoming considerably steeper across part of the Rift Valley Scarp Zone; the other rivers of this group show a similar contrast in gradient between their upper and lower courses. On entering the alluvial section of the Lake Shore Plain these rivers experience a great reduction in gradient, and deposit much of their load during annual flooding.

The second group comprises some 20 small rivers and a larger number of streams which have short and relatively direct north-eastward to eastward courses towards Lake Nyasa; these have their origins in the Rift Valley Scarp Zone or in the hills above it. Many of them fail to reach the lake, sinking into their own alluvial deposits on the Lake Shore Plain.

The river régime is a consequence of the marked seasonal concentration of the rainfall (*see* chapter II). It may be illustrated by reference to the Lilongwe River, gauged at Lilongwe Town[5]. From July to November the mean discharge is less than 50 cusecs, and in some years flow ceases for a short period. Discharge increases gradually during December and January, much of the rainfall during these months being taken up in replacing depleted soil moisture. By February the soil is normally at field capacity and discharge reaches a maximum of slightly over 1,000 cusecs. After this it declines progressively, the annual mean value falling below 100 cusecs in June. The total annual discharge at this point averages 167,000 acre-ft.

Other rivers have similar régimes, but most remain dry for longer periods. The main annual period with no flow on the Bua River where it leaves the Mid-Tertiary Surface is 25 days. The combined Linthipe-Lilongwe at Salima has a mean annual discharge of 829,000 acre-ft., larger than any gauged river of central and northern Nyasaland except the Songwe, yet ceases to flow on average for 26 days annually[5]. In contrast, this gauging station has recorded a maximum flow of 34,000 cusecs. The annual cessation of flow of even the major rivers of central Nyasaland is related to the absence of extensive High Plateau areas. This contrasts with Northern Province, where perennial flow is maintained on all major rivers rising on the Nyika and Vipya plateaux.

The mean annual discharge of the Bua at Bua Bridge, in the middle of its course, is 467,000 acre-ft.; the Dwangwa is not gauged, but has a discharge of a similar order. Flow on the shorter streams of the Rift Valley Scarp Zone, is considerably smaller; on one of the longest of them the Lingadzi, of Dowa District, the mean annual discharge is 63,000 acre-ft.

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Chapter II

Climate

Nyasaland experiences a tropical continental climate with a single rainy season. The chief features of the climate are firstly, that the rainfall is adequate for agriculture in all areas; and secondly, that this rainfall is markedly concentrated within a single season of four to five months. The following account is based principally upon information supplied by the Federal Meteorological Department, including tables of climate[1], rainfall[2], and winds[3], and unpublished information.

During the winter months of the southern hemisphere, Nyasaland is covered by the sub-tropical high pressure belt. The anticyclonic circulation system associated with this results in a dry south-easterly air-stream with a stable lapse rate over the country. This is characterized by gentle winds; speeds of 4–8 knots are recorded for 40–50 per cent. of the daylight hours. At Lilongwe 77 per cent. of the winds are from directions between 60° and 180° (east-north-east to south). Relative humidities in this air-stream are 50–60 per cent., and whilst it remains established, almost no rainfall occurs. During the months of May to August, temperatures are relatively low. Subsequently the sun moves southwards, passing overhead at mid-day during the second week of November; from July to November temperatures rise steadily, but conditions remain dry.

During December the inter-tropical convergence zone becomes established over Nyasaland. This is characterized by unstable air masses with a higher moisture content, the relative humidity averaging 75–85 per cent. Wind direction becomes variable. Rainfall occurs from December to March, continuing in the wetter areas into April. Heavy convectional storms occur throughout this season, but are particularly characteristic of December and early January.

As a result of these circulation conditions, three seasons are experienced:

(i) The cool season, May to August; dry, with relatively low temperatures.

(ii) The hot season, September to November, frequently continuing into early December; dry and hot with progressively increasing temperatures.

(iii) The wet season, December to March or April; wet and moderately hot.

TEMPERATURE

Using records from 30 stations, situated in all three provinces of Nyasaland, the following relationship between altitude, latitude, and temperature has been obtained:

$$T = 86.5 - \frac{3A}{1000} - \frac{L}{2}$$

where T = mean annual temperature in degrees Fahrenheit, A = altitude in feet, and L = latitude in degrees. The standard deviation between temperatures obtained from this formula and observed temperatures is 1·02; in two-thirds of all cases, computed temperatures will be correct to within plus or minus 1°, and in 95 per cent. of all cases to within plus or minus 2°.

The latitudinal extent of central Nyasaland affects temperatures only to the extent of 1°. These, therefore, vary largely with altitude. On the Mid-Tertiary Surface, and on other areas lying at 3,500–4,507 ft., the mean annual temperature is 66°–70°. At 5,000 ft., for example in the higher parts of the Dowa and Dedza hills (areas 29b, 32a), it is approximately 65°, and on the High Plateaux it falls to 60°–63°. On the Lake Shore Plain it is 74°–76°.

Fig I* shows the mean monthly temperatures for three stations. The annual cycle is the same at all altitudes. From a minimum in July there is a steady rise until November. The onset of the rains in December is accompanied by a fall, after which temperatures remain moderately high until March. From March onwards there is a progressive fall to June, which is warmer than July by one degree or less. The mean annual range is 13°–15°.

The presence of a large body of water in Lake Nyasa exerts a certain stabilizing effect on temperatures of stations exposed to it. Conversely, stations on the Mid-Tertiary Surface, sheltered from lake influence by intervening higher ground, show a greater degree of continentality in their temperature régime. The fall in temperature from December to February is 1° or more less at lake-

* p. 85.

shore stations (e.g. Kota Kota, *see* fig. 1), than at other sites. This differential is maintained during the cool season, so that the difference between mean July and mean annual temperatures averages −6.9° for stations exposed to lake influence, and −7.5° for sheltered stations. The stabilizing effect is greater with regard to mean diurnal range; this is 16°–19° on the Lake Shore Plain, but approximately 23°–25° on the Mid-Tertiary Surface.

The relative humidity shows no systematic variation between lake-shore and other stations. At Salima the annual averages are 67 per cent. for the mean of day and 71 per cent. at 0800 hrs., whilst at Kota Kota the corresponding figures are 71 and 73 per cent., and at Lilongwe 69 and 75 per cent. The value is probably higher for both the Dowa and Dedza hills, although the only record available is an 0800 hrs. value of 80 per cent. for Mwera Hill. From general observation, it is also probable that the Dowa and Dedza hills have a higher cloudiness and a greater frequency of mists than other parts of central Nyasaland, but no records exist.

RAINFALL

The mean annual rainfall is shown in map III. This has been drawn from observations extending over more than 20 years at 16 stations, and of shorter duration at 24 stations. The stations are unevenly distributed, and no records are available for much of the Kasungu Plain and the Kota Kota Scarp Zone.

The greater part of central Nyasaland, including the whole of the Mid-Tertiary Surface, receives 30–40 in. This may be subdivided into a central zone with 30–35 in. and marginal belts with 35–40 in. The eastward projection of the latter to the Chitala area (30f) is a result of the rain-shadow produced by the Dedza Hills. There are no long term means below 30 in., but on the South Lilongwe Plain (28a) Kampini records 27.6 in. and Mkwinda 26.2 in., both over short periods. It is, therefore, possible that a narrow belt, commencing south of Lilongwe and extending south-south-east to the Moçambique border, receives 25–30 in. An 11 year mean of 30.2 in. for Lisasadzi, in the extreme east of area 23d, suggests that another such area may occur over the western half of the Kasungu Plain, for which no records exist.

Rainfalls of more than 40 in. occur where rising ground faces the prevalent south-easterly winds, blowing off Lake Nyasa. The Dedza Hills and the Kota Kota Scarp Zone receive 40–50 in.; the broad peninsula east of Salima, although formed of low lying land, has a similar rainfall. The proximity of higher ground close to the lake shore results in a higher total along the Kota Kota Lake Shore Lowlands, the only record being 55.9 in. at Kota Kota. In the Nkata Bay Lake Shore Lowlands the shore direction turns to face south-east, and totals above 60 in. occur.

Table I* shows rainfall confidence limits for 9 out of 10 years. The main feature of agricultural significance is that over the large area with a mean annual rainfall of 30–40 in., annual totals of less than 20 in., giving a serious danger of crop failure, can be expected once in 10 years. At Lilongwe, for example, the lowest totals since records began in 1919 have been 18 in. in 1941-2 and 1948-9, and 21 in. in 1929-30 and 1952-3; Dowa received 18 in. in 1948-9, a season of serious famine in Nyasaland. The drought danger may be greater in the two areas which possibly have totals of 25–30 in., discussed above. In contrast, areas with an annual mean exceeding 40 in. are free from drought danger; for example at Dedza, with a mean total of 41.9 in., the two lowest values in 35 years have been 24 in. in 1948-9 and 30 in. in 1943-4.

The main monthly rainfall at six stations is shown in fig. 1. The occurrence of the great majority of the total in the four months December-March is a marked feature. Only in the case of Kota Kota do substantial falls continue into April. Over the whole of central Nyasaland more than 80 per cent. of the rainfall occurs in four months, and over a broad zone including Kasungu, Salima, Dedza and Lilongwe this parameter exceeds 85 per cent. Correspondingly, only Kota Kota records more than 2 in. for the six month period May-October; the Kasungu and Lilongwe Plains, the Dowa Hills, and the Salima Lake Shore Plain receive less than 1 in. in this period. The seasonal concentration reaches its maximum in a belt extending through Salima, Chitala, Dowa, Mponela, and Kasungu, all of which receive 89–91 per cent. of their total rainfall in December-March and less than 0.5 in. between May and October. July is the driest month; over a period of 35 years, Lilongwe has recorded only three days in July with measurable rain.

EVAPORATION AND SOIL MOISTURE

Measurements of evaporation have been made over periods of eight years and less, which is in-

* p. 77.

sufficient for the determination of reliable long term means. There is, nevertheless, a measure of agreement between two groups of stations. The following figures refer to evaporation from standard raised screened pans. On the Mid-Tertiary Surface, Lilongwe records 72 in., Chitedze 78 in. and Chongoni 71 in.; on the Lake Shore Plain, Salima records 83 in., Chipoka 92 in., and Kota Kota 101 in. Thus for sites on these two plains, at 3,500–4,500 ft. and 1,550–2,000 ft., ranges of 70–80 in. and 80–100 in. respectively, are experienced.

Fig. 1 shows the mean monthly evaporation at Lilongwe, on the Mid-Tertiary Surface, and Salima, on the Lake Short·Plain. During the hot season, with low relative humidities, evaporation rises steadily, corresponding to the increase in temperatures from July to November. It then falls sharply with the onset of the rains, and remains low during the cool season..

Due to the marked seasonal change, in both rainfall and evaporation, the relationship between these follows a similar cycle for all stations. In every part of central Nyasaland, evaporation considerably exceeds rainfall for seven months, from May to November, and rainfall is greater than evaporation for between two and four months. This results in a regular annual cycle of soil moisture change, which has been studied by Wood[4]. During the early part of the rainy season the soil moisture is raised to field capacity throughout the profile. The continuation of the rains results in downward water movement through freely drained soils, and waterlogging in profiles with impeded drainage. During the long dry season the soil moisture is depleted by evapotranspiration, and in the upper horizons it is reduced to wilting point. Details of this soil moisture cycle are given in the publications by Wood referred to above. Its effect on soil formation are discussed in the bulletin on northern Nyasaland.

CLIMATIC REGIONS

Map IV shows the climatic regions that may be distinguished, giving the range of mean annual temperature and rainfall associated with each. Although drawn primarily with reference to these two factors, each region has certain other distinctive characteristics, as described below. The same regions are used as were defined in the bulletin on northern Nyasaland, but on the basis of agricultural considerations these modifications have been made. A new region, Ia, has been added, transitional between regions I and III; VII, formerly covering all hot (lake shore) areas with less than 60 in. rainfall has been limited to a rainfall range of 45–60 in.; and a new region VIII has been added, to include the drier lake shore areas*.

In the following accounts of the principal characteristics of each climatic region the terms cool, wet, etc., will be used in a relative sense, as applied to the range of conditions experienced in Nyasaland. For monthly rainfall and temperature conditions, reference may be made to fig. 1.

I. **Cold, wettish.** Mean annual temperature 55°–65°, mean annual rainfall 40–50 in. This covers the higher parts of the Vipya Plateau and of the Chimaliro Hills. The low temperatures, combined with other environmental factors, make this region unsuitable for agriculture. The high degree of exposure to winds is an important factor in preventing cultivation of coffee. The region has a potential for afforestation.

Ia. **Cool, wettish.** Temperature 63°–67°, rainfall 35–50 in. The main areas are the Dowa and Dedza hills, and the plateau east of the Chimaliro Hills (area 22b). The climatic criteria for this region have been selected in order to define actual and potential coffee growing areas. The rainy season is longer than in most other regions, with convectional showers commencing in November and light rains continuing into April. Cloudiness is greater and mists are more frequent than at lower altitudes. Evaporation is probably 60–65 in., although no records exist.

II. **Cool-warm, wet.** Temperature 60°–70°, rainfall 60–80 in. Only a small part of central Nyasaland, in the East Vipya Scarp Zone, falls into this high rainfall region. Rain continues into April, and a winter rainfall of 5–10 in. occurs. Agricultural potential is low owing to the predominance of thin and stony soils.

III. **Warm, dryish.** Temperature 65°–70°, rainfall 30–40 in. This is by far the most extensive region, covering the whole of the Mid-Tertiary Surface and many hill areas rising above it. 85–90 per cent. of the rainfall occurs in four months, and from May to October there is almost complete drought. Mean monthly temperatures range from *c.*60° in June and July to *c.*75° in November, with a mean diurnal range of 20°–25°. Annual evaporation is 70–80 in. In any particular year there is a 10 per cent. chance of a rainfall of

* In northern Nyasaland the Misuku Hills and the lower, eastern part of the Vipya Plateau, formerly mapped as region I, fall into region Ia; part of the Karonga Lake Shore Plain, formerly mapped as region VII, on the revised definitions falls into region VIII.

less than 20 in. This is the main climatic region for the production of tobacco and groundnuts.

IV. **Warm, dry.** Temperature 65°–70°, rainfall 25–30 in. In the absence of definite evidence of areas with under 30 in. rainfall this region is not shown on map IV; it may be present, however, south of Lilongwe and west of Kasungu (*see* p. 10). It is characterized by a greater drought hazard than region III, therefore, in agricultural planning in these two areas, this possibility should be noted.

V. **Warm to hot, wettish.** Temperature 65°–75°, rainfall 40–60 in. This region is largely coincident with the Lake Shore Scarp Zone. With the exception of rainfall observations from Nchisi Forest Reserve there are no climatic records, and the values given for temperature and rainfall are derived by indirect means. Climatically the region is well suited for agriculture, but much of it is dominated by shallow and stony soils.

VI. **Hot, wet.** Temperature 74°–76°, rainfall 60–80 in. This high rainfall sector of the Lake Shore Plain occupies only a small corner of central Nyasaland, the Nkata Bay Lake Shore Lowlands. Rain continues into April, and a winter rainfall of 5–10 in. occurs. The region has a potential for tea, rubber, cocoa and rice.

VII. **Hot, wettish.** Temperature 74°–76°, rainfall 45–60 in. This and the following region occupy the Lake Shore Plain, and region VII is coincident with the Kota Kota Lake Shore Lowlands. Substantial rainfall continues into April, and on average it is only slightly less than evaporation in this month. Where topographic conditions are suitable there is a potential for rice cultivation.

VIII. **Hot, dryish.** Temperature 74°–76°, rainfall 30–45 in. This region covers the Salima Lake Shore Plain. Rainfall is low in April, and there is almost complete drought from May to October; in association with a high evaporation, this results in annual drying out of the soil profile extending to greater depths than in other regions. This is the main region for cotton growing.

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CHAPTER III

Vegetation

ACCOUNTS OF THE vegetation of Nyasaland have been given by Jackson[1], Topham[2], Jackson and Wiehe[3], and Hursh[4]; the broad features of its distribution are shown on the vegetation sheet of the Federal Atlas of Rhodesia and Nyasaland, on a scale of 1 : 2,500,000. The following description is based mainly on original field observations and air photograph interpretation, but has been compared with, and supplemented from, the above accounts. For vernacular names of vegetation, reference should be made to the check lists of trees[2] and grasses[3].

Table II* gives the vegetational communities of central Nyasaland, and map V shows their distribution. The classification is based principally on physiognomy, and to a lesser extent on dominant species. It relates to the vegetation as found at the present day, which over the greater part of the area has been extensively modified by human occupance.

1. **Montane grassland.** This consists of short grassland, usually with scattered short trees and shrubs. Montane evergreen forest (*see* below) occurs in valley floors and heads. It is believed that the forest was formerly more extensive, the grassland being a fire climax[1]. It occurs above 5,500 ft. on the South Vipya and plateau remnants to the south of it (areas 19b, 20d, and 22b), and in association with forest on Chongoni and Dedza mountains (32d).

2. **Low montane grassland.** This is distinguished from the preceding class by the occurrence of *Brachystegia* species and *Uapaca kirkiana,* as scattered trees and as patches of savanna woodland. It results from the replacement of a former cover of *Brachystegia* plateau woodland; the initial destruction of this is through clearance for cultivation, and regeneration is prevented by annual burning. There are two main areas, in the Dowa and Dedza hills (areas 29b, 32a), both of which lie at approximately 4,800–5,200 ft. With increase in altitude this community passes transitionally into montane grassland.

On moderately and steeply sloping land at lower altitudes a grassland formation tends to occur wherever destruction of woodland for cultivation is severe; this is the case over much of the Dowa area (29a) and the Dowa-Mvera Scarp Zone (29d).

3. **Marsh grassland.** All poorly drained areas which are subject to annual waterlogging, are occupied by a tufted grassland, normally without trees or shrubs. In its natural state this is a tall grassland, but it may be kept short by heavy grazing. Within Nyasaland it is known as *dambo* grassland. It occupies broad valley floor belts on the Mid-Tertiary Surface, only the larger of which can be shown on the scale of map V; these zones cover at least 10 per cent. of the total area on the Kasungu, Upper Bua, and Lilongwe plains. On the Lake Shore Plain, marsh grassland occurs as more extensive areas; in this zone, scattered short trees and shrubs are frequently present.

4. **Montane evergreen forest.** This community is commonly present in valley floors and valley heads amid areas of montane grassland. A few patches also occur on valley sides and interfluves, suggesting the former existence of a more extensive cover at altitudes above 5,500 ft. A number of such areas occur on the plateau crests of Chongoni and Dedza mountains (32d); patches are also found on Nchisi Hill (29e), Chipata Hill (40 miles north of Dowa), and east of Kwanadama Hill amid the plateau remnants of the East Vipya Scarp Zone (20d).

5. *Combretum - Acacia - Piliostigma* **cultivation savanna.** The more fertile soils of the Lilongwe Plain, principally in areas 28a–d, are almost entirely under cultivation. Amid the fields, and in a few small relict patches, are broad leaved deciduous trees; a limited number of species are present, the most common of which are listed in table II. It is probable that this community was formerly a deciduous woodland of medium height. It is valuable as an indicator of soil types, occupying ferruginous soils (*see* chapter IV) of relatively high fertility. Where it gives place to *Brachystegia* and *Julbernardia* woodland, less fertile, ferallitic soils are indicated. It is the principal community over a crescent shaped area on the Lilongwe Plain.

6. **Moist *Brachystegia* woodland.** This term is used to describe a type of woodland that occurs

* p. 78.

under a rainfall of more than 50 in. It consists of a woodland of trees of medium height (40–60 ft.), with a closed canopy and an open understory and sparse ground layer. In central Nyasaland it is confined to the Nkata Bay Lake Shore Lowlands (areas 21b, f). The relationship of this formation to semi-evergreen forest is described in the northern Nyasaland bulletin.

7. *Brachystegia - Julbernardia* **plateau woodland and savanna woodland.** This is the most extensive community in central Nyasaland, occupying the greater part of the Mid-Tertiary Surface (regions 16, 23, 26, 27 and areas 28e, f and 32b, c); patches also occur on raised beach areas of the Lake Shore Plain (areas 25b and part of 30e). It is part of the zone of *Brachystegia* woodland that occupies an area of three million square miles in East Africa, between latitudes 5° and 17° south[5]. In its natural state, seen for example in the plains area of the Dzalanyama Forest Reserve, it is an open woodland of trees of medium height, with a moderate grass cover. Owing to the high population density of central Nyasaland, formations resulting from regrowth following cultivation are very extensive. These typically consist of a savanna woodland of short trees, the canopy cover being of the order of 50 per cent. The composition varies widely, but is dominated by species of *Brachystegia* and *Julbernardia*; during the early years of growth following the abandonment of a cultivated area, *Julbernardia paniculata* is frequently dominant. In a study of this woodland by Hursh[4], the greater part of it is stated to be in a highly degenerate condition, due to late burning, the removal of straight saplings for house building, the stripping of bark for string, and the removal of other forest products. A number of degeneration stages, resulting from different intensities of past and present human occupance, are described by Hursh.

The natural forest products of *Brachystegia* woodland make an essential contribution to the village economy. The controlled management of this resource, to ensure a continuous supply of such products amid densely populated areas, is a problem presenting both physical and social difficulties.

8. **Mixed woodlands on foothills of the Rift Valley Scarp.** This is to some extent a class of convenience, to cover a variety of communities which occur at altitudes of 1,700–2,500 ft. to the west of the Lake Shore Plain. Savanna, savanna woodland and woodland formations occur. *Sclerocarya birrea* and *Pterocarpus angolensis* are frequent, and bamboo (*Oxytenanthera abyssinica*) is characteristic. *Brachystegia* hill woodland commonly occurs in association with these communities, on areas of thinner and more stony soil.

9. *Brachystegia* **hill woodland and savanna woodland.** Areas of moderate and steep slopes with stony soils, at all altitudes, are occupied by an open savanna woodland of short trees, with a sparse grass cover. Either or both of the species *Brachystegia boehmii* and *Uapaca kirkiana* are usually common. *Brachystegia floribunda* is particularly frequent amid the Dedza Hills. This community occupies the broad belt formed by the Rift Valley Scarp Zone, together with many isolated hills and hill areas rising above the Mid-Tertiary Surface. The latter include the Forest Reserves of the Perekezi Hills (17e), Chimaliro Ridge (22a), Nchinji Ridge (26b), and the Dzalanyama Range (31a).

10. *Acacia - Adansonia - Hyphaene - Sterculia* **cultivation savanna of the lake shore.** The alluvial section of the Lake Shore Plain carries two vegetational communities, in addition to extensive areas of marsh grassland; these correspond to fertile areas largely under cultivation, and sparsely cultivated areas. The former carry a cultivation savanna in which large trees of *Adansonia digitata* (baobob), *Sterculia africana* and *Acacia albida* are characteristic; the last species, when present as tall trees, is an indicator of highly fertile soils. Shorter *Acacia spirocarpa* and *A. campylacantha* are also common, and palms (*Hyphaene ventricosa*) are frequent. This community, which is rapidly distinguishable on air photographs, occurs as isolated belts, associated with certain of the main rivers, in both the Kota Kota and Salima regions (areas 25c, 30c); Salima is situated in the largest of these belts.

11. **Lake shore savanna and thicket.** The greater part of the Salima Lake Shore Plain is occupied by a savanna formation with thicket patches. Large trees of the same species as in the previous class occur, but the vegetation consists predominantly of short trees, often thorny, and shrubs; among the latter, *Combretum ghazalense* is frequent, exhibiting a quite different growth form to that which it possesses when found in *Combretum - Acacia - Piliostigma* cultivation savanna. In areas 30a and d, trees and shrubs are moderately closely spaced, the formation tending towards woodland in parts; in area 30b they are more widely scattered, and are interspersed with patches of marsh grassland.

12. **Vegetation of sands.** The lake shore areas of lacustrine sands present a specialized pedological environment. Whilst depositional processes are still active, much of the surface remains bare. Early colonization by grasses then helps to stabilize the surface forms; Jackson[6] records the following species from north Kota Kota: *Eragrostis lappula, Loudetia flavida, Diplachne fusca* and *Hemarthria natans*. At a later stage, a savanna woodland consisting largely of *Terminalia sericea* is commonly found, for example in the Senga Bay raised beach area (30e). When soil profile development is well advanced, *Brachystegia* woodland may become established.

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Chapter IV

Soils

For the purpose of agricultural utilization, the soil series is the most satisfactory unit of soil classification. A series possesses a limited range of morphological and analytical properties, and it may therefore be expected to respond similarly to agricultural treatments wherever it is encountered. This system of classification has the disadvantage, however, that the number of series identified in any survey is almost invariably large, and it becomes difficult to comprehend their properties, inter-relationships, and distribution as a whole. Furthermore, it is impossible in an extensive survey to map the distribution of individual series, both because the survey work involved would be excessive, and because the complexity of the boundaries is such that they could not be represented on small scale maps. Consequently, higher units of classification are necessary when discussing the distribution and origin of the soils of central Nyasaland as a whole, as in this chapter. The soil series, and their associated agronomy, will be considered in Part Two.

CLASSIFICATION

The two main systems of soil classification in use are the morphological and the genetic. In the morphological system, groups are defined in which the properties of the soil profile are similar, or fall within a limited range. The soil series is an example of the use of this system at a low level of classification. At a higher level it suffers from the disadvantage that the number of variations in the properties of a soil profile is very large, and the selection of which properties should be used to define the higher units is to some extent arbitrary. In the genetic system, the groups are defined according to their mode of origin. The genetic system is necessarily also a particular morphological system, as only morphological and analytical characteristics are available for direct examination; but the selection of which characteristics are to be used to define the groups is made according to considerations firstly of the past evolution of the soil, and secondly of the processes which are at present acting within the profile.

There are four major groups of soils in Nyasaland; the *latosols*, or reddish, freely drained soils; the *calcimorphic soils*, dominantly greyish brown in colour; the *hydromorphic* soils, black or mottled, and subject to waterlogging; and the *lithosols*, or thin and stony soils. The lithosols are unsuitable for agricultural use, and are most satisfactorily used to supply natural forest products. The hydromorphic soils are utilized for dry season grazing, and in small areas for rice-growing, but are for the most part not suitable for arable use. The calcimorphic soils are frequently of high fertility; they occur on level sites and, therefore, are highly suited to cultivation. The bulk of Nyasaland's cotton crop is grown on them, and they are also suited to intensive food crop production. The latosols comprise by far the greatest proportion of cultivable soils in the country, and range in fertility status from high to very low.

In subdividing this large class of latosols, a modified version of the classification of the Inter-African Pedological Service has been adopted[1]. The primary subdivision is into ferruginous soils, ferrisols, and ferallitic soils. These are believed to represent successive stages in soil development. The distribution of the groups in Nyasaland, and their relationships with environmental factors, suggest, however, that the principal development sequence is from ferruginous soils to ferallitic soils; the ferrisols appear not to occupy a position within the sequence, but to be formed under a different set of environmental conditions.

The definition of these groups is in terms of the quantity of weatherable rock minerals that remain within the profile. Of the rock forming minerals, quartz and muscovite (white mica) are practically unaffected by weathering processes, and remain within the soil as sand grains and flat, glistening flakes respectively. The remaining minerals, e.g. the feldspars, biotite and hornblende, are attacked by weathering processes, reduced in size, and ultimately altered to secondary minerals, chiefly the clay minerals, and to free iron oxides. During the successive stages of weathering within a soil profile, the quantity of rock minerals will be progressively diminished. Ferruginous soils are those which retain substantial quantities of weatherable rock minerals within the profile, and in particular in the subsoil*. Ferrisols have

*See note on horizon nomenclature, p. 23.

few minerals only in the immediate subsoil, although these may become numerous lower in the profile. In ferrallitic soils, weatherable minerals are very few or absent in the subsoil, this horizon consisting almost entirely of quartz sand, clay minerals, and secondary iron oxides.

The relative abundance of minerals is a characteristic which is difficult to assess, and which requires the use of a hand-lens for field examination. The three groups of soils possess, however, distinctive and contrasting morphological characteristics, including in respect of colour, texture, structure and consistency. The following account refers to the Nyasaland representatives of these groups, and does not necessarily cover the full range of properties that may be encountered in other areas.

Ferruginous soils are invariably reddish; the subsoil is frequently dark reddish brown, and below 24 in. depth the colour is usually dark red or red, or less commonly dark reddish brown†. The reddest horizon is invariably in the 2.5 YR or 10 R Munsell hues. The texture of the heaviest horizon is never lighter than sandy clay, and is frequently clay. The presence of a textural B horizon, i.e. a heavier texture in the subsoil than in the lower subsoil or in depth, is a reliable indicator of a ferruginous soil, with the important qualification that the lighter texture in depth should not be due to the presence of weathered rock patches. The converse is not the case, however, ferruginous soils without a textural B horizon being common. An invariable feature is that the subsoil structure is moderate or strong, fine or medium, blocky, the soil breaking readily along natural cleavage planes into structural aggregates, or peds. On the surfaces of these aggregates, ped cutans[2] ('clay skins') are visible; these are coatings of clay which give a shiny appearance to the ped surfaces, and are often of a slightly darker colour than the ped interiors. A structural B horizon is usually present, the grade of structure becoming weaker in depth than in the subsoil. Associated with this is a change in consistency, the soil becoming softer, more easily friable, in depth than in the subsoil; it should be noted, however, that this last feature is sometimes present also in ferallitic soils.

Ferrisols are of small extent in central Nyasaland, and need only be described briefly. The profile is usually deep and the lower horizons dark red and red. There is only slight textural differentiation within the profile, all lower horizons being sandy clays or clays with similar clay percentages, with the topsoil also frequently a sandy clay. The lower horizons have a moderate or weak, fine, blocky structure, which on crushing breaks down into a weak fine crumb structure. The soil is characteristically soft and friable, often with a floury consistency.

Ferallitic soils are frequently yellowish red, in the Munsell 5 YR hue; red ferallitic soils are also common, however, although never redder than the 2.5 YR hue. All red, reddish brown, or yellowish red soils in Nyasaland which have no horizon heavier than sandy clay loam belong to the ferallitic group. Clay horizons are rare, except in the humic ferallitic sub-group (*see* below). A sandy clay subsoil or lower subsoil is, however, a frequent feature of ferallitic soils, but the topsoil is almost invariably sandy, a loamy sand, sandy loam, or less frequently a light sandy clay loam (clay content below 25 per cent.). The principal morphological feature characterizing all ferallitic soils is the absence, or weak development, of structure in the subsoil. In fully ferallitic soils this horizon is massive, with no natural cleavage planes present; in very sandy profiles it becomes single-grain structure. Where the ferallitic characteristics are less strongly developed, a weak blocky structure can be detected, but ped cutans are absent. In consistency, a typical feature is that sandy clay horizons, if present, become very hard when dry; in this condition it is impossible to penetrate them with a soil auger.

Table III* shows the sub-groups which have been distinguished for central Nyasaland, together with the series that fall within each. Not all of these sub-groups are of equal importance: 3d, humic ferallitic soils, and 3e, ferallitic soils developed from sandy parent materials, could alternatively be classed as groups, since they possess characteristics in many ways distinct from the main body of ferallitic soils; the remaining sub-groups are of lesser status. Map VI shows the distribution of the genetic soil groups, and in the case of ferallitic soils of the sub-groups; associations of latosol groups with lithosols are also shown. An account of the sub-groups of the latosols, together with the three other genetic groups of table III, is given below.

GENETIC SOIL GROUPS AND SUB-GROUPS

1a. **High altitude ferruginous soils.** These occur at 4,500–5,500 ft. altitude, and are charac-

†The colour terms used are Munsell colours of the moist soil on broken but uncrushed aggregates, examined in the field.

* p. 79.

terized by dull colours, reddish brown and dusky red being more common than dark red or red. They are heavy textured, and the blocky structure of the subsoil is strongly developed. In certain profiles, ped cutans are more clearly developed than in any other Nyasaland soils with the exception of hydromorphic clays, smooth and shiny surfaces being present on the structural aggregates.

This sub-group occurs in the Mwera Hill (29b) and Dedza-Bembeke (32a) areas, in both of which it is used for coffee-growing. Elsewhere in Nyasaland, it is present in the Kirk Range.

1b. **Medium altitude ferruginous soils.** These occupy an altitude range of approximately 3,000–4,500 ft. They are typical ferruginous soils, with characteristics as described above (p. 18). They occupy much of the Lilongwe Plain, being extensive in natural areas 28a–c, also present in areas 28d and e, and extending into the lower parts of the Dowa Hills (29a). These areas together form the most fertile and productive part of central Nyasaland, with tobacco and groundnuts as the principal crops. They are also present as a mid-catena soil on the more dissected parts of the Kasungu Plain, areas 23a and b.

1c. **Low altitude ferruginous soils.** These occur principally below 2,500 ft. They have many similarities with the previous sub-group but tend to be darker in colour, dark reddish brown being characteristic. They occupy scarp foot sites near Mwansambo (29c) and Chitala (30f), both of which are cotton growing areas.

1d. **Shallow ferruginous soils.** Certain series possess ferruginous properties, but their agricultural value is limited by the frequency of shallowish or gravelly profiles. This is the case throughout the Chimutu area (28g), and is also frequent where red soils are developed on steeply sloping country, for example in the Dowa-Mvera Scarp area (29d).

1e. **Weakly ferruginous soils.** This sub-group and the weakly ferallitic soils represent intermediate stages between ferruginous and ferallitic soils. The weakly ferruginous soils possess a moderate blocky structure in the subsoil, with ped cutans visible, but lack at least one of the properties of typical ferruginous soils. Frequently their heaviest horizon is sandy clay, and they are often of only moderate depth. The Nathenje (28d) and North Visanza (24c) areas contain many profiles of this sub-group, which can be highly productive under good farming practices.

2. **Ferrisols.** The properties of this group have been described above (p. 18). In central Nyasaland it is confined to the small high rainfall area of the Nkata Bay Lake Shore Lowlands, where there is a potentiality for tea and rubber production.

3a. **Weakly ferallitic soils.** These soils are of considerable extent on the Mid-Tertiary Surface. They predominate in the Loudon (16d) and Tembwe (27a) areas; the red soils of pediments may usually be classed in this sub-group, which consequently occurs in the Jenda (16g) and Fort Manning (26a) pediment areas. In addition, many of the more sandy patches amid the Lilongwe Plain have weakly ferallitic soils. They are characterized by a sandy clay subsoil with a blocky structure which, although weak, is definitely distinguishable; ped cutans cannot normally be seen. The majority of profiles have a red colour in depth, although the subsoil may be yellowish red. Agriculturally they are soils with considerable potentiality for improvement, having a low natural fertility but a sufficient clay content to respond well to fertilizers and other treatment; under poor management they quickly lose their limited reserves of nutrients.

3b. **Strongly ferallitic soils.** These possess the typical characteristics of ferallitic soils (*see* p. 18). With a few exceptions they are yellowish red and not red. The topsoil is sandy, and there is commonly a substantial proportion of coarse sand in the profile. They are characterized by a massive structure in their subsoil. These soils have a low inherent fertility, and under cultivation require either heavy fertilizer or long fallow periods. They are suited to the growing of groundnuts.

In the bulletin on northern Nyasaland, this sub-group was referred to as sandy ferallitic soils.

3c. **Strongly ferallitic soils with laterite.** This is a subdivision of the preceding class. A horizon of abundant iron concretions or massive cemented laterite occurs in the subsoil, lower subsoil, or in depth. Above this the soil possesses ferallitic properties. The topsoil is normally at least as sandy as sandy loam. The iron concretionary horizon restricts root development, and suitability for cultivation is partly dependent on the depth at which it occurs. In addition, this horizon frequently causes impeded profile drainage.

Laterite horizons may also occur in most of the other sub-groups of latosols, but only series in which they are an invariable feature have been assigned to this class.

3d. **Humic ferallitic soils.** These occupy the Vipya Plateau and the small summit plateaux of Dedza and Chongoni mountains. They are characterized by a dark brown or black topsoil with a high humus content, and containing abundant grass roots. The lower temperatures necessary for such humus accumulation restrict these soils to altitudes above 5,500 ft. In depth they are more often red or reddish brown, than yellowish red. The heaviest horizon is usually sandy clay, although they differ from other ferallitic soils in that clays may occur. The subsoil has a weak or very weak blocky structure, with ped cutans absent; the latter may become visible in the lower subsoil or in depth. Although of very high nitrogen status they give unsatisfactory crop yields, due in part to exceptionally low cation saturation percentages. Profiles transitional with ferrisols are common at slightly lower altitudes, and these are suited to coffee and tung-growing.

3e. **Ferallitic soils developed from sandy parent materials (regosols).** In all other ferallitic soils the paucity of weatherable rock minerals is due to their progressive removal from the profile, over a long period of time, by weathering processes. In this sub-group it is caused by the lack of such minerals in the parent material. The latter consists in Nyasaland of sands of lacustrine origin, either recently deposited sand beaches, bars, and spits, or raised beach sediments of Quarternary and possibly late Tertiary age. Initially these consist almost entirely of quartz sand, mainly coarse; after active deposition has ceased they acquire a small proportion of finer material, probably from wind blown dust.

The resulting soils are light textured, with coarse sand dominant over fine; they are never redder than reddish brown (5 YR hue). Their subsoil structure is initially single-grain, becoming weakly massive at a later stage in development. Cassava can be grown on them, but they have a low agricultural potentiality.

3f. **Ferallitic soils with impeded site drainage.** The majority of series described during the present survey are the uppermost or the two upper members of catenas, occupying crest areas and valley sides. In the case of the Lilongwe catena two series on lower valley side and concavities have been described (*see* p. 41), which may be assigned to this sub-group.

4. **Alluvial calcimorphic soils.** The calcimorphic group is developed in central Nyasaland entirely on alluvial parent materials, its formation being associated with the soil moisture conditions found in these. They are restricted to sites on the Lake Shore Plain, where temperatures are higher than in the rest of the Province. In northern Nyasaland, however, they occur in a number of valley floor and low terrace sites at higher altitudes, indicating that site drainage conditions rather than temperatures are the main factor causing their formation.

The profile is greyish brown throughout, the Munsell shades 10 YR 3/2 and 2/2, very dark greyish brown, being the most common. Mottling usually occurs, commencing at any depth between the immediate subsoil and 60 in. As the parent material was deposited by periodic river floods, depositional bedding is a marked feature of the textural profile. The structure varies from massive in sandy horizons to strong coarse blocky in clay beds.

This group is extensively developed on the Salima Lake Shore Plain, and to a lesser degree on the Kota Kota Lake Shore Lowlands. It extends from the former, along the foot of the Dedza Scarp Zone, into the Bwanje Valley of southern Nyasaland. It possesses a high natural fertility, and cotton is the main cash crop.

5. **Hydromorphic soils.** These occupy valley floor sites in all regions, whilst a number of more extensive areas are found on the Lake Shore Plain. A frequent cause of the latter is that sand spits extend from the shore, such as that which at present protects Kota Kota harbour; where the ends of these subsequently become joined to the shore, lagoons are formed, and by alluviation these are transformed into marshes. The profile of hydromorphic soils is dark grey, black and mottled; pale grey horizons with a very prominent strong brown or yellowish red mottle, also occur. Grass roots in the topsoil are stained reddish brown by the deposition of ferric iron. Their texture is mainly or entirely clay, with a strong coarse blocky structure and very strong ped cutans. The clay minerals are predominantly montmorillonitic, as a result of which the clay has very slow permeability, and impeded profile drainage is added to poor site drainage. Annual flooding together with the difficulty of tilage renders these soils of limited use for cultivation. An exception is that a large proportion of the rice crop is grown on them along the Lake Shore Plain.

6. **Lithosols.** A large proportion of the Kota Kota and Dedza Scarp Zones are occupied by shallow and stony soils, in which quartz stones are frequently numerous. These can be utilized for the growth of indigenous woodland, which under good forest management can yield large quantities of firewood and small timber. Species from which good quality saw timber can be obtained are not numerous, and are in many cases slow growing. The more extensive areas of lithosols may be utilized as nature reserves.

ANALYTICAL CHARACTERISTICS

The great majority of latosols in central Nyasaland belong to the ferruginous and ferallitic groups (*see* table III); the ferrisols and also the sub-group of humic ferallitic soils, both of which have distinctive analytical properties, occupy less than 5 per cent. of the area. Further, the majority of the ferruginous and ferallitic soils have formed under a restricted range of environmental conditions, as follows:

Parent material: Metamorphic and igneous Basement Complex rocks.

Mean annual temperature: 63°-70°.

Mean annual rainfall: 30-45 in.

Seasonal rainfall distribution: 80-90 per cent. of the annual total in four months; a dry season of six months, over the whole of which the total is less than 2 in.

Corresponding to these environmental conditions there is a limited variation in analytical characteristics. The following is the range of values which predominates in all of the five sub-groups of ferruginous soils, and in the weakly ferallitic soils, strongly ferallitic soils, and strongly ferallitic soils with laterite; this includes 30 of the 40 soil series identified, and represents the characteristic ranges of analytical properties found in central Nyasaland latosols:

pH: 5·0-6·0.

Organic matter, topsoil: 0·5-3·0 per cent.

Base saturation, lower horizons: 40-80 per cent.

Base exchange capacity per 100 g. clay, lower horizons: 10-40 m.e. per cent. per 100 g. clay*.

Nitrogen, topsoil: 0·05-2·0 per cent.

Available phosphorus, topsoil: wide range of values.

Exchangeable potassium, topsoil: wide range of values.

Within these ranges, there are certain consistent differences between the ferruginous and ferallitic groups. The normal pH of ferruginous soils is 5·5-6·0, although slightly more acid horizons are also found; the ranges 5·0-5·5 and 5·5-6·0 are equally common in the ferallitic group. Corresponding to this difference the ferruginous soils are less strongly leached; the base saturation of their lower horizons is normally 60–80 per cent., whereas the saturation of ferallitic soils covers the range 40–80 per cent. The clay minerals of ferruginous soils always include at least small quantities of illite; the ferallitic group again overlaps this range, but also includes profiles in which the clay minerals are almost entirely kaolinitic.

Topsoil organic matter content and nitrogen status show a close correlation in Nyasaland soils. It is a characteristic of ferallitic soils (excluding the humic ferallitic sub-group) that both these are at low levels, with organic matter below 2 per cent. and topsoil nitrogen below 0·1 per cent. All such soils show responses to nitrogenous fertilizers. In the ferruginous group the organic matter content is normally 2–3 per cent. and the nitrogen level slightly above 0·1 per cent., although low values also occur. Ferruginous soils are characteristically low in phosphorus, below 20 p.p.m.*. Available phosphorus values in ferallitic soils vary widely, and no systematic trends have been distinguished; it is noteworthy that certain profiles which in field appearance possess every indication of an extremely poor soil nevertheless record high phosphorus values on analysis. Exchangeable potassium levels are medium or high (above 0·2 m.e. per cent.) in ferruginous soils, and low or medium (below 0·4 m.e. per cent.) in ferallitic soils.

Thus with respect to each of the major analytical characteristics the ferruginous and ferallitic soil groups, considered as a whole, cover ranges of values which overlap but extend to different limits.

Of the remaining latosols, the ferrisols are strongly acid, pH 4·0-5·5, with correspondingly low base saturation percentages of 15–40 per cent. They normally have moderate organic matter content and moderate (0·1–0·2 per cent.) nitrogen status. The humic ferallitic sub-group is also strongly acid; it differs from all other freely drained Nyasaland soils in having a high organic matter content, 4–10 per cent., with a high nitrogen status. The ferallitic soils developed from sands possess a wide range of analytical characteristics.

* Indicating a clay mineral composition varying from almost entirely kaolinitic to kaolinite with illite.

* The Dedza and Kanyama series, both of which occur in the Dedza Hills, are exceptions to this.

The calcimorphic group strongly contrasts with the latosols in respect of three major analytical properties. It is weakly acid to neutral, pH 6·0–7·0; the subsoil base saturation is 80–100 per cent.; and the base exchange capacity values indicate that the montmorillonitic group of clay minerals is present in substantial quantities. Nitrogen values are medium or low, whilst high levels of available phosphorus (above 50 p.p.m.) and exchangeable potassium (above 0·4 m.e. per cent.) are normally found. The hydromorphic group also has high values of base saturation, and has predominantly montmorillonitic clay minerals; reaction is frequently alkaline, the normal pH range being 6·5-8·0.

The analytical values and nutrient status recorded for individual soil series are shown in tables VII* and VIII*.

DISTRIBUTION

The distribution of soil groups and sub-groups is shown on map VI. For three groups, associations with lithosols are given; in the case of ferruginous soils, a distinction is also made between areas where lithosols are of lesser extent, and those in which lithosols predominate but with patches of ferruginous soils. This distribution pattern may be analyzed with respect to the environmental factors which have produced it. A comparison of maps I and VI shows a considerable degree of correlation of soils with the major relief units; these will therefore be taken as a basis for discussion.

The High Plateaux are of limited extent (natural areas 19b and parts of 29e and 32d), and are covered by humic ferallitic soils. This is the result of the lower temperatures associated with the high altitude of this unit. The plateau remnants of central Nyasaland are dissected areas with moderate slopes predominating, as a result of which the humic ferallitic soils occur in association with lithosols in all cases.

Three soil groups and associations occur on the High Altitude Hill Zones. Where these consist of hill areas with steep slopes, lithosols predominate (e.g. Chimaliro Ridge (22a), Nchinji Ridge (26b), the Dzalanyama Range (31a), and numerous isolated hills); the Perekezi Hills (17e), although having only moderate slopes and relief, also fall within this class due to the presence of quartzitic parent rocks. Other areas of moderate slopes carry associations of lithosols with one of the latosol sub-groups. In the Mzimba (17d) and Mphunzi (32c) areas these are strongly ferallitic soils; in an irregular belt extending through parts of the Dowa and Dedza hills, ferruginous soils predominate (areas 29b, 29a, 28g, 32b, and 32a). The agricultural potential of the latter is considerably greater. This contrast in soils is probably due to parent material differences, acid rocks underlying the ferallitic soils and intermediate and basic rocks predominating below the ferruginous soils.

The Mid-Tertiary Surface is divided between ferruginous, weakly ferallitic, and strongly ferallitic soils, including the sub-group with laterite. A comparison with the landforms (map II) shows that the almost level plains are mainly occupied by ferallitic soils with laterite (area 23d), and to a lesser extent by ferallitic soils. There remains the contrast between the ferruginous soils of most of the Lilongwe Plain (areas 28a–d) and the ferallitic and weakly ferallitic soils of parts of the Kasungu Plain (23a–c), the Upper Bua Plain (27a), and the Nsaru (28e) and Kampini-Sinyala (28f) areas of the Lilongwe Plain, all of which have similar climatic conditions and landforms. This is due primarily to parent material, hornblende rich gneisses of intermediate and basic composition predominating in the areas of ferruginous soil.

The Rift Valley Scarp Zone is divided pedologically into the lithosols of the Kota Kota and Dedza sectors, and the lithosol-ferruginous soil association of the Dowa sector (29d). It is again probable that this is partly caused by less acid parent rocks in the Dowa-Mvera Scarp area, although it is also the case that dissection is less steep in much of the latter area.

Thus the total extent of ferruginous soils on map VI suggests the existence of a zone of Basement Complex rocks of intermediate and basic composition. This is approximately semi-circular in shape, with the curved boundary to the west and the diameter of the circle running in a north-south direction on the eastern side. The latter boundary is very irregular, and includes an eastward projection to the Chitala area (30f). Within this zone, areas of relatively acid rocks occur, the largest of which is the Mphunzi area (32c).

On the Lake Shore Plain, the undulating scarp foothills of the Salima region carry latosol-lithosol associations. The remainder of the plain exhibits a contrast between its southern and northern sectors. The Salima Lake Shore Plain contains an extensive area of alluvium, at altitudes

* pp. 83 and 84.

only slightly above that of Lake Nyasa. The parts with imperfect and impeded drainage are occupied by alluvial calcimorphic soils and those with poor drainage by hydromorphic soils. The Kota Kota Lake Shore Plain contrasts with this. It has three main areas of hydromorphic soils, associated with the outwash plains of major rivers draining the Rift Valley Scarp Zone. Apart from these it contains raised beach areas, carrying ferallitic soils with laterite where level, and lithosols where dissected. Alluvial calcimorphic soils are of very limited extent.

The Nkata Bay Lake Shore Lowlands are occupied by ferrisols, associated with the high rainfall which occurs on them. On all regions of the Lake Shore Plain, areas of ferallitic soils derived from lacustrine sands are common.

These distributions indicate that the main factors which have produced the soil pattern of central Nyasaland are as follows:

1. Climatic factors are dominant in producing areas of ferrisols, under high rainfall, and humic ferallitic soils, under low temperatures. Over the remainder of the Province, climate determines that latosols shall form on freely drained sites, but the extent of climatic variation is insufficient to dominate the soil pattern.

2. The major relief units determine the broad division into latosols on the Mid-Tertiary Surface, and lithosols on the High Altitude Hill Zone and the Rift Valley Scarp Zone.

3. Landforms influence the detailed soil pattern in four main ways. The distinction between latosol-lithosol associations and areas dominated by lithosols is primarily caused by slope steepness; the area of ferallitic soils with laterite is associated with a high degree of planation of the land surface, and the absence of dissection following planation; alluvial calcimorphic soils result from alluvial deposition and particular drainage conditions associated with it; and hydromorphic soils result from poor drainage caused by topography.

4. Parent material has a dominant effect on the distribution of ferruginous and ferallitic soils, both on plains and in areas of moderate slope. The true extent of this influence, and its relative importance compared to the degree of planation, cannot be assessed without geological survey.

COMPARISON WITH NORTHERN NYASALAND

A comparison with the soil distribution shown on map X of the northern Nyasaland bulletin shows the following differences:

1. High Plateaux are considerably less extensive in central Nyasaland, as a result of which humic ferallitic soils occupy a much smaller area; there is consequently less land suitable for afforestation.

2. The High Altitude Hill Zones are also less extensive, therefore the lithosols associated with it cover a smaller area in central Nyasaland.

3. The Mid-Tertiary Surface is much more extensive in central than in northern Nyasaland, resulting in a greater area of latosols; further, the areas of ferruginous soils are greater. The combination of these two differences results in the much higher agricultural potential of central Nyasaland.

4. The Rift Valley Scarp Zone, with its associated lithosols, is of similar extent. The broad dissected area of the Karonga Scarp Zone is comparable with that of Kota Kota, and the narrow Lake Shore Scarp Zone with that of Dedza; the East Vipya Hills extend into both areas.

5. High rainfall areas are of limited extent in central Nyasaland, and ferrisols are consequently restricted in distribution.

6. The Lake Shore Plain has two comparable regions in each province. The Karonga and Salima Lake Shore Plain both contain broad belts of alluvial calcimorphic soils, together with areas of hydromorphic soils. The Nkata Bay and Kota Kota Lake Shore Lowlands both contain dissected country at altitudes predominantly 200 ft. or more above the level of Lake Nyasa; in both regions the steeper slopes carry lithosol, but on the gentler areas the types of latosols developed are quite different. Both provinces have a comparable potential for cotton and rice cultivation.

A NOTE ON HORIZON NOMENCLATURE

Horizon differentiation is poorly developed in many tropical soils; furthermore, the various systems of horizon designation that have been proposed apply principally to soils of temperate latitudes. Therefore terms defined mainly by depth in the profile have been used throughout the present work, both in the above chapter and in the soil series descriptions given in Part Two. These are as follows:

Topsoil: from the ground surface usually to between 4 and 8 in.; in this case, however, a clear boundary where the influence of organic matter on the colour ceases is usually visible.

Subsoil: from the base of the topsoil to *c*.18 in.

Lower subsoil: c.18–*c*.36 in.

In depth: below 36 in., particularly from 48 to 60 in. It is convenient to have some way of referring to the whole of the profile other than the topsoil; the term *lower horizons* is used with this meaning .

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CHAPTER V

Natural Regions

A NATURAL REGION is a part of the earth's surface in which the physical environment possesses the same major features, and in which individual environmental factors have a limited range of variation. This regional unity results from the existence of a balance between the interaction of the various factors. In some cases one *dominant factor* may exist, defined as a factor which exercises a controlling effect over the environment as a whole; examples of this are high altitude in the Vipya Plateau region, steep slopes in the Dzalanyama Range and high rainfall in the Nkata Bay Lake Shore Lowlands. In other regions, as for example in the Lilongwe Plain, the balance may result from the interaction of many factors.

The natural region is consequently a basic unit for agricultural planning in which the whole environmental complex must be taken into account. The unity of each region can be illustrated by reference to its predominant soil types. Vegetation and soils, alone among the factors of the physical environment, are influenced by all of the other factors, and are themselves closely interdependent. Vegetation is in addition greatly influenced by human occupance, whereas the basic properties of soils are only modified by this in extreme cases, e.g. as a result of severe soil erosion. There are a number of exceptions to the following correlation, but a comparison between the map of soils (map VI) and that of natural regions and areas shows a considerable degree of correspondence:

16. Upper South Rukuru Valley: Weakly ferallitic soils.
17. Central Mzimba Hills: Ferallitic soils and lithosols.
19. Vipya Plateau: Humic ferallitic soils.
20. East Vipya Scarp Zone: Lithosols.
21. Nkata Bay Lake Shore Lowlands: Ferrisols and lithosols.
22. Chimaliro Hills: Humic ferallitic soils and lithosols.
23. Kasungu Plain: Ferallitic soils, including feralitic soils with laterite.
24. Kota Kota Scarp Zone: Lithosols.
25. Kota Kota Lake Shore Lowlands: Ferallitic soils with laterite and calcimorphic soils.
26. Fort Manning Hills: Weakly ferallitic soils and lithosols.
27. Upper Bua Plain: Ferallitic and weakly ferallitic soils.
28. Lilongwe Plain: Ferruginous soils.
29. Dowa Hills: Ferruginous soils, including high altitude type.
30. Salima Lake Shore Plain: Calcimorphic soils.
31. Dzalanyama Range: Lithosols.
32. Dedza Hills: Ferruginous soils, including high altitude type.
33. Dedza Scarp Zone: Lithosols.

The natural regions distinguished during the present survey are mainly 500–3,000 square miles in extent, although four regions (22, 26, 31, 33) are of the order of 200 square miles. The regions have been subdivided into *natural areas*. In each of these, all of the environmental factors are relatively uniform. Limitations caused by the scale of mapping necessitates exceptions to this. For example, Dedza and Chongoni Mountains, classed as area 32d, each include two contrasting subareas, the summit plateaux and the bounding scarps. The former are each 2 square miles in extent, and therefore cannot be mapped on a 1 : 500,000 scale. The areas are mainly of the order of 100–500 square miles in extent, but there is considerable variation in size. On the area covered by the maps accompanying this bulletin, 17 natural regions and 58 natural areas are represented. The natural areas form units for agricultural planning on a local scale, since the range of conditions found within a region is in some respects too great for this purpose. The areas, however, are too numerous to be comprehended as a whole, and the regions provide a framework to which they may be related.

It has been found convenient to distinguish five areas that are common to many regions. The two most important of these are hills, on which the dominant environmental factor is steep slopes, causing lithosols; and *marshes*, subject to annual flooding and with hydromorphic soils. Two other areas are special classes of hill zones, namely *scarps* and *gorges*. A fifth area is that formed of *lacustrine sands*, which occurs in all regions that adjoin the shore of Lake Nyasa. These five areas are indicated separately on the map of natural regions and areas.

COMPARISON OF NORTHERN AND CENTRAL PROVINCES

The administrative boundary between the Northern and Central provinces of Nyasaland shows a noteworthy coincidence with the natural boundary between two landscape patterns. Regions 1–22 lie largely in Northern Province, and regions 23–33 in Central Province. Ncheu District, administratively part of the Central Province, lies outside the area covered by the present survey. 120 natural areas have been distinguished in the former, but only 44 in the latter, although the two provinces are of comparable extent. The mean size of natural areas is 90 square miles in Northern Province, and 290 square miles in Central Province. In the initial stages of air photograph interpretation nearly 300 primary mapping units were distinguished in Northern Province, but only 120 in Central Province. Thus the landscape of Northern Province is very highly diversified, whilst in comparison Central Province contains relatively large areas with uniform environmental characteristics. The difference is of significance in considerations of agricultural development on a national scale. It should be noted, however, that even in Central Province, the least diversified of the three provinces of Nyasaland, the range of environmental conditions and the variation of these over short distances is considerably greater than in most other parts of central and southern Africa.

MAJOR NATURAL REGIONS

A classification of the landscape into more generalized units than the natural region is of limited value in respect of agriculture, since the range of conditions that must be included within each unit is considerable. Consequently these need only be discussed briefly in the present context.

Any division of the Nyasaland landscape into a small number of major regions should be based on the major relief units (*see* pp. 4-6). A comparison of map I with maps II–VII shows that the pattern of all environmental factors, and consequently also of the agricultural potential, follows the distribution of these units to a substantial degree. These may therefore be termed the *major natural regions* of Nyasaland. Table IV* shows the relation between major relief units and climatic regions. A summary of the environmental factors associated with each of the major natural regions is given below; the principal crops grown, or other land use, are also indicated. In certain cases the regions have been subdivided into two associations. The natural regions belonging to each major region are shown, including those described in the bulletin on northern Nyasaland.

I. **The High Plateaux.** High altitude, moderate slopes; low temperatures, wettish, climatic region I; montane grassland and montane evergreen forest; humic ferallitic soils, strongly leached, often shallowish; afforestation, coniferous plantations. Dominant factor: low temperatures. Natural regions 8, 19.

II. **High Altitude Hill Zones.** Cool, wettish, climatic region Ia.

(a) *Association with moderate slopes*: low montane grassland; ferruginous soils, of high-altitude type; coffee, vegetables. Natural regions 7, 10, 13, 17, 29, 32.

(b) *Association with steep slopes*: *Brachystegia-Julbernardia* hill woodland; lithosols; natural forest. Dominant factor: steep slopes. Natural regions 1, 3, 4, 9, 22, 31.

III. **The Mid-Tertiary Surface.** Gentle and very gentle slopes; warm, dryish, climatic region III; latosols. Dominant factor: gentle slopes.

(a) *Association with ferruginous soils*: gentle slopes; *Combretum-Acacia-Piliostigma* cultivation savanna; ferruginous soils, of high fertility; intensive farming, maize, tobacco, groundnuts. Dominant factor: soils of high fertility. Natural regions 15, 28.

(b) *Association with ferallitic soils*: very gentle or gentle slopes; *Brachystegia-Julbernardia* plateau woodland; weakly ferallitic and ferallitic soils, of low fertility; extensive farming, maize, tobacco, groundnuts. Dominant factor: soils of low fertility. Natural regions 2, 11, 12, 16, 18, 23, 26, 27.

IV. **The Rift Valley Scarp Zone.** Steep slopes, high relief; wettish, climatic region V; *Brachystegia-Julbernardia* hill woodland; lithosols; natural forest. Dominant factor: steep slopes. Natural regions 5, 14, 20, 24, 33.

V. **The Lake Shore Plain.** Low altitude, level depositional plains common, dissected areas of low relief also present, marshes common; hot.

* p. 80.

(a) *Association with high rainfall.* Mainly dissected areas with moderate and gentle slopes. This is coincidental and no casual association with high rainfall is implied; wet, climatic region VI; moist *Brachystegia* woodland and forest; ferrisols; high-rainfall crops, tea, rubber, cocoa, rice. Dominant factor: high rainfall. Natural region 21.

(b) *Association with moderate rainfall.* Depositional plains common; dryish to wettish, climatic regions VII and VIII; *Acacia - Adansonia - Hyphaene-Sterculia* cultivation savanna, and lake shore savanna and thicket; alluvial calcimorphic soils; cotton, rice, with intensive farming on more fertile areas. Dominant factor: calcimorphic soils. Natural regions 6, 25, 30.

NATURAL REGIONS

The environmental conditions of the natural areas are summarized on the key to the map of natural regions and areas. The regional accounts given below supplement this key in two ways. Firstly, they describe the environmental factors which are characteristic of each natural region. Secondly, they indicate the main factors which differentiate each of the natural areas from the region as a whole. For reasons of space it has been necessary to keep the accounts mainly descriptive, although the major effects of one factor upon others are noted where possible.

16. **The Upper South Rukuru Valley.** The part of this lying in central Nyasaland is one of the highest sections of the Mid-Tertiary Surface, standing at 4,000–4,800 ft. Gentle slopes are predominant. The climate is warm and dryish, with a rainfall of 30–35 in. A typical *Brachystegia Julbernardia* plateau woodland and vegetation occurs. The soils are weakly ferallitic latosols, mainly red, and of moderate fertility; the intensity of cultivation in this southern part varies from moderate to very high.

The *Loudon-Mbawa area* (16d) is gently undulating, with intensively cultivated soils on level interfluves and poor, sandy soils on lower valley sides. *Marsh areas with termite mounds* (16f) the latter being large and regularly spaced, occur near the South Rukuru. The *Jenda area* (16g) is characterized by low hills surrounded by gently sloping pediments, with weakly ferallitic soils, many of which are exceptionally red.

17. **The Central Mzimba Hills.** This is a north-south belt of dissected country lying along the watershed between the South Rukuru and rivers to the east; the southern part includes the headwaters of the South Rukuru. It stands at highish altitudes, 4,400–5,300 ft., and is characterized by moderate relief and moderate slopes. An association of lithosols and poor, sandy, ferallitic soils occurs, with a cover of *Brachystegia Julbernardia* woodland.

In the *Mzimba area* (17d), broad ridges are characteristic. Small fields, abandoned after a few years of cultivation, are scattered over the ground and the woodland is in a degenerate condition. Slopes are slightly steeper in the *Perekezi Hills* (17e), with lithosols predominant; the area has no value for agriculture, and is partly coincident with the Perekezi Forest Reserve.

19. **The Vipya Plateau.** Only the *dissected high Vipya Plateau* (19b) occurs in central Nyasaland. The dominant factor is high altitude, above 5,000 ft., which causes low temperatures; the rainfall is moderately high, 45–55 in. Mainly as a consequence of climatic conditions, an association of montane grassland and evergreen forest occurs. The low temperatures, in conjunction with this vegetation, cause the formation of humic ferallitic soils, with a high humus content in the topsoil; as a result of the dissected topography, with moderate slopes predominant, shallow phase profiles are common with lithosols also present. The unsuitability for agriculture results from a combination of low temperatures, exposure to winds, and soils which are strongly leached and frequently shallow.

20. **The East Vipya Scarp Zone.** This is a deeply dissected hill zone, with high local relief, the main valleys having depths of 1,000 ft. and more. It consists of rising ground which faces south-east, intercepting the prevailing winds, and the region therefore receives a high rainfall, mainly above 60 in. Lithosols predominate, but due to the high rainfall a closed *Brachystegia* woodland of moderate height tends to occur in place of normal hill woodland. Steep slopes are the dominant factor. With respect to agriculture the presence of lithosols nullifies the favourable effect of high rainfall.

The main dissected area is termed the *East Vipya Hills* (20a). The deep and very steep sided valleys of main rivers, which are perennial and have relatively high discharges, are mapped as *gorge areas* (20b). Within the hills a number of *dissected plateau remnants* (20d) occur, with steeper slopes than those of the main Vipya Plateau (19b); agriculturally these are probably marginal, and are not utilized at present owing to their extreme inaccessibility.

21. **The Nkata Bay Lake Shore Lowlands.** This region consists largely of gently and moderately dissected country mainly lying 200–500 ft. above the level of Lake Nyasa; as a result of this, latosols predominate, in place of the calcimorphic soils found on low lying parts of the Lake Shore Plain. The climate is hot and wet. High rainfall, 60–90 in. is the dominant factor, causing the formation of ferrisols, and an association of moist *Brachystegia* woodland and forest. The potential for tea, rubber, rice and other high rainfall crops is largely undeveloped, and cassava is at present the principal crop.

The southern extension of the *Nkata Bay Lake Shore Ridge* (21b) possesses moderate and gentle slopes. Near the mouths of certain rivers *fertile alluvial areas* (21e) are entirely under cultivation. The *level areas* (21f) are probably of raised beach origin, and are largely uncultivated; their soils have not been examined during the present survey, but are probably deep ferrisols.

22. **The Chimaliro Hills.** This small region might alternatively be considered as a southerly extension of the Vipya Plateau; it is formed of two areas, both of which are covered partly by low montane and montane grassland and partly by *Brachystegia Julbernardia* hill woodland. The *Chimaliro Ridge* (22a) is a high, massive ridge, rising to nearly 6,000 ft.; the relief is strongly influenced by the east-north-east strike, resulting in subsidiary ridges and a rectangular tendency in the drainage pattern. It has steep slopes with lithosols, and extends north-eastwards beyond the present boundary of the Chimaliro Forest Reserve. A grassed, dissected plateau with moderate slopes lying east of this may be referred to as the *Upper Lupache Plateau* (22b). It has been only briefly examined during the present survey, but may have a potential for coffee growing if soils of sufficient depth are present.

23. **The Kasungu Plain.** This is the largest region in central Nyasaland, and is one of the three regions occupying the main area of the Mid-Tertiary Surface. Extensive areas with markedly uniform characteristics occur. It lies at 3,500–4,300 ft., with mean annual temperatures of 68°–70°. The rainfall is mainly 30–35 in. falling from east to west; it is possible that the western half of the region receives slightly below 30 in. with a correspondingly greater drought hazard. Relief is low and slopes are gentle, becoming very gentle in the south-west. All areas have a cover of *Brachystegia - Julbernardia* plateau woodland, mainly in the form of a savanna woodland of short trees. Ferallitic soils in which the coarse sand fraction is prominent occupy the greater part of the ground surface; laterite is frequently present in the lower subsoil. A catena commonly occurs in which level interfluve crests have ferallitic soils with laterite (Kasungu series), which give place to ferruginous soils of considerably greater agricultural value (Chamama and Luziwa series) on gently sloping valley sides; consequently there is a correlation between the amount of dissection and soil fertility. A further characteristic, of great utility in air photograph interpretation, is the presence of large and regularly spaced termite mounds over the western half of the region; these indicate poor, lateritic soils. The region is an important producer of flue cured tobacco, although detailed soil survey is necessary prior to planting this crop, in order to avoid shallow or excessively sandy soils.

The extent of dissection decreases from east to south-west. The *east Kasungu undulating area* (23a) has gentle slopes, becoming moderate in parts, and is less subject to drought hazard than the other areas. The proportion of the ground under cultivation varies from 5 to 30 per cent. The *central Kasungu Plain* (23b) has gentle slopes and low relief, but level areas are not extensive. Termite mounds are not systematically developed. The *north-west Kasungu Plain* (23c) is characterized by wide valleys with broad, very gently convex interfluves. Although slopes are from gentle to very gentle, level areas (0°- ½°) are not extensive, and the valley pattern is well defined. Termite mounds occur in belts along valley floor margins and at valley heads. Parts of this area comprise the Kasungu Game Reserve and the Fort Alston Forest Reserve. The *south Kasungu Plain with termite mounds* (23d) is the least dissected, and agriculturally the poorest area of the plain. Slopes are entirely below 2°, with broad level areas; valley floors consist of wide, poorly defined belts. The Bua and Rusa rivers cross the plain in level flood-plains of marsh grassland, ½–1 mile in width. Drainage impedence is extensive, and in parts is of a sufficient degree to cause the replacement of woodland by marsh grassland. Termite mounds extend over the whole surface, from interfluve to valley floor. The area is uncultivated. The *Phazi area* (23e), in the north of the plain, has gentle slopes and moderate cultivation. It includes weakly ferallitic soils, and pedologically has greater similarity with the Upper South Rukuru Valley (areas 16d and 16g) than with the Kasungu Plain.

24. **The Kota Kota Scarp Zone.** This is the largest region that is dominated by steep slopes, with lithosols. Relief is high to moderate, and the main rivers cross the region in deep and very steep sided valleys. Temperatures vary with altitude, and rainfall is 35–55 in. *Brachystegia-Julbernardia* hill woodland occupies all areas.

The main hill area, the *Kota Kota Hills* (24a) has a high relief; much of it is characterized by numerous small valleys and gullies cut into the sides of the main valleys. It is largely occupied by the Kota Kota Game Reserve. Clearly separate from this, with only moderate relief, are the *Kota Kota Scarp Foothills* (24b); these have a uniformity of crest height, but close dissection has resulted in the predominance of moderate slopes, with lithosols. The *North Visanza* area (24c) consists of dissected country with moderate slopes; lithosols are common but pockets of fertile ferruginous soils occur. The *hills above Kota Kota Scarp* (24d) include two areas with strong structural influence on relief, in one of which bare rock hills are common.

25. **The Kota Kota Lake Shore Lowlands.** This part of the Lake Shore Plain includes both depositional plains and areas lying 200–300 ft. above the level of Lake Nyasa. The climate is hot, with a moderately high rainfall, 50–60 in. This is partly the cause of an unusual soil type, in which profile drainage impedance occurs, associated with much iron deposition in depth (Kota Kota series); this may, however, be a relict soil, formed at a time when the level of Lake Nyasa stood at approximately 1,700 ft. Calcimorphic and hydromorphic soils, lithosols, and ferallitic soils developed from sands, also occur. The vegetation is varied, as a result of the different soil types. Numerous marshes, lakes and lagoons are a feature of the region. The largest of these are Chia Lagoon, enclosed behind the lake shore ridge (*see* below) but connected to Lake Nyasa by a short channel; and the Bana Swamp, a marsh area enclosed behind a complex of sand spits and lagoons. The conjunction of extensive marsh areas, outwash plains of major rivers, and a high rainfall, provides favourable conditions for rice production.

The *Kota Kota Lake Shore Ridge* (25a) has the surface form of a cuesta, although underlain by Basement Complex rocks. On its westward, inland, side, it is bounded by a low but continuous and undissected scarp, of fault origin. The surface of the ridge has a gentle overall slope eastwards; the upper part of this slope is dissected, with lithosols predominant; the lower part is covered by sandy deposits fringing the shore of Lake Nyasa. West of the scarp, a linear depression occurs, in which a number of small lakes are being converted to marshes by alluviation. Close to this ridge are *level areas* (25b), standing at 1,700–1,800 ft., and mainly undissected. These are probably of raised beach origin; sedimentary deposits have not been definitely identified on them, but are probably present. Soils include ferallitic soils developed from sands, but which have reached a fairly advanced stage of profile development (Senga series) and ferallitic soils with laterite. The vegetation is a lake shore type of *Brachystegia-Julbernardia* plateau woodland. The *fertile alluvial areas* (25c) were formed as river terraces. They possess alluvial calcimorphic soils of very high fertility, and are entirely under cultivation, with a vegetation of *Acacia-Adansonia-Hyphaene-Sterculia* cultivation savanna. The *outwash plains* (25d) are the flood plains of major rivers draining from the scarp zone to the west. These are subject to frequent flooding, and the river courses are impermanent. Although predominantly marsh, they include slightly higher areas of calcimorphic soils.

26. **The Fort Manning Hills.** This small region is occupied by Mafingi Series rocks. Quartz schists are common among these, and remain as hills, distinguishing the region from the plain to the east. Temperatures are moderate, and rainfall is approximately 40 in. *Brachystegia-Julbernardia* woodland occurs on both hills and gently sloping areas.

The *Fort Manning pediment area* (26a) is formed mainly of gently sloping pediments below hills. These have weakly ferallitic, red, soils, on which maize, tobacco and groundnuts are grown. It is bounded on the east by *Nchinji Ridge*, a massive curving ridge of quartz schist, rising to 5,755 ft., and utilized as a forest reserve.

27. **The Upper Bua Plain.** This is a gently to very gently undulating plain, with a warm, dryish climate. All parts have a cover of *Brachystegia-Julbernardia* plateau woodland, and soils vary from weakly ferallitic to ferallitic. The *Tembwe area* (27a) has gentle slopes, lowish relief, and weakly ferallitic soils, with a moderate cultivation density. In the *Mkanda area* (27b) slopes are very gentle, nowhere exceeding 2°, with low relief; ferallitic soils of very low fertility predominate, and cultivation is sparse. Geomorphologically this should be grouped with the south Kasungu Plain with termite mounds (23d), the two areas forming a region dominated by very gentle slopes and low

relief; pedologically, however, those areas are distinct, possessing soils which have affinities with those of regions 23 and 27 respectively. The large termite mounds which cover the south Kasungu Plain are absent from the Mkanda area.

28. **The Lilongwe Plain.** This is the second largest region in central Nyasaland, but with respect to both agricultural production and potential it is by far the most important. It forms part of the Mid-Tertiary Surface, lying mainly at 3,600–4,200 ft., but descending to 3,400 ft. close to the Lilongwe River and rising to 4,400 ft. near the northern and southern margins. It is characterized by gentle slopes, broad valleys, and level interfluve areas of varying extent. The valleys are typically 150–300 ft. deep, with maximum slopes of $2\frac{1}{2}°$–4°; in the tributary valleys the valley floors are continuously concave, and there is frequently no incised stream channel. The plain is formed of Basement Complex rocks, in which hornblende rich gneisses, of intermediate to basic composition, are common. Climate is relatively uniform, with mean annual temperatures of 67°–69° and a mean annual rainfall of 30–35 in. 85–90 per cent. of this rainfall comes in the four months December to March and from May to October there is almost complete drought. Rainfall totals of 15–20 in. can be expected with a frequency of one year in ten. In a narrow belt commencing south of Lilongwe and extending southwards to the Moçambique border the mean annual rainfall is possibly 25–30 in., with a correspondingly greater drought hazard, but the evidence for this is uncertain.

The plain is characterized by the presence of ferruginous soils. The formation of these results from: (i) parent rocks of intermediate to basic composition; (ii) gentle slopes, but sufficient relief to ensure good drainage; (iii) a lowish rainfall. These soils have a relatively high fertility status, although crop yields can be increased by the addition of nitrogen. The region produces a maize surplus, and has the largest production of groundnuts and fire-cured tobacco of any region in Nyasaland. In most areas almost the whole surface except in valley floors, is under cultivation. As a result, the present vegetation consists of isolated trees amid fields, termed cultivation savanna. The trees belong to a limited and distinctive range of species, among which *Combretum*, *Acacia* and *Piliostigma* species are important (*cf.* table II, p. 78). This is the only extensive part of the Mid-Tertiary Surface which does not carry *Brachystegia-Julbernardia* woodland.

The *south Lilongwe Plain* (28a) and the *north Lilongwe Plain* (28b) are similar to each other; the latter stands at slightly higher altitudes, and tends to have darker soil colours. In both areas the Lilongwe catena (*see* p. 41) occurs. Broad, gently concave valley floors, with hydromorphic soils and marsh grassland, occupy up to 10 per cent. of the ground surface. Very few hills occur. The *Lilongwe Valley area* (28c) has similar soils, but is affected by the deeper and somewhat incised valleys of the Lilongwe River and certain of its tributaries; slopes of 3°–6° are common, relief is 200–300 ft., well defined river beds are present, and hydromorphic soils are not extensive. In the *Nathenje area* (28d) low hills occur, and soil profiles of moderate depth are common. Ferruginous and weakly ferruginous soils predominate, but weakly ferallitic soils are also present. *Combretum-Acacia-Piliostigma* cultivation savanna occurs in the above four areas.

In the *Nsaru area* (28e), weakly ferallitic soils, carrying *Brachystegia-Julbernardia* vegetation, are extensive. A qualification is necessary regarding the mapped extent of this area. Where these soils are entirely under cultivation they are indistinguishable on air photographs from areas 28a and 28b. The area mapped as 28e has been distinguished as likely to have poor soils by the presence of estates and of woodland patches. The true extent of these red, weakly ferallitic soils can only be determined by detailed field survey.

The *Kampini–Sinyala area* (28f) has predominantly ferallitic soils, and is distinguishable on air photographs by patchy cultivation and a larger field size. Towards the south-west slopes become very gentle, with extensive areas of 0°–1°; part of this area is included in the Dzalanyama Forest Reserve, and carries mature *Brachystegia-Julbernardia* plateau woodland. The *Chimutu-Lumbadzi* (28g) area is transitional between the plain and the Rift Valley Scarp Zone. It has broad valleys up to 500 ft. in depth, with moderate slopes (5°–10°) predominant. Ferruginous profiles occur but are usually shallow or gravelly, and lithosols are common.

29. **The Dowa Hills.** This region covers a range of altitude from 2,100 to 5,200 ft. Its unifying features are a moderate to highish rainfall, 35–45 in., the predominance of dissected country with moderate slopes, and the occurrence of ferruginous soils in association with lithosols.

The *Dowa area* (29a) lies at 4,200–4,800 ft. and includes a number of groups of hills. On the lower ground between these, red ferruginous soils of moderate fertility occur. The *Mwera Hill area* (29b) lies at 4,800–5,200 ft. Valleys are deep but wide, and with moderate slopes; broad, smooth convexities are characteristic, with a gradual increase in slope from the interfluve crest to 10° or 15°. Altitude is the dominant factor, causing lowish temperatures, greater cloudiness, and consequently lower evaporation. This allows greater dry season soil moisture retention than on the Mid-Tertiary Surface, giving conditions favourable to coffee-growing. The high altitude type of ferruginous soils occur, with moderate organic matter content, and dull reddish colours. Vegetation is transitional between montane and low montane grassland. The *Mwansambo area* (29c) is a restricted zone of ferruginous soils on gentle to moderate slopes at 2,100–2,300 ft. Scarp foothill woodland occurs, with *Pterocarpus angolensis* common, and cotton is grown. The *Dowa-Mvera scarp area* (29d) is dissected to a moderate depth, with moderate and steep slopes. It differs from the scarp zones to the north and south in that patches of cultivable ferruginous soils are common. Extensive soil conservation measures are necessary in this area. *Nchisi Hill* (29e) is a broad, massive ridge, on the crest of which is a patch of montane evergreen forest; the slopes carry lithosols, with *Brachystegia-Julbernardia* hill woodland.

30. **The Salima Lake Shore Plain.** This is a low altitude plain, with high temperatures and a moderate rainfall, 30–50 in. There is a high degree of seasonal concentration of rainfall, with almost complete drought, from May to October. This feature, combined with the high evaporation associated with high temperatures, leads to a marked drying out of the soil during the hot season.

Two sub-regions may be distinguished, underlain by superficial deposits and by Basement Complex rocks respectively. The depositional plain comprises areas 30a–d. It lies mainly at 1,550–1,700 ft., and is characterized by level depositional surfaces, and by associations of calcimorphic and hydromorphic soils. The *alluvial plain* (30a) contains greyish brown, sandy, calcimorphic soils, and a lake shore savanna and thicket vegetation, tending towards woodland in parts. The *low lying areas* (30b) are more poorly drained, with hydromorphic soils common. There is little cultivation of either of these areas at the present. The *fertile alluvial areas* (30c), the largest of which includes Salima, are associated with certain main rivers. They carry alluvial calcimorphic soils of high fertility, which are almost entirely under cultivation. The vegetation of these is *Acacia-Adansonia-Hyphaene-Sterculia* cultivation savanna. The *Dedza lake shore plain* (30d) is a narrow scarp foot alluvial belt joining the Salima plain to the Bwanje Valley of southern Nyasaland. It has sandy soils similar to those of area 30a. Cotton is the principal cash crop grown on the calcimorphic soils of the above areas, whilst certain hydromorphic soil areas have been developed for irrigated rice cultivation.

The depositional plain is a triangular area projecting eastwards into Lake Nyasa, and at its apex a small area of acid igneous rocks projects through the alluvium to form Senga Hill. Lacustrine depositional processes associated with this hill have formed a complex of sands and marshes, the *Senga Bay raised beach* (30e).

The second sub-region of the Salima Lake Shore Plain is a belt formed of Basement Complex rocks, comprising areas 30f and 30g. This is gently to very gently undulating, with low relief, and carries scarp foothill woodland. The *Chitala area* (30f) has ferruginous soils of the low altitude type, and a moderate cultivation density, cotton being grown. The greater part of the sub-region, the *undulating scarp foot area* (30g) has an association of lithosols and ferallitic soils, often shallowish. It is agriculturally unutilized at present.

31. **The Dzalanyama Range.** This hill range rises abruptly and steeply above the Mid-Tertiary Surface. It contains steep slopes, with lithosols and a cover of *Brachystegia-Julbernardia* hill woodland, and is included in the Dzalanyama Forest Reserve. The crest is moderately level in profile, lying mainly at 5,000–5,400 ft. It forms the watershed separating drainage towards Lake Nyasa from that towards the Zambezi. In the north-western part it includes massive ridges trending north-north-west, due to strong structural influence.

32. **The Dedza Hills.** This region is characterized by the presence of isolated hills, including five high and massive mountains (Dedza, Chongoni, Mlunduni, Dzenza and Mnanda Mountains) and numerous smaller hills and ridges. Between these the ground is gently to moderately undulating. Most of the region stands at 4,400–5,200 ft., giving temperatures of 64°–66°. Rainfall is 35–50 in. and evaporation is lower than on the Mid-Tertiary Surface.

The *Dedza-Bembeke area* (32a) lies at 4,800–5,200 ft. Ferruginous soils of the high altitude type are present, with a vegetation of low montane grassland. A rainfall of 40–50 in. occurs, with the rainy season continuing into April; these two factors, combined with a lowish evaporation, result in good dry season soil moisture retention, permitting coffee growing. The relief consists of wide valleys of moderate depth, with broad, smoothly convex interfluves. The *Tambala area* (32b) lies at lower altitudes, and contains dissected country with irregular relief, but with areas of gentle slopes. The soil pattern is complex, and includes both ferruginous and ferallitic soils. The *Mphunzi area* (32c) is characterized by strongly ferallitic soils, shallowish and often with much coarse sand. It is occupied by *Brachystegia-Julbernardia* woodland, and is sparsely cultivated. *Dedza* and *Chongoni Mountains* have been grouped together as area 32d. Each includes a small summit plateau standing above 6,000 ft. with patches of montane evergreen forest amid montane grassland, and humic ferallitic soils. Steep scarps surround these which on Dedza Mountain have been utilized for coniferous plantations. The *hill areas above Dedza Scarp* (32e) include both hills and deep valleys, and are occupied by lithosols.

33. **The Dedza Scarp Zone.** This is a narrow zone of steep slopes, with lithosols. The *Dedza Scarp* (33a) although dissected by deep gorges, retains the form of a continuous scarp, being the only sector of the Rift Valley Scarp Zone in Central Province where this is the case. The *Dedza Scarp foothills* have a moderate to low relief; the more gently sloping parts of them carry scarp foothill woodland, with gravelly ferallitic soils. Recent faulting has produced low but undissected scarps, linear in plan form, in this area.

Part Two

Soil Series and Agriculture

CHAPTER VI

Agriculture

ONE OF THE objects of this bulletin is to set down, as accurately as our present knowledge permits, the agricultural potential of the country under review*. As this potential may vary, depending on the use to which one wishes to put the land and the general farming pattern at the time in force, it is necessary to define our terms of reference, the conditions which at present prevail and from which improved farming systems may evolve. A general picture will first be given of farming conditions in central Nyasaland. Then each of the *major natural regions* described in chapter V will be taken in more detail. Finally notes will be given to guide the reader in the uses and limitations of the agricultural interpretation of the soil series, set out in chapter IX.

Except for the freehold and leasehold estates owned by the European community, there are very few holdings that can really be termed farms in the European sense of the word. There are however some, and the number is increasing, especially in those parts of the country at present under-populated by reason of surface water shortage and relatively poor soil. Nevertheless, it may be argued that every adult African is a farmer, for, almost without exception, every citizen of Nyasaland has some stake in the land, even if it is only a right to cultivate, at some future date, a stony hillside in his native village. The average land unit is under five acres in size and many of the plots registered in the Kandiani and Maonde Land Reorganization Schemes were of less than one acre. Though the head of a family may control a number of units, the number of consolidated farms of ten acres or more is probably only of the order of several hundred in central Nyasaland. The vast majority of the agricultural land is held communally and is allocated by the traditional *Mwini dziko* (usually, but not necessarily, the village headman) to those who have a right to cultivate in the village area or to strangers who apply to settle therein. There is a negligible amount of freehold land, and though the right of an individual, or his or her descendants, to cultivate a given piece of land may be upheld by the *Mwini dziko* even after a lapse of many years, there is a danger that land left fallow may be taken back by the community and allocated to someone else. In some tribes such as the Achewa, inheritance is matrilineal, in others, such as the Angoni, it is patrilineal[1]. In matrilineal societies particularly, tenure of a given piece of land is by no means secure, and there is little incentive towards making permanent improvements to a holding. This system, stemming from the days when shifting cultivation for subsistence sufficed and the growing of crops was women's work, militates against the evolution of static farming for food, profit and export.

Change is however coming to the traditional farming background. The idea of cash cropping has been accepted in part, though very few farmers would be willing to replace their subsistence foodcrop acreage on marginal land with a better adapted or more highly profitable cash crop. However, tobacco, groundnuts and cotton are recognized as crops that a man may grow without loss of dignity, crops that may in fact bring him a handsome cash return by his standards. With the advent of a cash economy, there is hope that the use of economic rates of fertilizer and manure may become a practicable tradition, and that stable progressive farming may develop on soil which will be regarded as a valuable and productive asset, rather than as an essential last line of defence against starvation and a destitute old age.

The present farming community may therefore be regarded largely as smallholders (of about 4 acres) with a small proportion of small farmers (of 10–50 acres), and a number of men with holdings of several hundred acres, as yet only in part developed. There are also very large numbers of elderly men and women cultivating pocket handkerchief-sized gardens purely for subsistence.

Though a number of the small farmers have oxen and use ox-drawn equipment for ploughing, ridging and cultivating, there is no tractor cultivation done and by far the greater part of the acreage is cultivated by hand-hoe. Transport and communications are still very inadequate, though more and more ox-carts are being bought by villagers, and where there are ox-carts, rough tracks are prepared and maintained along which it is often possible to drive motor vehicles during the

* Table V, p. 81, gives the interpretation used to produce map VII from the charge map of Natural Regions and Areas.

dry season. The feeder road network also slowly expands. Nevertheless, the greater part of all produce taken by farmers to the primary markets is conveyed by headload or on the carriers of bicycles, and this takes time.

The majority of the area under cultivation is used for maize monoculture, usually without manure or fertilizer. On the poorer soil types this land is left to bush fallow when yields no longer give an adequate return for the labour involved in weeding. Three or four bags per acre would be considered adequate in this respect. On the richer soil types this level of yield can be maintained fairly easily, provided that the soil is not lost by erosion, and no weed, pest or disease develops to epidemic proportions. However, more and more people are coming to see the value (through prestige and greater prosperity) of high yields per acre, and simple rotations, based on alternating maize and a cash crop of either tobacco, cotton or groundnuts, are becoming accepted practice. The value of farmyard manure is in parts accepted, and more and more fertilizer is being bought, now that its beneficial effects have been demonstrated widely over a number of years and more cash is circulating in the villages. Though a number of progressive farmers now use manure and fertilizer on fairly complex rotations, there is still a long way to go, both in ensuring that the systems advised and attempted are in fact both *practicable* and *profitable*, and in persuading the rank and file to follow suit.

A more detailed description of agricultural background will now be attempted for the major natural regions.

I. **The High Plateaux.** These areas are of limited extent in central Nyasaland, being confined to the South Vipya, Dedza Mountain and Chongoni Mountain. Their value is for afforestation, provided that access to the plateau top can be gained. Dedza Mountain and the Vipya have access roads and have been, and are being, extensively developed. Chongoni is difficult of access and has had no development. It would be possible on the Vipya to grow arable crops of temperate cereals, beans and potatoes and to raise sheep on planted pastures, were there any markets available nearby for these products. These areas are very sparsely populated.

II. **The High Altitude Hill Zones.** Of these the only two with any agricultural potential are the Dowa Hills and the Dedza Hills. The remainder, by reason of their steep slopes, thin soils and dry climate should be left for the exploitation of indigenous timber.

(a) The Dowa Hill Region, with which the Mwera Hill and Nchisi areas are included, is broken country with some gently rolling hill crests. What soil there is is of good quality, but it is often shallow. Strict soil conservation measures are essential. The population is evenly distributed on the ground and of fair density for so broken a country. Most of the deep, gently sloping soil is occupied and more and more gardens are being opened up on sites too steep or too thin for stable arable cultivation. Maize is grown universally, with groundnuts at the lower altitudes, covered in nature by *Brachystegia* woodland, and beans, potatoes and vegetables in the higher areas of grassland.

There are numerous small valleys in which streams flow for much of the year and, if small storage dams are built, good fruit and vegetables can be grown under irrigation[2]. On the more sheltered slopes of the grassland area there is a potential for coffee-growing, provided that the crop is planted only on deep soils and that it is carefully tended. Conditions are marginal. Stem borers in maize are a considerable threat. There are a fair number of cattle in the hills and they thrive, but special care must be taken to avoid overstocking on these often very steep slopes. Motorable tracks are tortuous and steep and often cannot be used in the wet season. However, distances as the crow flies are not very great, and as one of the main roads of the territory passes up the middle of the zone the problems of distribution and crop extraction are not as difficult as they might be. There is considerable scope for agricultural development in this region, though considerable capital outlay in soil conservation works, small irrigation schemes and local roads will be necessary. Most of the region does not lend itself to tractor cultivation, though oxen are used in the more gently rolling areas.

(b) The Dedza Hill Region has a much greater proportion of more gently rolling country than the Dowa Hills, but there is still much broken country with steep slopes. The soils are mostly of good quality though often shallow. Unfortunately, the population is dense and has been in occupation a long time, so many of the parts best suited for farming have been overcropped and eroded. Soil conservation measures are essential. Subsistence maize is everywhere grown, but in the higher areas the climate is rather too cold, the season too short and the threat of stem borer too great to make it a profitable crop. Early planted crops, dusted with DDT against the stem borer, are the only hope for the cultivator of the area, until such time as alternative cash crops can be developed. Beans and potatoes can yield well provided that, in the latter crop, varieties resistant to late blight are used. Dimba vegetables and fruit can also be developed if a market is available. Coffee growing is very risky at present, as the areas most suitable in soil and climate are almost completely devoid of trees and the young crop dies of exposure. There is a large cattle population, and trade in livestock, potatoes and beans, and a considerable influx of money in the form of family remittances from migrant labourers in South Africa and Rhodesia, enables the local population to supplement by purchase their poor yields of maize. This is one of the areas of Nyasaland particularly liable to food shortage. The area is quite well served with motorable tracks and a good all weather road runs along the southern edge of the region. Future development is rather bedevilled by dense population, but when large urban centres come into being and the main north-south road is tarmaced, the best hope for the farming community will probably lie in supplying meat, potatoes, fruit and vegetables, to the towns, as these can be profitably produced on smallholdings. An immediate step in the right direction would be the planting or conservation of adequate shelter belts. Tractor power could be used in many parts of the area.

III. **The Mid-Tertiary Surface.** This will be dealt with in three parts, the Lilongwe/Dowa/Dedza plain, the Fort Manning/Kasungu plain and the South Rukuru Valley.

(a) The Lilongwe/Dowa/Dedza plain (Region 28). This is mostly gently undulating country with fertile or very fertile soils. However, on the northern and eastern edges, where it abuts the High Altitude Hill Zones, the country becomes more broken and the slopes steeper. Soils may become shallow—particularly in the Chimutu/Nathenje area (28g). The population is dense for an agricultural community and there is little unallocated land, but it is still possible for individuals to control consolidated holdings of about 20 acres, on loan from the community. The inheritance here is matrilineal. The region may be regarded as the granary of Nyasaland, and with a more stable land tenure and improved farming methods the productivity in maize, tobacco and groundnuts, could be quite easily doubled. The main obstacle to such development is the difficulty in getting the people to regard farm work as a productive investment, rather than as a tedious but necessary chore or an occasion for having a beer party. About 10 per cent. of the land area is covered by 'dambo' grasslands and a large proportion of the cattle population of the territory is concentrated in this region. Oxen are used to an ever increasing extent for carting and a beginning has been made in getting the larger holdings at least ploughed and ridged by oxen. Although the land is eminently suited to tractor cultivation, the holdings are too small to carry even a small four wheeled tractor, unless both are run on extremely efficient business lines. Few farmers are yet in a position to do this. It may be possible in future to organize tractor cultivation co-operatively or on a contract basis, but the multiplicity of smallholdings and the absence of access to them, except by narrow footpaths, militates against successful operation. Two attempts to reorganize areas of land into rational units, capable of co-operative tractor cultivation, failed, partly due to the political climate, partly to the hopelessly uneconomic size of the holdings of many of the most conservative of the villagers, and partly due to an over-theoretical approach to the problems arising. The network of main and secondary roads in this region is fairly good, though the secondary roads are rough and are often impassable in the wet season. Dry season cart tracks join nearly every village to a motorable road and marketing is relatively easy. Lilongwe stands at about the centre of the area and is joined by a tarmac road to the railhead at Salima. The haul up and down the escarpment is however hard on heavy vehicles and transport charges to the coast are not cheap. The potential of this region is great, and the biggest obstacles to achieving this potential are ignorance, insecurity of tenure and the multiplicity of smallholdings.

(b) The Fort Manning/Kasungu plain (Regions 23, 26 and 27). Except in the north-east and the south-west where they abut hill areas, these regions comprise very gentle slopes of moderate to poor soil. In parts the plain is almost level, and here very poor soils with laterite are to be found. Conservation measures in the more level areas should aim at removing excess storm water without loss of the sandy topsoil. The lighter showers should be conserved *in situ*, however, as there is a danger of drought restricting crop growth in one or two years in ten. The population is still small and concentrated locally on the better soil series. However, the regions are being actively opened up and holdings on these poorer soils are larger than is normal for the more fertile areas. Ox-cultivation is fairly frequently utilized and there is more scope here for tractor work than in the Lilongwe/Dowa region. Yield potential of maize, groundnuts and Turkish or Western tobacco is lower, and a larger acreage must be cultivated to make a livelihood. Because most of the soils are poor and yet respond markedly to improved methods of cultivation, farmers tend to be rather more receptive of new ideas in these regions than in the last. There is still room for expansion, and if the soil is mismanaged, the farmer goes hungry. Communications are rather more extended in these regions than in the last, and are more likely to become overgrown than impassably muddy or eroded. Marketing is correspondingly difficult. This is one of the parts of Nyasaland where, with a little encouragement and a will to progress, farms and farmers, rather than peasant smallholdings, may first develop. Effort should however first be directed on the more fertile eastern and southern parts.

(c) South Rukuru valley (Region 16). Most of what has been said in the last section applies also to this region, except that the fertility and potential are slightly higher, and the distance from railhead and centres of population greater. It is rather more developed than the Kasungu plain and there are more cattle. The people have a tradition of cattle management, unlike their southern neighbours, and the standard of ox-cultivation is considerably higher. The proportion of farmers to the total land cultivating community is probably higher here than anywhere else in Nyasaland.

IV. **The Rift Valley Scarp Zone.** This zone is typified by steep slopes, shallow soil and moderate to heavy rainfall. It is very difficult to prevent erosion on these soils and they should be left to indigenous timber until they have been more carefully explored for sheltered pockets of deep soil where coffee or other perennial cash crops may be grown on terraces. Communications are difficult except in the immediate vicinity of the few east-west roads. Nevertheless population pressure in neighbouring highland areas, and the poor standards of husbandry therein, drives more and more people over the edge on to the escarpment proper, where the forest is cleared and the often precipitous slopes prepared for maize. It is a trend greatly to be deplored unless the cultivators are willing to conform to the strictest principles of soil conservation. There is little sign of this.

V. **The Lake Shore Plain.** This will be taken in three sections, the high rainfall Kota Kota belt of the lake shore proper, the low rainfall Salima belt of the lake shore proper, and the associated foot hills, which occur in varying width between the alluvial plains and the escarpment.

(a) Kota Kota Lake Shore (Region 25). This region consists of small patches of rich alluvial soil interspersed amidst areas of marsh, outwash plains and low stony ridges. There is likely to be too much water rather than too little. If adequately drained, the alluvial soils will grow good crops of maize, and if water control in the swamps were possible, excellent crops of rice could be obtained. On the ridges, cassava is the chief crop, and it is likely to remain so, as the soils are poor and sandy. The population is heavily concentrated in a few areas, leaving much of the country wild. Cattle can be kept, but there are few of them, as the inhabitants are not cattle people. Land communications along the coast are bad owing to the extensive marshy land and to the presence of numerous rivers which come down in flash floods, washing away the bridges. No part is very far from the lake, so fish can provide the protein in the local diet. Coastal transport is available on a small scale, though there are few sheltered harbours and savage storms can arise very quickly on the lake. Development could proceed along the line of flood control for the cultivation of rice, for which there is a ready market. Considerable capital outlay would probably be involved. Citrus should do well on better drained areas of deep soil, though it will probably require some irrigation.

(b) Salima Lake Shore (Region 30). This is potentially a very productive area of level alluvial soils with some patches where fertile basement complex soils rise above the level of the alluvium. Excess water is the main problem on much of the area, and conservation measures should aim at safe removal of excess water. On the wetter areas (30b) camber beds may offer one solution, as these can easily be formed in a few years in the course of ox or tractor ploughing. The area is densely populated in parts, areas 30c being crowded, 30a being moderately populated, and 30b hardly opened up at all. Good crops of cotton, groundnuts and maize can be grown. Other crops are of potential, notably rice, castor, cassava, simsim, cashew and kapok.

Citrus does well under irrigation on the better drained soils. There are as yet few cattle in the zone, as it has only recently been cleared of tsetse fly, but they can and do thrive. Insect pests of cotton and weed growth and waterlogging in all crops, are the major hazards. Communications are fairly good, considering the number of rivers and swampy patches, as the railhead is at Salima in the centre of the zone and there is a good all weather road running north from here along the western edge of the alluvium. Feeder roads have to run parallel to the rivers and are likely to be impassable in the rains. Coastal transport is possible for small boats which can be beached, as there are very few safe harbours. Fishing supplements agriculture and provides protein in the diet. The productivity of the area could be very greatly increased by means of greater use of suitable spraying régimes on cotton (which have been worked out) and by improved drainage of wet but otherwise fertile land (no system has yet been worked out and proved in practice).

(c) The foot hill areas (24b, 29c and 30f and g). Much of this land is broken and carries thin, stony soils, which ought to be left to indigenous forest or put down to grass on the more level sites. However there are, interspersed amongst the stones, areas of potentially fertile red soils, of which the biggest recognized area is 29c (Mwansambo), or red soils covered by alluvium, typified by 30f (Chitala). The other parts of this zone are sparsely populated, are at present inaccessible except by foot, and have a very limited potential for development. We will, therefore, concentrate on the more productive areas.

Mwansambo, and its associated areas southwards, consists of undulating ridges of deep, red, fertile soils, carrying a heavy population. The soils are well drained and can grow cotton, tobacco, maize and groundnuts, as well as other minor crops. Conservation measures are necessary. There are few cattle, but they could be kept, especially in the larger areas which have been cleared of tsetse fly. Communications are a problem, for the areas are often of limited extent, and a road of some tens of miles may have to be maintained by relatively few villagers through broken stony country. The Mwansambo area does, however, lie across a tertiary road which runs up the escarpment and out to the coast, but this is usually cut each rainy season.

The Chitala area is typified by much more gently undulating country, often with broad level interfluves where the underlying red soils have been covered by alluvium and affected by impeded site drainage. Conservation measures need to reflect the danger of waterlogging. The area is moderately populated and opened up, and could support a larger population growing cotton, groundnuts and maize once the drainage problem has been overcome. Communication should offer no difficulty as the area lies astride a good all weather road and the railhead is only some 30 miles away. One of the main obstacles to immediate development is the provision of adequate domestic water supplies, as the dry season is long and hot and few of the rivers are perennial.

A GUIDE TO THE AGRONOMIC INTERPRETATION OF THE BULLETIN

No attempt has been made here to give a detailed economic survey of the areas demarcated[3]. Some data exist which would enable this to be done, but they have not yet been collected and correlated. Statistics anyway are liable to alter at an alarming rate in a developing country, and if this bulletin is used for an exercise in the economic development potential of any area, it should provide a background against which the latest statistics of the Ministry of Natural Resources, and the latest tax and census records should be studied.

In the use of the data provided on individual soil series, it should be borne in mind that the figures given for unfertilized yield potential are those that may be expected from land well cultivated and in its second or third year from fallow, and the fertilizer responses are similarly related. The 'heart' or degree of misuse of each field will have to be judged by the planning officer, and adjustments made to the figures published here, in the light of local experience. Some of the factors which must be taken into account are these:

(a) Root room. If there are local patches where rooting depth is limited by rock, laterite or water to less than 3 ft., the basic yields and responses are likely to be lower than here given.

(b) Pests and diseases. In an area where a pest or disease is prevalent, both basic yield and fertilizer response may be lower than here given. The latter may disappear altogether.

(c) Weeds. Failure to weed adequately, especially if the soil is infested with witch weed, may reduce basic yields and may eliminate response to fertilizer completely.

(d) Late planting and late application of fertilizer. Late planting of the crop will certainly drastically reduce the basic yield and the fertilizer response by up to 25 per cent. per fortnight's delay. Late application of fertilizer may render it ineffective.

(e) Use of farmyard manure and fertilizer. If a farmer has been using good farmyard manure regularly, basic yields may be higher and the fertilizer responses lower than here given, especially as regards phosphate.

(f) Opening of fallow land or ploughing of leys. If this is done late in the season, or a lot of dry lignified organic matter is buried in the process, the basic yields of certain crops, notably maize, may be less and the response to nitrogen more than is here given.

(g) Where a soil series is classified in Table VIII, as low in nitrogen, economic responses to moderate levels of nitrogenous fertilizer may be confidently expected, but where the series extends into the medium range, circumspection is necessary.

(h) Where a soil series is classified in Table VIII as low in phosphorus, phosphatic fertilizers may give economic responses once available phosphorus level drops below 10 p.p.m., i.e., after a long or intensive period of cropping. If the series is classified as moderate or high in phosphorus, it is highly unlikely that phosphatic fertilizer will give economic returns at the present intensity of crop production.

(i) Samples of organic manure so far analysed[4] show a very wide range of analyses, but nearly all of them are low in nitrogen. Thus, though the long term beneficial effects of regular applications of organic manure are fairly certain, disappointing results may be obtained on certain soils in the year of application unless fertilizer nitrogen is added as well.

Finally it should be noted that no mention of potash has been made. This is because most soil analyses indicate a level of soil potash adequate for present needs, and, in past fertilizer trials at the main stations, there has been no worthwhile response to applied potash. It is possible however that with heavier cropping the level of soil potash will become inadequate to the level of productivity achieved, and it may need to be applied later by the better and more productive farmers. Secondly, it may at present be short in those fields which have been grossly overcropped, and which have to date been overlooked, as they usually belong to the least progressive farmers.

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CHAPTER VII

Soil Series

INTRODUCTION

THE SOIL SERIES is defined as a group of soils having horizons similar in differentiating characteristics and arrangement in the soil profile, and developed from a particular type of parent material. This is entirely a morphological unit, considerations of the manner of origin of the profile or of the processes currently acting within it being excluded. The analytical properties of any one series have a limited range, but it is desirable to consider these as accessory characteristics, the defining properties of the series being restricted to those observable in a soil inspection pit.

In chapter IX the descriptions and agronomy of 40 series are given. Eight of these were previously described in the bulletin on northern Nyasaland. Their morphological and analytical characteristics are given in tables VI*, VII*, and their nutrient status in table VIII*. In identifying and defining series, the same two principles have been followed as in northern Nyasaland, these being conditioned by the extensive nature of the survey. Firstly, each series has been defined somewhat broadly, a moderate range of characteristics being permitted provided that certain essential features are present. Secondly, soils with apparently similar characteristics but occurring in widely separated areas have been distinguished as different series, since the number of profiles examined during the survey was insufficient to establish their identity with certainty. For the purpose of determining their agronomy it is therefore preferable to treat them as separate. Reference to table III, in which the series are assigned to genetic groups and sub-groups, will indicate which series have some degree of similarity.

Two *phases* are of frequent occurrence, and may be distinguished for many series:

1. Profiles which possess the typical properties of a series, but in which weathered rock commences at a depth of less than 36 in. should be described as belonging to the *shallow phase* of the series. This may also be applied to profiles in which a thick stone line, consisting of abundant quartz gravel or stones, occurs at such a depth. The criterion in all cases should be that the rock, stones, or gravel are present in a sufficient proportion to restrict root development seriously.

The shallow phase should not be distinguished for series which are by definition shallow (Chimutu, Kamenya, Kanyama and Kombedza, series).

2. Profiles which possess the typical properties of a series, but in which abundant iron concretions or hard, massive laterite occurs at a depth of less than 60 in., should be described as belonging to the *lateritic phase* of the series. Where the laterite horizon occurs above 36 in. a *shallow laterite phase* may be distinguished.

The lateritic phase should not be distinguished for series which by definition possess a laterite horizon (Jalira, Kasungu, Kota Kota).

Other phases have been defined for the Kamphuru, Kasungu, Maonde and Mwanjema, series.

THE LILONGWE CATENA

The Lilongwe Plain is agriculturally the most important region of central Nyasaland, and the soils which occupy it have been studied in greater detail. Most parts are occupied by a well developed catena, the uppermost member of which is the Lilongwe series. The lower members of this catena have many similarities with low catena soils associated with other series, in different natural regions. They have therefore been defined as series, and are included in the series descriptions and agronomy given in chapter IX.

The catena was first described by Jackson[1], in a survey of the Kandiani area of Lilongwe District, and later by Young and Jackson[2] in the Maonde area of Dedza District. The soils of these two areas have subsequently been identified as belonging to the same series; the correlation between the series nomenclature in these and in the present survey is as follows:

Number in catena	*1.*	*2.*	*3.*	*4.*	*5.*
Kandiani area:	Ngongonda	Kandiani	Mwanjema	Manzi	Mbabzi
Maonde area:	Kachere	Fosa	Macdonald	Maonde	Dambo clay
Present survey:	Lilongwe	Kandiani	Mwanjema	Maonde	Mbabzi

* pp. 82, 83 and 84.

The *Chipinika* series of the Kandiani survey is described in the present survey as the *Maonde series, very sandy phase.*

The *Lilongwe catena* occupies a gently undulating plain at an altitude of 3,500–4,000 ft., with broad, widely spaced valleys; the maximum valley side slope is typically between 2° and 3°. The upper member of the catena, the *Lilongwe series,* is a dark red sandy clay or clay, possessing the typical properties of a ferruginous soil. This occupies crest areas with slopes of 0°–1°, and in some cases the upper parts of valley sides also.

The point at which the Lilongwe series gives place to the second member of the catena is variable, but tends to be where the valley slope steepens to 1½°. This is the *Kandiani series,* a yellowish red profile with a sandy clay subsoil. The subsoil structure is considerably weaker than in the Lilongwe profile, and the series may be classified as weakly ferallitic.

The catena found in the Kampini-Sinyali area (28f), in which the Mkwinda series is frequently found above the Sinyala series, exhibits similar changes to the Lilongwe-Kandiani succession, the red profile of the former gives place on valley sides to the yellowish red and more weakly structured profile of the latter. Similar changes were recorded in the northern Nyasaland bulletin below the Fort Hill series.

On lower valley sides the Kandiani series passes transitionally into the *Mwanjema series.* There is no sharp contrast in properties between the two soils, but the Mwanjema series possess a deep subsoil of dark brown colour, below which the lower subsoil is less red than in the Kandiani series. The site drainage is free in the Kandiani series but imperfect in the Mwanjema series, many profiles of which are mottled in depth.

A more marked change in soil properties takes place on the concavities at the base of valley sides. These are normally overlain by a lens shaped deposit of colluvial coarse sand, thinning both upslope on the valley side and downslope towards the gently concave valley centre; this is probably derived by sheet wash from the slopes above. On it is developed the *Maonde series,* a coarse sandy, ferallitic soil, with the lower horizons mottled, and impeded site drainage.

In the Loudon-Mbawa area a comparable change occurs in which the red Loudon series of crests is replaced by the coarse sandy Bulala series on valley sides; in this case the change to a sandy soil takes place at a higher point in the catena than is the case in the Lilongwe catena. Stevens[3] has reported very similar sandy colluvial soils at the base of the catena below the Jandalala series in northern Nyasaland.

The gently concave valley floors of the region are occupied by the *Mbabzi series,* which extends on to the lower parts of concavities up to an angle of approximately ½°. This is a black, hydromorphic clay, subject to seasonal waterlogging. Similar soils, known within Nyasaland as 'dambo clays', occur at the base of the majority of latosol catenas.

The vegetation of the Lilongwe and Kandiani series is *Combretum-Acacia-Piliostigma* cultivation savanna; the latter series is often characterized by the frequency of *Afrormosia angolensis.* On the Mwanjema series this vegetation commonly but not invariably, gives place to *Brachystegia-Julbernardia* woodland; *Acacia campylacantha* is also very frequent on this part of the catena. The vegetation cover on the Maonde series is transitional, whilst the Mbabzi series is occupied by marsh grassland.

The existence of detailed surveys of two small areas occupied by this catena[1, 2] permits an estimate to be made of the relative extent of each of its members: Lilongwe 35 per cent. of the catena, Kandiani 30 per cent., Mwanjema 15 per cent., Maonde 15 per cent., Mbabzi 5–10 per cent. Four series are of similar extent in the two surveys, but the Maonde series varies from 5 per cent. at Maonde to 25 per cent. in the Kandiani area.

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CHAPTER VIII

Soil Series : Regional Keys

IN AN EXTENSIVE survey it is not possible to plot the boundaries between individual soil series. The legend to the map of Natural Regions and Areas shows the series that are known to occur within each natural area. Using this as a basis, the following keys enable a soil encountered in the field to be identified as belonging to a particular series. Lithosols and hydromorphic soils occur in all regions, and ferallitic soils derived from sandy parent materials in regions adjacent to the Lake Nyasa shore; consequently the key to these is given separately, preceding the regional keys.

To identify to which series the soil at a particular site belongs, the natural area in which the site lies should be identified from the map of Natural Regions and Areas, and the soil series which are known to occur in it noted from the legend of this map. A soil inspection pit 5 ft. in depth should be dug, and the profile examined. The following are the principal characteristics used in the regional keys:

- Colour of reddest horizon, normally found in depth.
- Texture of heaviest textured horizon.
- Dominance of coarse or fine sand in the sand fraction.
- Presence or absence of depositional bedding.
- Grade of structure in the subsoil.
- Depth at which weathered rock commences.
- Presence of many iron concretions or massive laterite.

In observing the colour, the Munsell hue should be recorded wherever possible; if Munsell charts are not available, the following is an approximate guide: Strikingly red: 10 R. Red: 2.5 YR. Yellowish red or reddish brown: 5 YR. Brown or dark brown: 7.5 YR. Greyish brown: 10 YR.

The structure of a large majority of Nyasaland soils is fine or medium blocky. The grade of structure is the degree to which the structural aggregates, or peds, are defined. A lump of soil several inches in size should be separated, and gently broken down into smaller units. The following are the grades of blocky structure:

Strong: soil breaks very readily along natural cleavage lines, but the resulting peds can be broken only with considerably more difficulty. Ped cutans are easily visible; these are clay coatings on ped surfaces, which are slightly shiny, and often a slightly darker colour than the soil of the ped interiors.

Moderate: soil breaks easily along natural cleavage lines, and the resulting peds can be broken with somewhat more force; ped cutans can be seen, but are not strongly developed.

Weak: natural cleavage lines are present, but can be detected only with care; ped cutans are not visible to the naked eye.

Massive: no natural cleavage lines or structural aggregates exist in the soil, which therefore breaks equally readily along any planes; ped cutans are not visible with a hand-lens.

Whilst the above criteria, combined with details of site, may enable a provisional series identification to be made, a full profile description is necessary before the identification can be confirmed; reference may be made to standard works on soil profile description [1, 2]. Mechanical analyses and pH measurements of all horizons are also desirable.

The manner of use of the regional keys may be illustrated by reference to that for region 28, the Lilongwe Plain (p. 46). Having ascertained from the key to All Regions (p. 45) that the soil is not a lithosol, hydromorphic soil, or ferallitic soil derived from lacustrine sands, consider A. of the key. Suppose that no gravel or stones are present in the subsoil, proceed to B. If coarse sand is not a marked feature of the profile continue to C., and if the soil is not sited on a pediment, to D. Suppose that the colour in the lower horizons is predominantly red, rather than yellowish red, proceed from D. to a., b., and c. below it. These require an assessment of whether the grade of structure in the subsoil is strong, moderate, or weak blocky, and also of the texture of the heaviest horizon. If the latter is sandy clay, and the subsoil structure of moderate grade, then the soil is provisionally identified as belonging to the Nathenje series. By turning to the description of this series (p. 70) the identification may be confirmed by reference to other morphological characteristics. In this case, the description is followed by a comparison of the Lilongwe, Nathenje, and Mkwinda series; similar comparisons will be found following the description of certain other closely related series.

Since the keys are intended only to serve as an empirical guide, certain site characteristics have been included, in addition to properties of the soil profile. The chief of these is altitude, approximate values to within *c*.500 ft. only being necessary; landforms and vegetation (woodland or grassland) are also employed.

It should be noted that in constructing a key of this nature, it is necessary to put series with exceptional characteristics first. The most extensively developed soils of a region will therefore in many cases be found towards the end of the key.

REFERENCES

[1]Soil Survey Staff, 1951. *Soil survey manual.* 2nd Edn., U.S. Dept. Agric., Washington D.C., 503 pp.

[2]Clarke, G. R., 1957. '*The study of the soil in the field.*' 4th Edn., Oxford, 204 pp.

REGIONAL KEYS

All Regions — **Series**

A. Stones or gravel abundant in the subsoil, and/or weathered rock commencing at a depth of less than 18 in.; often *Brachystegia boehmii* and *Uapaca kirkiana* common . . . . Lithosols

B. All horizons black, dark grey, or mottled; marsh grassland, valley floor site:
  a. All horizons, with the possible exception of the topsoil, clay . . . . *Mbabzi*
  b. At least one horizon, other than the topsoil, sandy clay loam or lighter . . . . . . Sandy hydromorphic soils

C. Site within 5 miles of Lake Nyasa Shore; coarse sand exceeding fine, heaviest horizon sandy clay loam or lighter: *ferallitic soils derived from lacustrine sands:*
  a. Heaviest horizon loamy sand . . . . *Kashata*
  b. Heaviest horizon sandy loam *or* heaviest horizon sandy clay loam and reddest horizon 10 YR or 7.5 YR . . . . *Mankhambira*
  c. Heaviest horizon sandy clay loam and reddest horizon 5 YR . . . . *Senga*

16.* *Upper South Rukuru Valley*

A. Very sandy, no horizon heavier than sandy clay loam, coarse sand exceeds fine; valley side site . . . . *Bulala*

B. Red or dark red in depth:
  a. Pediment site; usually 10 R hue in depth . . . . *Jenda*
  b. Level crest site; usually 2.5 YR hue in depth . . . . *Loudon*

17. *Central Mzimba Hills*

A. Topsoil and subsoil sand to coarse sandy loam; not red in any horizon . . . . *Kafukule*

19. *Vipya Plateau*

20. *East Vipya Scarp Zone* and

22. *Chimaliro Hills*

A. Topsoil dark brown or black, with many roots and strong crumb structure; montane grassland, above 5,000 ft. . . . . *Vipya*

21. *Nkata Bay Lake Shore Lowlands*

A. Predominantly red, with lower horizons sandy clay or clay . . . . *Nkata Bay*

B. Not red, no horizon heavier than sandy clay loam, coarse sand exceeding fine . . . . *See* key to *All Regions* C.

23. *Kasungu Plain*

A. Reddest horizon 5 YR hue, yellowish red or reddish brown:
  a. Coarse sand exceeding or equal to fine:
    i. Laterite present . . . . *Kasungu*
    ii. No laterite present . . . . *Kamphuru*
  b. Fine sand exceeding coarse:
    i. Heaviest horizon sandy clay loam, subsoil structure massive . . . . *Sinyala*
    ii. Heaviest horizon sandy clay, subsoil structure moderate blocky . . . . *Luziwa*

B. Reddest horizon 2.5 YR or 10 R hue, red or dark red:
  a. Subsoil structure strong blocky; site gentle valley sides on plains . . . . *Chamama*
  b. Subsoil structure moderate blocky; site undulating country of moderate and gentle slopes . . . . *Visanza*
  c. Subsoil structure weak blocky; site crest areas and very gentle slopes . . . . . . *Loudon*

24. *Kota Kota Scarp Zone*

A. Heaviest horizon clay or sandy clay:
  a. Grassland, altitude above 4,500 ft., dull colours, heaviest horizon usually clay . . . *Mwera Hill*
  b. Woodland, altitude below 4,500 ft., heaviest horizon sandy clay . . . . *Visanza*

B. Heaviest horizon sandy clay loam or sandy loam:
  a. Altitude above 2,500 ft., much coarse sand, yellowish red or other pale colours . . . *Kafukule*
  b. Altitude below 2,500 ft., gravel present in subsoil, shallowish, dark reddish brown or other dark colours . . . . *Kombedza*

25. *Kota Kota Lake Shore Lowlands*

A. Abundant iron deposition in depth . . . . *Kota Kota*

B. Fine sand exceedingly coarse, depositional bedding present, greyish brown:
  a. Texture predominantlly sandy clay loam and sandy loam, subsoil not mottled . . . *Salima*
  b. Texture predominantly clay, subsoil usually mottled . . . . *Pemba*

C. Coarse sand exceeding fine, not greyish brown, no horizon heavier than sandy clay loam *See* key to *All Regions*, C.

26. *Fort Manning Hills*, and

27. *Upper Bua Plain*

A. Laterite present above 36 in., subsoil structure massive . . . . *Jalira*

B. Dominantly red:
  a. Sited on pediments; subsoil structure moderate or weak blocky . . . . *Fort Manning*
  b. Not sited on pediments; subsoil structure weak blocky . . . . *Mkwinda*

* Regions 1-15 and 18 occur only in the area covered by the bulletin on northern Nyasaland.

C. Dominantly yellowish red:
   a. Subsoil with weak blocky structure . . . . *Tembwe*
   b. Subsoil massive . . . . *Sinyala*

28. *Lilongwe Plain*

A. Gravel or stones present in the subsoil, moderate depth or shallow, dominantly dark reddish brown . . . . *Chimutu*
B. Coarse sandy, no horizon heavier than sandy clay loam, mottled in depth . . . . . . *Maonde*
C. Site on pediments, very red . . . . *Jenda*
D. Dominantly red:
   a. Subsoil structure moderate or strong blocky, consistency markedly softer in depth than in subsoil, heaviest horizon usually clay, profile usually deep:
      i. All horizons dark shades; occurring mainly on north Lilongwe Plain, natural area 28b *Nambuma*
      ii. Dark shades less marked . . . . *Lilongwe*
   b. Subsoil structure moderate blocky, heaviest horizon sandy clay, profile frequently of moderate depth . . . . *Nathenje*
   c. Subsoil structure weak blocky . . . . *Mkwinda*
E. Dominantly yellowish red:
   a. Marked textural change at *c.*18 in. depth; sandy, with massive structure, above this, heavier textured below . . . . *Mngwangwa*
   b. Subsoil structure massive . . . . *Sinyala*
   c. Subsoil structure weak blocky; occupying sites on crests, at top of catena, as well as on valley sides . . . . *Tembwe*
   d. Subsoil structure weak blocky; occupying mid-catena, valley side sites, with redder soils (having distinctly reddish topsoils) at top of catena on crests; subsoil dark brown:
      i. Dark brown subsoil replaced by paler lower subsoil at less than 18 in. depth; reddish horizon 5 YR hue or slightly redder . . . . *Kandiani*
      ii. Dark brown subsoil replaced by paler lower subsoil at more than 18 in. depth; reddest horizon 7.5 YR hue or between 7.5 YR and 5 YR hues . . . . . . *Mwanjema*

29. *Dowa Hills*

A. Above 4,500 ft., reddish brown or red:
   a. Subsoil structure very weak, heaviest horizon sandy clay or sandy clay loam . . . . *Bembeke*
   b. Subsoil structure moderate or strong, heaviest horizon usually clay . . . . *Mwera Hill*
B. 3,000–4,500 ft., subsoil dark reddish brown with strong blocky structure . . . . *Dowa*
C. Below 3,000 ft., subsoil dark reddish brown with moderate or strong blocky structure . . *Tanga*

30. *Salima Lake Shore Plain*

A. Gravel present in subsoil, shallowish, dark reddish brown or other dark colours . . . *Kombedza*
B. Dominantly dark reddish brown or dark red:
   a. Heaviest horizon usually clay, no lightening of texture or softening of consistency in depth; level site . . . . *Chitala*
   b. Heaviest horizon sandy clay, consistency softer in depth than in subsoil; gently or moderately sloping site . . . . *Tanga*
C. Greyish brown, fine sand exceeding coarse, depositional bedding present:
   a. Texture predominantly sandy clay loam and sandy loam, subsoil not mottled . . . *Salima*
   b. Texture predominantly clay, subsoil mottled . . . . *Pemba*
D. Coarse sand exceeding fine, not greyish brown, no horizon heavier than sandy clay loam . See key to *All Regions* C.

31. *Dzalanyama Range*

A. Topsoil sand to coarse sandy clay loam, not red in any horizon . . . . *Kafukule*

32. *Dedza Hills*

A. Laterite present above 36 in., subsoil structure massive . . . . *Jalira*
B. Reddish horizon 5 YR or 7.5 YR hue, yellowish red, reddish brown or dark brown, sandy, subsoil structure massive . . . . *Kamenya*
C. Topsoil dark brown or black, with many roots and strong crumb structure; above 5,500 ft. Humic ferallitic soils, *cf. Vipya*
D. Reddest horizon 2.5 YR or 10R, red, dark red or dark reddish brown:
   a. Shallowish, weathered rock commencing above 36 in., subsoil structure moderate . . *Kanyama*
   b. Subsoil structure very weak . . . . *Bembeke*
   c. Above 4,500 ft., subsoil structure usually strong blocky . . . . *Dedza*
   d. Below 4,500 ft., subsoil structure moderate blocky . . . . *Nathenje*

33. *Dedza Scarp Zone*

A. Above 3,000 ft., subsoil structure moderate blocky, shallow or moderate depth . . . . *Kanyama*
B. Below 3,000 ft., subsoil gravelly with massive to weak structure, shallow or moderate depth *Kombedza*

C. Dominantly yellowish red:
  a. Subsoil with weak blocky structure . . . . *Tembwe*
  b. Subsoil massive . . . . *Sinyala*

28. *Lilongwe Plain*

A. Gravel or stones present in the subsoil, moderate depth or shallow, dominantly dark reddish brown . . . . *Chimutu*
B. Coarse sandy, no horizon heavier than sandy clay loam, mottled in depth . . . . . . *Maonde*
C. Site on pediments, very red . . . . *Jenda*
D. Dominantly red:
  a. Subsoil structure moderate or strong blocky, consistency markedly softer in depth than in subsoil, heaviest horizon usually clay, profile usually deep:
    i. All horizons dark shades; occurring mainly on north Lilongwe Plain, natural area 28b *Nambuma*
    ii. Dark shades less marked . . . . *Lilongwe*
  b. Subsoil structure moderate blocky, heaviest horizon sandy clay, profile frequently of moderate depth . . . . *Nathenje*
  c. Subsoil structure weak blocky . . . . *Mkwinda*
E. Dominantly yellowish red:
  a. Marked textural change at *c.*18 in. depth; sandy, with massive structure, above this, heavier textured below . . . . *Mngwangwa*
  b. Subsoil structure massive . . . . *Sinyala*
  c. Subsoil structure weak blocky; occupying sites on crests, at top of catena, as well as on valley sides . . . . *Tembwe*
  d. Subsoil structure weak blocky; occupying mid-catena, valley side sites, with redder soils (having distinctly reddish topsoils) at top of catena on crests; subsoil dark brown:
    i. Dark brown subsoil replaced by paler lower subsoil at less than 18 in. depth; reddish horizon 5 YR hue or slightly redder . . . . *Kandiani*
    ii. Dark brown subsoil replaced by paler lower subsoil at more than 18 in. depth; reddest horizon 7.5 YR hue or between 7.5 YR and 5 YR hues . . . . . . *Mwanjema*

29. *Dowa Hills*

A. Above 4,500 ft., reddish brown or red:
  a. Subsoil structure very weak, heaviest horizon sandy clay or sandy clay loam . . . . *Bembeke*
  b. Subsoil structure moderate or strong, heaviest horizon usually clay . . . . *Mwera Hill*
B. 3,000–4,500 ft., subsoil dark reddish brown with strong blocky structure . . . . *Dowa*
C. Below 3,000 ft., subsoil dark reddish brown with moderate or strong blocky structure . . *Tanga*

30. *Salima Lake Shore Plain*

A. Gravel present in subsoil, shallowish, dark reddish brown or other dark colours . . . *Kombedza*
B. Dominantly dark reddish brown or dark red:
  a. Heaviest horizon usually clay, no lightening of texture or softening of consistency in depth; level site . . . . *Chitala*
  b. Heaviest horizon sandy clay, consistency softer in depth than in subsoil; gently or moderately sloping site . . . . *Tanga*
C. Greyish brown, fine sand exceeding coarse, depositional bedding present:
  a. Texture predominantly sandy clay loam and sandy loam, subsoil not mottled . . . *Salima*
  b. Texture predominantly clay, subsoil mottled . . . . *Pemba*
D. Coarse sand exceeding fine, not greyish brown, no horizon heavier than sandy clay loam . *See* key to *All Regions* C.

31. *Dzalanyama Range*

A. Topsoil sand to coarse sandy clay loam, not red in any horizon . . . . *Kafukule*

32. *Dedza Hills*

A. Laterite present above 36 in., subsoil structure massive . . . . *Jalira*
B. Reddish horizon 5 YR or 7.5 YR hue, yellowish red, reddish brown or dark brown, sandy, subsoil structure massive . . . . *Kamenya*
C. Topsoil dark brown or black, with many roots and strong crumb structure; above 5,500 ft. Humic ferallitic soils, *cf. Vipya*
D. Reddest horizon 2.5 YR or 10R, red, dark red or dark reddish brown:
  a. Shallowish, weathered rock commencing above 36 in., subsoil structure moderate . . *Kanyama*
  b. Subsoil structure very weak . . . . *Bembeke*
  c. Above 4,500 ft., subsoil structure usually strong blocky . . . . *Dedza*
  d. Below 4,500 ft., subsoil structure moderate blocky . . . . *Nathenje*

33. *Dedza Scarp Zone*

A. Above 3,000 ft., subsoil structure moderate blocky, shallow or moderate depth . . . . *Kanyama*
B. Below 3,000 ft., subsoil gravelly with massive to weak structure, shallow or moderate depth *Kombedza*

Chapter IX

Soil Series : Descriptions and Agronomy

In reading the following accounts of soil series, reference should also be made to tables VI–VIII,* in which the morphological and analytical characteristics and nutrient status of each series are shown. In most cases only two profiles from each series have been chemically analyzed. Consequently the values shown for analytical characteristics and nutrient status only represent the known range of variation; whilst in many cases this range is well defined, in others it is probable that additional values will be found to occur.

DESIGNATIONS OF FERTILITY STATUS IN SOILS

As estimated for soil samples analysed in the Laboratory at Chitedze

Nitrogen (%)		
Kjeldhal		
	0 – 0·06	very low.
	·06 – 0·11	low.
	·11 – 0·16	medium.
	·16 – 0·20	adequate.
	·20 – 0·30	high.
	> 0·30	very high.
Available phosphorus (p.p.m.)		
Bray's Method No. 1 (Rapid)		
	0 – 5	very low.
	6 – 10	low.
	10 – 25	medium.
	25 – 50	adequate.
	50 – 80	high.
	> 80	very high.
K m.e. %		
Flame photometry		
	0 – 0·08	very low.
	·08 – 0·18	low.
	·18 – 0·40	medium.
	·40 – 0·60	adequate.
	·60 – 1·00	high.
	> 1·00	very high.
pH.		
Pye pH meter on 1 part soil to 1·5 parts water		
	4·8	very strongly acid.
	4·8 – 5·3	strongly acid.
	5·4 – 5·7	acid.
	5·8 – 6·0	moderately acid.
	6·1 – 6·5	slightly acid.
	6·6 – 7·0	very slightly acid.
	7·1 – 7·5	very slightly alkaline.
	7·6 – 8·0	slightly alkaline.
	> 8·0	alkaline.

BEMBEKE SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol.

Parent material. Basement Complex rocks, probably of acid composition.

Site. Crests and convexities of broadly convex ridges at high altitudes, 4,800–5,300 ft., mainly 0°–3° slopes.

Vegetation. Low montane grassland; *Brachystegia floribunda* and *Uapaca kirkiana* common.

Occurrence. Dedza Hills, in association with the Dedza series, and Dowa Hills, in association with the Mwera Hill series; natural areas 32a and 29a, b.

Morphology. A yellowish red or red profile of uniform appearance, with very weak medium blocky structure and soft consistency. The topsoil is a dark reddish brown sandy clay loam, below which the texture usually becomes sandy clay; the clay minerals are strongly kaolinitic, and permeability is rapid. Weathered rock patches commonly commence below 40–56 in. and a few ferric iron concretions may occur in depth.

This soil contrasts markedly with the ferruginous series with which it is associated, lacking the strong structure, dark subsoil colour, and heavy texture of the latter; it has a lower capacity for moisture retention.

AGRONOMIC DATA

Type sites. Kantande village (Dedza).

Potential. A ferallitic soil of moderate potential for crops tolerant of fairly acid conditions and of the rather cold, damp climate that usually occurs with it.

Nutrient status of topsoil. The soil series occurs frequently in densely populated and overcultivated areas and the profile is often truncated by erosion. The topsoil is a sandy clay loam or occasionally a sandy clay with a distinctly yellowish red appearance especially in the truncated profile. It tends to be acid. Total nitrogen is moderate to low, while phosphate and potash status are usually adequate for the rather poor crops of maize and beans grown. Should better adapted or protected crops be introduced, added manure and fertilizer will be necessary to produce the best potential yields.

* pp. 82-84.

Agricultural characteristics. Soils in this series offer moderately deep profiles of uniform appearance, and as the clay fraction is largely montmorillonitic they lack structure and stickiness in spite of their heavy texture. Permeability is rapid and the soil is easy to work, but it should be left alone when saturated as it puddles readily. Mineral reserves and cation exchange capacity are both low and the soil should not be expected to go on producing annual crops for more than three or four years without periods of fallow and adequate return of organic matter and plant nutrients.

The climate tends to be cold and wet and the growing season is short for the varieties of crop normally grown in Nyasaland. Also stem borer is a bad pest of maize in this area. People tend to plant late in an attempt to avoid its most virulent attacks and, as a result of late planting, yield potential suffers. Unfertilized yields of maize range from 2–6 bags/acre, groundnuts and beans give up to 400 lb./acre seed and potatoes one or two tons/acre.

Response to fertilizers. (Data from Bembeke '58 and '60, sundry observations '61 and Kantande '62.)

Responses to nitrogenous fertilizer have been very varied, as the effects of climate and pest or diseases are often greater limiting factors than soil nutrients. Given early planting and control of stem borer, yields of maize may be doubled from 4 bags/acre to 8 bags/acre by the use of 200 lb./acre of sulphate of ammonia. Under the prevailing conditions it is unwise to apply more than 200 lb./acre of sulphate of ammonia and it is better to apply a lower rate to a larger area if the supply of fertilizer is limited. Phosphate is not normally limiting except on really worked out soil, and here an NP mixture should be applied. Farmyard manure is usually heavily leached in this area and should be applied together with fertilizer nitrogen if any increase is to be expected in the year of application. Potatoes should respond readily to a dressing of 2½ tons/acre of farmyard manure *plus* 200 lb./acre of sulphate of ammonia, or to a mixed fertilizer containing about equal proportions of N and P. The requirement for potash has not been tested.

Suitable crops.

Subsistence maize if early planted and dusted against stem borer.
Beans.
Potatoes if blight resistant varieties can be grown (Walanga, Loman or Pimpernel).
Buye (*Coleus esculentus*).

BULALA SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol.

Parent material. Basement Complex rocks, partly with sandy colluvial cover.

Site. Gently sloping valley sides, 2°–4°, 3,500–4,500 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Xeromphis obovata* common.

Occurrence. Upper South Rukuru Valley, in catena below the Loudon series; natural area 16d.

Morphology. A coarse sandy, structureless soil, occupying the middle to lower parts of the catena. In all horizons the colour becomes no redder than the 7·5 YR hue (brown, dark brown, or yellowish brown), and the texture no heavier than sandy clay loam. The coarse sand fraction exceeds the fine, and the structure is from single grain to weakly massive.

The topsoil is a loamy coarse sand or coarse sandy loam. There is a continuous downward increase in clay to a maximum of 20–35 per cent. Despite the low organic matter content the topsoil is very dark grey, contrasting clearly with the brown subsoil. No weathered rock patches are present above 60 in.

This soil differs from the Kafukule series in having a deep profile, and in occurring in the middle and lower part of the catena only.

AGRONOMIC DATA

Type sites. The lower slopes of the gardens of Agricultural Instructor at Kanyanji and Agricultural Instructor at Bulala. The nursery and land below the training school at Mbawa.

Potential. A soil of moderate potential only for arable farming. Sparsely cultivated.

Nutrient status of topsoil. Grey brown sandy loams or loamy sands which may get rather acid. Total nitrogen is low (·05 or less). Available phosphate status is variable from adequate to low, and the soil should be sampled before phosphate recommendations are made. Sulphur may be a limiting factor for groundnut production.

Agricultural characteristics. The profile is deep and offers no hindrance to root development. Drainage is free. The soil is easily worked and easily eroded, as ridges easily get flattened in heavy rain. Well cultivated local maize should yield 4 or 5 bags/acre, groundnuts 500–800 lb./acre, and finger millet 800 lb./acre. This soil should not be cultivated without the use of manure or fertilizer for more than two or three years.

The soil is moderately responsive to fertilizers and manures, but would probably do better as permanent pasture or trees, as it lies in catena below the Loudon and Mpherembe series which have a better farming potential.

Responses to fertilizers. (Data from Mbawa '57 and Bulala '58 and '59.) Nitrogen and phosphate at low levels give large responses. Sulphate of ammonia will give increases of 5 bags, 2 bags and 1 bag/acre maize for successive increments of 100 lb./acre fertilizer up to a limit of 300 lb. The maximum economic dressing of single superphosphate, 200 lb./acre, will give increases of up to 2 bags/acre maize. No figures are available for responses to farmyard manure. A 200 lb./acre dressing of sulphate of ammonia has raised finger millet yields by 1,000 lb. seed. A 200 lb./acre dressing of gypsum has raised groundnut yields by 300 lb./acre seed.

Farmyard manure should give big increases, if it contains adequate nitrogen.

Suitable crops for the area.

Turkish tobacco.
Groundnuts.
Finger millet.
Maize.
Grass.

CHAMAMA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol.

Parent material. Basement Complex rocks, of intermediate and basic composition; including: 1. Muscovite-schist; 2. Granodiorite, with quartz, oligoclase, biotite and clinopyroxene; 3. Olivine-pyroxenite, with augite.

Site. Convexities and valley sides, 1°–3°, 3,700–4,000 ft.

Vegetation. Modified *Brachystegia-Julbernardia* plateau woodland, with *Pterocarpus angolensis, Acacia campylacantha,* and *Albizzia harveyi* present.

Occurrence. Kasungu Plain, in catena below the Kasungu and Kamphuru series, natural areas 23a, b; it has been recorded principally in east Kasungu District.

Morphology. A markedly red profile, with a dark reddish brown topsoil overlying dark red or dusky red lower horizons, often in the 10 R hue. The topsoil is sandy clay loam, usually becoming clay in the subsoil or lower subsoil; the latter horizons are strongly structured with clear cutans. A textural and structural B horizon is present, the texture lightening to sandy clay loam in depth. A substantial quantity of weatherable minerals remain in the profile; the depth is variable.

Similar but yellowish red profiles, with weaker structure, are classed as the Luziwa series.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Chamama and Wimbe, also at Kaomba and Ndeule (Kasungu).

Potential. A ferruginous soil of good potential for arable crops provided that the rainfall of the area is adequate.

Nutrient status of topsoil. This soil of good potential occurs in small patches amongst much poorer sandier soils, and has therefore been picked out by cultivators and tends to suffer from overcropping. It is a slightly acid red brown sandy clay loam or sandy loam having a moderate to very low total nitrogen content, low phosphate and adequate potash.

Agricultural characteristics. Soils of this series have deep or moderately deep, free draining profiles and a topsoil which tends to keep its structure fairly well. Mineral reserves and cation exchange capacity are fair to good, and with sound cultivation and rotation and a moderate use of fertilizer this series should be capable of giving good yields for many years. The unfertilized yield levels obtained are very variable, ranging from 15 bags of maize or 1,000 lb. of groundnuts/acre on the more recently opened fields, to yields of little more than one fifth of the above figures on the oldest gardens. Fire-cured tobacco yields of 600 lb./acre should be obtainable.

Response to fertilizers. (Data from Kasungu, Dwangwa and Chimakala '60, and Kasungu and Chitseko ('59). Responses to sulphate of ammonia should be of the order of 2 bags/acre for the first 100 lb. and 1 bag/acre for the second 100 lb. applied. It is not economic under present conditions to apply more than this. In most gardens, where phosphate is low, an application of 200 lb./acre single superphosphate will give increases of the order of 2-3 bags/acre. Phosphate shortage may limit the response to nitrogen, and it is as well to apply an NP mixture on these soils.

Suitable crops.

Maize (Aaskari or Mthenga).
Groundnuts (Mwitunde).
Tobacco.
Sweet potatoes.
Cassava.

CHIMUTU SERIES

DESCRIPTION

Genetic group. Shallow ferruginous latosol.

Parent material. Basement Complex rocks, mainly of intermediate composition; including: 1. Biotite-gneiss, with pyrite, graphite, and zircon; 2. Graphite-biotite-gneiss; 3. Banded diopside-biotite-gneiss. Acid, quartzo-feldspathic rocks commonly occur amid the above, remaining in the soil profile as little weathered stones, and gravel.

Site. Convexities and valley sides in moderately undulating country, 0°–6° slopes, 3,600–4,000 ft.

Vegetation. Transitional between *Combretum-Acacia-Piliostigma* cultivation savanna and *Brachystegia-Julbernardia* woodland, the latter occupying areas of shallower and stonier soils; *Acacia campylacantha, Piliostigma thonningii*, and *Pterocarpus angolensis* common.

Occurrence. Chimutu–Lumbadzi area of the Lilongwe Plain, 28g; possibly of limited extent in the Nathenje area, 28d.

Morphology. A dark reddish brown ferruginous soil, of moderate depth only, and with gravel or stones present in the profile. The topsoil is a dark brown sandy loam or sandy clay loam. The subsoil is a sandy clay, or heavy sandy clay loam, with moderate medium blocky structure; it is gravelly to a variable degree, but has sufficiently clear ped cutans for it to be classified as ferruginous. Stone lines are common, and weathered rock commences at 24–48 in. Dark colours (Munsell value 3/) are characteristic of the entire profile. The shallower profiles of this series are transitional with lithosols.

AGRONOMIC DATA

Type sites. Instructors' gardens at Mbuka, Malemia and Mtande (Lilongwe). Shallow, stony phase at Gumulira and Lumbadzi (Lilongwe).

Potential. A shallow ferruginous soil of moderate potential limited by depth and by slope.

Nutrient status of topsoil. The dark brown and often gravelly sandy clay loam or sandy loam topsoil is usually only slightly acid. As much of it has been intensively overcultivated, the nitrogen and phosphate levels vary from moderate to low though the potash status is usually adequate.

Agricultural characteristics. Though the soil is of good quality it is usually gravelly and often very thin. Drainage is no problem and the soil is fairly easy to work. Mineral reserves and cation exchange capacity are in moderately good supply, but because the soil is often so thin, it will need regular dressings of farmyard manure and fertilizers to keep it productive. Unfertilized yields of maize in a sound rotation may be of the order of 5–10 bags/acre. If good farmyard manure is regularly used 10–15 bags/acre may be expected. Soil conservation measures are essential on most fields of this soil type.

Response to fertilizers. (Data from Lumbadzi '56–'59 and Mbuka '56.) It should be noted that all data are obtained from fields which have had khola manure regularly applied, usually at the beginning of the season before that in which the experiment was conducted. Responses to sulphate of ammonia of the order of 2 bags/acre for each 100 lb. fertilizer applied may be expected up to the limit tested which was 200 lb./acre. There has been little response to phosphate recorded, but this may well be due to the applications of khola manure mentioned. A 200 lb./acre dressing of single superphosphate may give a return of about 1 bag of maize.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde).
Bambarra groundnuts (Northern Rhodesian or Barotseland).
Tobacco (on the deeper phases).
Sweet potatoes.
Grass (on the shallower phases).

CHITALA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol, low altitude type.

Parent material. Basement Complex rocks, probably of intermediate composition; including feldspathic hornblende-gneiss.

Site. Level to very gently sloping crest areas, $0°–\frac{1}{2}°$, *c*.2,000 ft.

Vegetation. Mixed woodlands on foothills of the Rift Valley Scarp; *Acacia campylacantha* very common.

Occurrence. The series occupies Chitala Agricultural Experiment Station but is of only limited extent in natural area 30f, being replaced by the Tanga series wherever slopes are steeper.

Morphology. A dark reddish brown heavy textured soil. The combination of a level site and a texture which remains clay or sandy clay from the subsoil to a depth of more than 60 in. gives the series a strong tendency towards drainage impedance. As a result of this, in any slight depression it is replaced by a mottled clay.

The topsoil is dark or very dark reddish brown, varying considerably in texture from place to place, between sandy loam and sandy clay. The lower horizons are dark reddish brown and dark red, sandy clay or clay, with moderate or strong medium angular blocky structure. There is no lightening of texture in depth, a moderately structured sandy clay or clay continuing to more than 60 in. Permeability is slower than in most latosols.

AGRONOMIC DATA

Type Sites. Chitala Experiment Station.

Potential. A ferruginous soil of high potential, if properly drained, for rain grown crops adapted to a hot climate.

Nutrient status of the topsoil. The dark reddish brown sandy clay or sandy clay loam topsoil is moderately acid, and its nutrient status tends to be moderate to low in nitrogen and phosphate though potash is adequate.

Agricultural characteristics. These soils occur on level sites and have a subsoil of heavy clay. They therefore tend to suffer from waterlogging and mottling comes to within a foot of the surface wherever there is a slight depression. The soils are not particularly easy to work as they get very hard in the dry season and very sticky after rain. Owing to the hot forcing conditions, the waterlogging, and the difficulty experienced in weeding such soil unfertilized maize yields may not rise above 10 bags/acre, but groundnuts yield 1,500 lb./acre of kernels and sprayed cotton up to 2,000 lb./acre seed cotton on well drained sites. Continuous maize grown for seven years without fertilizer at Chitala now yields about 4 bags/acre, but is very varied. Conservation works should aim at getting rid of excess water.

Response to fertilizers. (Data from Chitala Station.) Records show responses to sulphate of ammonia of the order of $3\frac{1}{2}$, 2, $1\frac{1}{2}$ and 1 bag/acre maize for successive increments of 100 lb./acre fertilizer up to 400 lb./acre. It is not economic to apply more than this quantity at present. Responses to single superphosphate are erratic and not large in spite of some very low phosphate levels recorded in soil samples. 100 lb./acre single superphosphate is probably adequate to make up any deficit and this will give an increase of about 1 bag/acre. A continuous maize plot well cultivated and given 5 tons of farmyard manure, 200 lb./acre sulphate of ammonia and 200 lb./acre superphosphate has given 10–15 bags/acre over the last 4 years.

Legumes have shown little response to superphosphate and cotton, if sprayed, has given increases of the order of 500–600 lb./acre seed cotton when given 200 lb./acre sulphate of ammonia backed with a small dressing of superphosphate to balance any phosphate deficit.

There has been no significant response to potash in any crop.

Suitable crops.

Maize for subsistence (Askari).
Groundnuts (Early Runner or Mwitunde).
Soya beans.
Bambarra groundnuts.
Cotton.
Cassava.
Cashew.
Castor.
Simsim.

DEDZA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol, high altitude type.

Parent material. Basement Complex rocks.

Site. Convexities and valley sides of broad ridges and valleys at high altitudes, 4,800–5,200 ft.; mainly 0°–10°, also on slopes of up to 25°.

Vegetation. Low montane grassland, with patches of *Brachystegia* plateau woodland; *Brachystegia floribunda, Uapaca kirkiana, Parinari mobola,* and *Cussonia kirkii* common.

Occurrence. The principal series in the Dedza-Bembeke area of the Dedza Hills, 32a, in association with the Bembeke and Kanyama series.

Morphology. The topsoil is a dark reddish brown sandy clay loam, or less commonly sandy clay. The dark colour continues to a depth of between 12 and 24 in., and the profile is characterized by a contrast between the dark reddish brown (2.5 YR hue) or dusky red subsoil and a red lower subsoil. The subsoil is usually clay, with strong medium blocky structure and clear ped cutans; weatherable minerals are common in the profile. Weathered rock commences at 40–50 in., but remains highly weathered, with soil patches also present, to below 65 in. Similar but shallower soils, with gravel present in the profile, are classed as the Kanyama series.

AGRONOMIC DATA

Type sites. Coffee plots at Kasumbu, and Kapenuka; Agricultural Instructors' gardens at Kangunda, Kulongwe, and Dedza.

Potential. A ferruginous soil of good potential for arable crops adapted to high altitudes, or for coffee on the deeper phases in sheltered sites in areas of adequate rainfall (40–50 in. with some winter rain).

Nutrient status of topsoil. The dark reddish brown sandy clay loam topsoil is moderately acid and normally has a moderate nitrogen status and adequate soil reserves of phosphate and potash.

Agricultural characteristics. These soils occur in densely populated areas and may be frequently badly overcropped. The profiles are moderate to deep and freely drained. As there is a plentiful supply of minerals in the soil and cation exchange capacity is high, the soil should be quite resilient and should respond to good treatment. Unfertilized maize yields of the order of 5–10 bags/acre may be expected in the warmer parts, together with 600–700 lb./acre groundnuts seed and 500–600 lb./acre beans.

Soil conservation measures are likely to be necessary on soils of this series as they occur in undulating hilly country.

Response to fertilizers. (Data from garden statistics '61, Dedza Prison Farm '61 and Mwalawankhondo '62.) Responses to fertilizer depend largely upon the incidence of pest, disease or unseasonable weather, and so are very variable. On average local maize may be expected to give increases of 1½ bags/acre for the first 100 lb. of sulphate of ammonia applied and 1 bag/acre for the second 100 lb. It is not worth applying more than 200 lb./acre of sulphate of ammonia to local varieties, but this position may change when suitable hybrids and improved varieties have been introduced. There is little response to phosphate from either maize or groundnuts. Farmyard manure should be applied with a dressing of nitrogen.

Suitable crops.

Maize subsistence only (beware stem borer).
Groundnuts in lower altitudes.
Beans.
Grass.
Potatoes.
Coffee on deeper soils in sheltered sites of the wetter areas.
Fruit trees.
Vegetables.

DOWA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol.

Parent material. Basement Complex rocks, mainly of intermediate composition; including: 1. Biotite-hornblende-gneiss; 2. Garnetiferous hornblende gneiss; 3. Muscovite-pegmatite, with quartz and feldspar; 4. Amphibolite.

Site. Moderately undulating country, 0°–7° slopes, ranging in altitude from 3,000 to 4,500 ft.

Vegetation. Modified *Combretum-Acacia-Piliostigma* woodland, with *Pterocarpus angolensis*, *Erythrina tomentosa*, and *Cussonia kirkii* common.

Occurrence. In the Dowa Hills this is the principal series of the Dowa area, 29a, and the higher parts of the scarp zone, 29d. Above 4,500 ft. it gives place to the Mwera Hill series, and below *c.*3,000 ft. to the Tanga series.

Morphology. A dark reddish brown and dark red heavy textured soil, with strong structure. A dark reddish brown (5 YR hue) sandy clay loam or sandy clay topsoil overlies a subsoil also dark reddish brown (2.5 YR hue). This gives place to a dark or dusky red colour in the lower subsoil, sometimes becoming markedly red (10 R hue); all horizons are dark (Munsell value 3/). The subsoil or lower subsoil is usually clay, with a strong, fine to medium, angular blocky structure and strong ped cutans. Stone lines may occur, and the profile varies from deep to moderate depth.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Dowa, Zidunge, Chimangasasa, Mvera (Dowa) and at Nkhuwi and Malenga Court (Visanza).

Potential. A ferruginous soil of good potential, in its deeper phase, for arable crops adapted to a moderately cool climate.

Nutrient status of topsoil. The dark reddish brown sandy clay loam or sandy clay topsoil is moderately acid with a fair nitrogen status, low phosphate and adequate potash.

Agricultural characteristics. This soil occurs in very broken country and thus has moderate and variable depth limited by stone lines or rock. It needs adequate soil conservation measures, but is freely draining and quite easy to work. It has a good cation exchange capacity and is so quite resilient. Because of the nature of the terrain it ought to be largely under grass or permanent crops. Well rotated and manured land without fertilizer should give yields of 10–15 bags/acre of maize and 1,000 lb./acre of groundnuts, provided pests and diseases are controlled.

Response to fertilizers. (Data from Dowa, Mvera and Zidunge '62.) A 200 lb./acre dressing of sulphate of ammonia is likely to give an increase of 2–4 bags/acre maize where stem borer is controlled. Except where a field has been cultivated for many years, phosphate is not likely to give large returns, but if the soil phosphate level falls below 5 p.p.m. worthwhile increases may result from a dressing of 200 lb./acre single superphosphate. Farmyard manure should be applied with a dressing of nitrogen. Groundnuts do not respond to phosphatic fertilizer.

Suitable crops.

Maize (Askari or Mthenga) (beware of stem borer).
Beans.
Potatoes.
Groundnuts (Mwitunde).
Grass.
Fruit trees.
Vegetables.

FORT MANNING SERIES

DESCRIPTION

Genetic group. Weakly ferallitic latosol.

Parent material. Basement Complex rocks, of acid and intermediate composition, and colluvium derived from these; including: 1. Feldspathic gneiss; 2. Quartz-schist.

Site. Pediments, 2°–3°, 3,900–4,300 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Syzigium guineense* and *Ochna schweinfurthiana* common.

Occurrence. The main series of the Fort Manning pediment area, 26a. Also on pediments below isolated hills in the Tembwe area, 27a.

Morphology. A red soil with the topsoil dark reddish brown and a dark red colour commencing in the immediate subsoil and continuing through all the lower horizons. The topsoil is a sandy clay loam and the heaviest horizon typically a sandy clay; fine sand is frequently dominant over coarse, except on the uppermost parts of pediments, adjacent to hill slopes. The subsoil structure and ped cutans are moderate or weak, and the profile has a uniform appearance.

AGRONOMIC DATA

Type sites. Farmer Shadreck Kadulamalambo's garden at Kadula village and Agricultural Instructor's garden at Kazyozyo (sandy topsoil).

Potential. A weakly ferallitic soil of moderate to good potential for arable crops.

Nutrient status of topsoil. The dark reddish brown sandy clay loam topsoil is moderately acid to acid with low nitrogen and phosphate status and adequate potash. Organic matter tends to be low.

Agricultural characteristics. A deep, freely draining and easily worked soil on pediments, often with an appreciable slope. Soil conservation measures are necessary. Structure and nutrient reserves are not very good and this soil will need regular dressings of farmyard manure or a high proportion of grass to arable in its rotations if it is to be maintained in a productive condition. Unfertilized yields of maize of the order of 5–10 bags/acre may be expected, and groundnut yields of 1,000 lb./acre shelled nuts. Yields of 400–500 lb. air-cured western tobacco should be obtained.

Response to fertilizers. (Data from Shadreck '61 and '62 and Tikolowe '60.) A dressing of 200 lb./acre sulphate of ammonia is likely to double the yield of maize, most of the response being to the first 100 lb. of fertilizer applied. It is best to advise applying 100 lb./acre sulphate of ammonia over as wide an area as possible, rather than concentrating heavier dressings on smaller areas. There is little response to phosphate from either maize or groundnuts. Farmyard manure must be applied together with a dressing of nitrogen as it may otherwise give disappointing results.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde or Chalimbana).
Bambarra groundnuts.
Western tobacco.
Grass.

This soil is very similar to the Jenda series, but occurs under higher rainfall conditions.

JALIRA SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol, with laterite.

Parent material. Basement Complex rocks, and colluvium derived from these; including syenite-gneiss.

Site. Gentle slopes, especially lower sides, and level areas, 0°–3°; altitude variable, mainly 3,500–4,800 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Brachystegia boehmii, B. longifolia, Uapaca kirkiana* common.

Occurrence. This series has been recorded mainly in the Mphunzi area of the Dedza Hills, 32c, in association with the Kamenya series; it may also occupy limited areas on many parts of the Mid-Tertiary Surface.

Morphology. A horizon consisting predominantly of iron concretions, cemented to a variable degree, occurs at a depth of less than 36 in. Above this the soil is at least as sandy as sandy clay loam, no redder than the 5 YR hue, and has massive structure. The topsoil is a sand, loamy sand, or sandy loam. Site drainage may be imperfect, and profile drainage is normally so.

The iron concretions are typically $\frac{1}{4}$–$\frac{1}{2}$ in. diameter, sub-rounded, and hard; they have black to bluish black centres and reddish brown or strong brown skins or coatings of a thickness varying from 1/50 in. to $\frac{1}{4}$ in.

This series has also been previously described as the Samu series (*Ann. Rep. Dept. Agric. Nyas. Pt. II, 1958/9*, (1960), p. 145.

AGRONOMIC DATA

Type sites. Garden of the Agricultural Instructor at Jalira (Rukwapaliza). There are no data available for this series which is virtually uncultivated, as the root room is limited to $1\frac{1}{2}$ to 2 ft. by a layer of massive laterite. It occurs in catena below the very poor but slightly better soils of the Kamenya series and should be under trees or permanent grass.

JENDA SERIES

DESCRIPTION

Genetic group. Weakly ferallitic latosol; transitional towards ferrisol.

Parent material. Basement Complex rocks, mainly of intermediate composition, and colluvium derived from these; including biotite-hypersthene-gneiss, with quartz and andesine.

Site. Pediments, 2°–3°, 4,000–4,500 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland.

Occurrence. Chiefly in the Jenda pediment area of the Upper South Rukuru Valley, 16g; also recorded in the Chalandu group of hills, between Mponela and Nambuma, part of area 28e.

Morphology. A very red soil, with the topsoil dark reddish brown (5 YR or 7·5 YR hue), the subsoil dark red or dark reddish brown (2·5 YR or 10 R hue), and the lower subsoil 10 R 3/6 dark red. The topsoil is sandy clay loam and the subsoil sandy clay or clay. The subsoil structure varies from very weak to moderate, and ped cutans can only be distinguished with difficulty. Permeability is rapid in all horizons, and the profile is deep.

This soil is similar to the Fort Manning series, the main difference being the greater redness of the profile.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Jenda (Mzimba), Pitara (Kasungu) and at Sintala, Dangaliro and Chisepo (Dowa).

Potential. A weakly ferallitic soil of moderate potential for arable crops.

Nutrient status of topsoil. The distinctly red brown sandy clay loam topsoil is acid with a low nitrogen status, variable phosphate and adequate potash. In north Kasungu and Jenda areas the soil may be heavily overcultivated, very poor and lacking adequate organic matter.

Agricultural characteristics. A deep, free draining soil of gentle pediment areas. The topsoil structure is only moderate and soil conservation measures are necessary. Nutrient reserves are moderate to poor and this soil cannot support good crops without fertilizer for more than 4 or 5 years. It is capable, however, of maintaining good yields if fertilizer and farmyard manure or leys are used. Unfertilized yields of maize of 5–15 bags/acre may be obtained, depending upon the 'heart' of the field and the damage done by stem borer, which can be severe in the north. Yields of 800 lb./acre of groundnut seed may be expected, and 400–500 lb./acre of fire-cured western tobacco.

Response to fertilizers. (Data from Jenda '57, Katete '60, Gideon Soko '60, Samson Luzi '59 and '62 and Dangaliro '57 and '62.) Very large responses to sulphate of ammonia may be expected, of the order of 4½ bags for the first 100 lb. and 3 bags for the second 100 lb./acre fertilizer applied. It is probably economic to apply up to 300 lb./acre sulphate of ammonia provided that farmyard manure or a small dressing of single superphosphate (100 lb./acre) is also applied. Superphosphate by itself rarely gives a useful return on maize or groundnuts. Farmyard manure must be applied together with a dressing of nitrogen, for while manure alone frequently depresses maize yields, the best combination so far tested is 5 tons of manure and 200 lb. of sulphate of ammonia/acre.

Suitable crops.

Maize (Askari or Mthenga). (Beware stem borer.)
Groundnuts (Chalimbana or Mwitunde).
Bambarra groundnuts.
Western tobacco.
Grass.

KAFUKULE SERIES

DESCRIPTION

Genetic type. Strongly ferallitic latosol.

Parent material. Basement Complex rocks, of acid and intermediate composition.

Site. Gentle and moderate slopes, 0°–8°, 4,400–5,000 ft.

Vegetation. *Brachystegia - Julbernardia* hill woodland and plateau woodland; *Cryptosepalum psenudotaxus* and *Brachystegia boehmii* common.

Occurrence. Extensive in the Central Mzimba Hills, natural areas 17d, e; typical of dissected areas with moderate slopes, in association with lithosols, and probably present in parts of the Kota Kota Scarp Zone, natural areas 24b, c.

Morphology. The combined percentages of coarse sand and gravel amount to more than 50 per cent. in the topsoil and subsoil, and more than 40 per cent. in the lower subsoil. In all horizons the structure is single grain to weakly massive. The lower horizons are brown, strong brown, or yellowish red, becoming no redder than the 5 YR hue.

The topsoil is a brown or dark brown loamy coarse sand or coarse sandy loam, with a very low organic matter content. The texture may remain similar in the lower horizons, or the clay extent may increase downwards to a coarse sandy clay loam. The profile is of moderate depth or shallowish.

This soil differs from the Bulala series in the presence of weathered rock above 60 in., the absence of sandy colluvium and in its occurrence on crest areas as well as in mid-catena sites.

AGRONOMIC DATA

Type sites. This series covers a range of gravelly or sandy soils of reasonable depth in dissected country north and south of Mzimba.

Potential. A soil of moderate potential only for arable farming, occurring in pockets among uncultivable lithosols. Best used for subsistence food and fodder crops for animals. Sparsely cultivated.

Nutrient status of topsoil. Brown or dark brown coarse sandy loams or loamy sands with a fair proportion of gravel. The soils *may* be distinctly acid. Total nitrogen is very low (·04 or less) and available phosphate likewise will probably be low (20 p.p.m. or less). Potash supplies are not good. The soils do not seem to suffer sulphur deficiency however.

Agricultural characteristics. Depth of profile is moderate to shallow (4 to 5 ft.). Drainage is good. As the soils are often on fair slopes and are light, soil conservation measures are essential. The soil is fairly easy to work, though gravel may wear tools rather quickly. Well cultivated local maize may give 5–7 bags/acre on newly opened land, and groundnuts 800–1,000 lb./acre, but the yields deteriorate very badly and if no fertilizer or manure is used gardens should be returned to fallow after two or three years' cultivation.

The soil can give large responses to low levels of fertilizer but needs very careful management if good yields are to be sustained.

Responses to fertilizers. (Data from Jendalala '59, Mzimbamuli and Madise '60.) Sulphate of ammonia will give responses of the order of 3 bags and 1½ bags/acre maize to successive increments of 100 lb./acre, fertilizer up to a maximum of 200 lb./acre. Where no farmyard manure has been applied in the past and soil P is low, a 200 lb./acre dressing of single superphosphate should give a response of up to 3 bags/acre maize.

No other data are available.

tween massive and weak blocky. Ped cutans are usually not visible. The soil is distinguished from the Kasungu series by the absence of laterite in the profile.

Very sandy phase. This phase comprises profiles with a topsoil of coarse sand or loamy coarse sand, and no horizon heavier than sandy loam. The subsoil may be no redder than the 7·5 YR hue.

Catenary associates. The very sandy phase commonly occurs on lower valley sides, in catena below the normal profile. Downslope the texture continues to become sandier and the colour less red, until the subsoil reaches a yellowish brown (10 YR) loamy coarse sand. At valley-floor margins this passes into a pale grey mottled coarse sand, with single grain structure.

AGRONOMIC DATA

Type sites. Agricultural Instructor's garden at Kamphaisi (Kasungu) and at C.D.C.'s Kamphuru estate.

Potential. A strongly ferallitic soil with a potential for flue cured tobacco and beef in the Rhodesian sandveld tradition.

Nutrient status of topsoil. The dark grey brown or dark brown topsoil is a coarse loamy sand, distinctly acid and with low levels of all nutrients, including organic matter.

Agricultural characteristics. These soils have a deep profile with massive structure, so permeability in the subsoil is inclined to be slow. The topsoil erodes easily, but the series usually occurs on nearly level sites, and for tobacco growing, open ridges draining into graded bunds are probably the best conservation measures to adopt. Unfertilized maize yields may range from 5–8 bags/acre on well farmed soil, while groundnuts may be expected to give 800 lb./acre seed. Flue cured tobacco may give about 800 lb./acre cured leaf if well managed.

Response to fertilizers. (Data from M. Banda '62.) What little data there is indicates that a 200 lb./acre dressing of sulphate of ammonia will double maize yields, while 200 lb./acre superphosphate may increase them by a further 50 per cent. Farmyard manure, unless very rich in nutrients, is likely to depress the yield in the year of application, and should always be supported by a good dressing of artificial fertilizer. Flue cured tobacco responds largely to nitrogen with small balancing dressings of phosphate and potash.

Suitable crops.
Maize (Askari or Mthenga).
Groundnuts (Chalimbana).
Turkish or flue-cured tobacco.
Grass.

KANDIANI SERIES

DESCRIPTION

Genetic group. Weakly ferallitic latosol.

Parent material. Basement Complex rocks.

Site. Convexities and gentle valley sides, 1°- 3°, 3,500-4,000 ft.

Vegetation. Modified *Combretum-Acacia-Piliostigma* cultivation savanna, with *Julbernardia paniculata, Afrormosia angolensis,* and *Acacia campylacantha* common.

Occurrence. Lilongwe Plain, the second member of the Lilongwe catena (*see* p. 41), and also in catena below the Nambuma, Nathenje, and Mkwinda series; natural areas 28a–e. The series was the second most frequently seen during the survey, 16 profiles being recorded.

Morphology. The topsoil is a dark brown sandy clay loam or sandy loam, and the subsoil dark brown or dark reddish brown. This gives place to a yellowish red colour in the lower subsoil, the change usually taking place at 12–18 in.; profiles in which the immediate subsoil is yellowish red also occur.

The heaviest horizon is a sandy clay, and the subsoil structure is normally weak, with only faint cutans. The texture may either remain sandy clay in depth, or may lighten to sandy clay loam. Except in the laterite phase, the profile is deep.

Downwards in the catena, this soil passes into the Mwanjema series. The change between a dark brown subsoil and a paler or redder lower subsoil takes place at a depth of above 18 in. in the Kandiani series, and below 18 in. in the Mwanjema series; the reddest horizon is in the 5 YR hue or slightly redder in the Kandiani series, but slightly less red than 5 YR, or in the 7·5 YR hue, in the Mwanjema series. Any profile in which a faint mottle is present in depth is classified with the Mwanjema series.

Lateritic phase. In half of the profiles observed, abundant iron concretions or massive laterite commenced at 36–56 in.

AGRONOMIC DATA

Type sites. Parts of Chitedze, notably fields B south and C south, Agricultural Instructors' gardens at Chafumbwa and Masinja (Dedza), Lumbe (Visanza), Makwani (Dowa), Padzamphandu and Mkumbiti (Lilongwe), and the F.M.B. Market gardens at Nambuma, Kasiya, Malangalanga, Mpingu and Chileka.

Potential. A weakly ferallitic soil with a high potential for arable crops.

Nutrient status of topsoil. The dark brown sandy clay loam or sandy loam topsoil is moderately acid with highly variable levels of nitrogen and phosphate, depending upon the intensity of past cultivation, and normally adequate levels of potash.

Agricultural characteristics. These soils may be deep or have a profile limited to 3 or 4 ft. by laterite. They have a fair structure, drain freely and are easily worked. If well cultivated with a rotation but no manure, yields of maize of the order of 10–12 bags/acre may be expected, while groundnuts should give 800 lb./acre shelled nuts and fire-cured tobacco 500–600 lb./acre of cured leaf.

Response to fertilizers. (Data from Chitedze, Chirikanda '56 and '57, Kasiya '57, Namwili '58, Curwen Bot '60.) Responses by maize to sulphate of ammonia are of the order of 2 bags, 1½ bags and 1 bag/acre for the first, second and third increments of 100 lb./acre of fertilizer applied. There is little point in going above 300 lb./acre sulphate of ammonia with the varieties at present used. Recorded responses to 200 lb./acre single superphosphate under village conditions have been of the order of 1 bag per acre, but there are indications from Chitedze that after a period of heavy cropping, particularly after a ley cut regularly for hay or silage, phosphate may become limiting at the higher levels of nitrogen application and increases of some 3 or 4 bags may be expected from a dressing of 200 lb./acre single superphosphate. Farmyard manure, unless very rich in nutrients or applied with a dressing of fertilizer nitrogen, may give disappointing results in the year of application. It is however a valuable insurance against long term loss of fertility. Tobacco reacts in the same manner as maize, and is best treated with 2 or 3 tons/acre of farmyard manure plus 200 lb./acre of sulphate of ammonia. Groundnuts show no response to fertilizer.

Suitable crops.
Maize (Askari or Mthenga).
Groundnuts (Mwitunde).
Bambarra groundnuts (Barotseland).
Soya beans (medium term).
Western tobacco.
Sweet potatoes.
Cassava.
Grass.

KANYAMA SERIES

DESCRIPTION

Genetic groups. Shallow ferruginous latosol.

Parent material. Basement Complex rocks.

Site. Moderately dissected country, on slopes of 0°–10°, tending to pass into lithosols on steeper slopes; 4,000–5,000 ft.

Vegetation. Low montane grassland; *Uapaca Kirkiana* very common.

Occurrence. Dedza Hills, common in the Tambala area, 32b, and of limited extent in the Dedza-Bembeke area, 32a, in association with the Dedza series; possibly also on small patches of gently sloping ground in the Dedza Scarp Zone, area 33a, in association with lithosols.

Morphology. The profile is shallow or of moderate depth, but with the subsoil structure and ped cutans sufficiently strong to place it in the ferruginous group. Weathered rock commences below 18–36 in. The topsoil is a sandy clay loam, and the lower subsoil a reddish brown or red clay or sandy clay. The subsoil structure is moderate or strong, often angular, fine-medium blocky, with clear ped cutans; there is frequently a colour difference between the cutans and the ped interiors, the latter being less red. Gravel may occur in the subsoil.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Kanyama and Magunditsa, and coffee plots at Semuka and Kumanyani (Dedza).

Potential. A shallow ferruginous soil of moderate to low potential for shallow rooting arable crops, but of very doubtful value for coffee.

Nutrient status of topsoil. A dark reddish brown sandy clay loam topsoil, distinctly acid with moderate to low nitrogen and usually adequate phosphate and potash.

Agricultural characteristics. This is a shallow, gravelly profile on rather steep slopes. What soil there is is of good structure and drains freely, and it is fairly easy to work by hand. It has a low cation exchange capacity and cannot be expected to show much resilience. Unless liberally manured and fertilized, it should remain under long leys with short 2 to 3 year spells of arable cultivation. Unfertilized maize yields recorded are of the order of 3–6 bags/acre while groundnuts and beans may produce 400–600 lb./acre seed.

Response to fertilizers. (Data from garden census '61, Tambala '60 and Kanyama '62.) 200 lb./acre of sulphate of ammonia is likely to more than double maize yields, increases of 6–8 bags having been recorded. There has been no recorded response to superphosphate by maize or groundnuts. Farmyard manure unless rich in nutrients should be applied with a top dressing of nitrogen.

Suitable crops.

Maize subsistence (Askari). (Beware stem borer.)
Beans.
Potatoes.
Groundnuts (possibly).
Grass.

KASHATA SERIES

DESCRIPTION

Genetic group. Depositional sands, little altered by pedogenesis; developing towards a ferallitic latosol derived from sandy parent materials.

Parent material. Lacustrine sands, dominantly coarse.

Site. Lacustrine constructional features, including sand bars and spits; 1,500–1,600 ft.

Vegetation. Bare sand, or specialized vegetation of sands.

Occurrence. Discontinuous belts of up to one mile in width along the Lake Nyasa shore, natural regions 21, 25, and 30.

Morphology. Coarse sand or loamy coarse sand in all horizons, with single grain structure; depositional bedding is frequently present. The only profile development to have occurred is the formation of a dark brown topsoil; the lower horizons retain the yellowish brown colour of the parent material. Profile drainage is excessive, whilst site drainage varies from free to impeded.

Catenary associates. In hollows between sub-parallel sand bars, sandy hydromorphic soils occur, with the water table permanently close to the ground surface.

Relationship of the Kashata, Mankhambira, and Senga series. In the Kashata series the heaviest horizon is loamy sand; in the Mankhambira series it is sandy loam, or possibly just within the sandy clay loam class, and the reddest horizon has hue 10 YR or 7.5 YR; in the Senga series the heaviest horizon is a sandy clay loam and the reddest has hue 5 YR. Profile development, other than the formation of a humic topsoil, is absent in the Kashata series, slight in the Mankhambira series, but definite in the Senga series.

The Kashata series normally occurs on lacustrine constructional features of very recent origin; the Mankhambira series is found where no sand deposition has taken place for a longer period, and is also developed on sandy alluvium of fluvial origin; the Senga series occurs principally on raised beaches, which have been subject to pedogenesis for at least a substantial part of Quarternary time.

AGRONOMIC DATA

Type sites. None. Sand bars and dunes generally. These are found mostly on the lakeshore, though they occur occasionally in the alluvial deposits of the lower South Rukuru. They are of no value for arable cropping and should be left to indigenous vegetation.

KASUNGU SERIES

DESCRIPTION

Genetic type. Strongly ferallitic latosol, with laterite.

Parent material. Basement Complex rocks, including: 1. Leucocratic quartzo-feldspathic granulite, with quartz, microline. and magnetite; 2. Feldspathized biotite-gneiss, with microline, microperthite, and garnet.

Site. Level crest areas on very gently undulating plains, the slope on which this series is found rarely exceeding $1\frac{1}{2}°$; 3,500–4,000 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Julbernardia paniculata* and *Brachystegia manga* common.

Occurrence. Extensive on the Kasungu Plain, in catena above the Chamama and Luziwa series, and in association with the Kamphuru series, natural areas 23a–d.

Morphology. A series in which abundant hard iron concretions or massive laterite commences at between 18 and 48 in. This horizon is of variable thickness, and passes into weathered rock; abundant deposition of iron, chiefly ferric, occurs within the rock, giving to it a multicoloured appearance of reds, yellows, and browns. The boundary between these two horizons is wavy, and commonly transitional.

The overlying soil is ferallitic, with a weak blocky to massive subsoil structure. The topsoil is a dark greyish brown sandy loam or loamy sand, and the subsoil typically yellowish red or reddish brown (5 YR hue, less commonly 7.5 YR). The heaviest horizon may be sandy clay or sandy clay loam; the coarse sand fraction exceeds the fine.

Similar soil but with laterite absent is classed as the Kamphuru series.

Tsemembwe phase. This phase is characterized by a sharp textural change within the subsoil. At a depth of between 12 and 24 in. (less commonly 6–12 in.) the texture changes either from loamy sand above to sandy clay loam below, or from sandy loam to sandy clay. The topsoil is usually loamy sand, occasionally sand.

AGRONOMIC DATA

Type sites. Parts of Lisasadzi Experiment Station, Kasungu Market plot, and Agricultural Instructors' gardens at Nkhakomseza, and Kalaluma (Kasungu).

Potential. A strongly ferallitic soil of low to moderate potential for arable crops if well manured and fertilized. Probably best used for grass production on an intensive ranching scale.

Nutrient status of topsoil. The dark greyish brown coarse sandy loam or loamy sand topsoil is only slightly acid. It is very low in nitrogen and organic matter, though phosphate and potash levels are usually adequate.

Agricultural characteristics. This is a moderate or shallow profile, limited by massive laterite. Because of the very flat topography in which the series is found site drainage is poor and water may stand in spite of the sandy nature of the soil. On these level sites, soil conservation methods should allow for safe removal of heavy rainfall—not easy in so light a soil. There is little reserve of nutrients in the soil and it cannot stand being cropped for more than 2 or 3 years without liberal doses of manure and fertilizer. It is probably best used for pastures for beef. Unfertilized yields of maize are of the order of 2–5 bags/acre, though groundnuts may produce 1,000 lb./acre or more of seed on the deeper soils.

Response to fertilizers. (Data from Kasungu Market plot '58–'60, Kasungu '59, Kalaluma '60 and N. Chimbongo '62.) Responses by maize to sulphate of ammonia are of the order of 3 bags/ 100 lb. fertilizer applied up to the limit of 200 lb./acre. No higher dressings have been tried, but it may well be worth while going higher, and yields of 15 bags/acre of maize may be obtained. There has been no recorded response to superphosphate. Farmyard manure is likely to depress maize yields in the year of application unless nitrogen is also applied. The manure probably has a long term value, but this has not yet been measured. Groundnuts may respond to both superphosphate and gypsum on this soil type.

Suitable crops.
Groundnuts (Chalimbana).
Maize (subsistence) (Askari).
Grass.

KOMBEDZA SERIES

DESCRIPTION

Genetic group. Ferallitic latosol, tending towards lithosol.

Parent material. Basement Complex rocks, mainly of acid and intermediate composition; including: 1. Leucocratic quartz-feldspar-biotite gneiss. 2. Hornblende-biotite gneiss. 3. Quartz-feldspar granulite, with magnetite.

Site. Gently to moderately undulating country at low altitudes, slopes of 0°–7°, altitude 1,700–2,100 ft.

Vegetation. Mixed woodlands on foothills of the Rift Valley scarp; *Bauhinia petersiana, Sclerocarya birrea, Adansonia digitata, Acacia spirocarpa* and *Combretum ghazalense* common; *Sterculia quinqueloba* may be present.

Occurrence. Frequent on dissected country lying west of the lake shore alluvial plains, in association with lithosol; including natural area 30g, in the Dedza scarp foothills, 33b, and in the Kota Kota scarp foothills, 24b.

Morphology. A shallow, gravelly soil, with weathered rock or abundant gravel commencing at 18–48 in. Gravel occurs in the lower subsoil, and usually also in the subsoil. The subsoil structure may be from weak to massive. The colour and texture are variable; the topsoil is sandy, typically a very dark brown sandy loam, and the subsoil is unusually a dark reddish brown sandy clay loam or sandy clay.

AGRONOMIC DATA

Type sites. F.M.B. house at Mankhamba (Ntakataka) and Agricultural Instructors' gardens at Katengeza and Kamuona (Salima).

Potential. A shallow ferallitic soil of moderate to low potential for arable cropping, better used to produce grass for beef.

Nutrient status of topsoil. This series is very variable covering thin non-alluvial soils of the foothills bordering the Salima/Dedza lake shore. The reaction may be neutral or mildly acid, nitrogen and phosphate status are moderate to low and potash is usually adequate.

Agricultural characteristics. This shallow gravelly soil is not much cultivated as yet, but it is being opened up as population pressure increases. Because of its shallow depth it will not stand cropping for more than 2 or 3 years unless heavily manured and fertilized. Well cultivated crops of maize without fertilizer may give 5-8 bags/acre. Groundnuts may be expected to yield 500–600 lb./acre seed and cotton, if sprayed, some 600–800 lb./acre seed cotton. It is probably best put under a long ley rotation once the tsetse fly has been eliminated. As the series frequently occurs in broken country, conservation measures are necessary.

Response to fertilizers. (Data from Katengeza '62.) 200 lb./acre of sulphate of ammonia may be expected to give a response of some 5 bags/acre of maize. Soil phosphate is likely to be very low, but there are no records of a response to superphosphate. Farmyard manure may however be effective without the added nitrogen usually required, though by far the best results are obtained with a mixture of manure and nitrogen. With such manuring 15 bags/acre of maize may be obtained. Groundnuts do not appear to respond to superphosphate. Cotton is expected to respond to nitrogen, but no records are available.

Suitable crops.
Maize subsistence (Mlonda or Mthenga).
Groundnuts (Early Runner or Mwitunde).
Cotton.
Grass.

KOTA KOTA SERIES

DESCRIPTION

Genetic group. Ferallitic latosol with impeded profile drainage.

Parent material. Basement Complex rocks, mainly of acid or intermediate composition; including: 1. Biotite-granite. 2. Quartz-feldspar-gneiss, with biotite. 3. Acid pegmatites. 4. Highly siliceous fault rocks. Possibly also sedimentary raised beach deposits.

Site. Mainly level areas, 0°–1°, probably of raised beach origin; also on slopes of 0°–5°; 1,600–1,800 ft.

Vegetation. Mixed woodlands of Rift Valley scarp foothills; *Terminalia sericea* very common, *Afrormosia angolensis, Piliostigma thonningii, Bauhinia petersiana, Brachystegia longifolia,* and *Combretum ghazalense* common.

Occurrence. Kota Kota Lake Shore Lowlands, extensive on the level areas, 25b, and common in association with lithosols on the lake shore ridge, 25a.

Morphology. The characteristic feature is the contrast between a sandy topsoil and a mottled, heavy textured lower subsoil. The topsoil is a dark brown or dark greyish brown loamy sand or sandy loam, whilst the heaviest horizon is a sandy clay. A mottle commences at between 6 and 24 in., and becomes prominent in the lower subsoil or in depth. There may either be a sharp textural boundary between the topsoil and the sandy clay horizon, or a sandy clay loam horizon of variable thickness may occur between. The sandy clay horizon has a moderate or strong medium blocky structure. Much iron deposition occurs in depth, in the forms of diffuse ferric iron, ferric iron mottles, and ferrous concretions. Site drainage is normally free, but profile drainage is impeded.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Musa, Kalimanjila and Chibothera (Kota Kota), and the upper slopes of the Departmental Plot at Kota Kota.

Potential. A ferallitic soil of moderate to low potential for arable cropping.

Nutrient status of topsoil. The dark brown or greyish brown loamy sand or sandy loam topsoil is moderately acid and is moderate to low in all nutrients and organic matter.

Agricultural characteristics. This is a rather shallow soil of impeded profile drainage. Root room in the rains is limited to about 2 ft. by a rising water table, and there is usually well cemented laterite at about 4 ft. Topsoil is sandy and easily worked and eroded and conservation measures must aim at getting excess water off the land with the minimum of damage. If well cultivated, unfertilized maize yields of about 5 bags/acre may be obtained. Cassava is more usually grown. In the wetter parts rice may be grown on this soil to yield up to 2,000 lb./acre of paddy.

Response to fertilizers. (Data from observations 1961.) The little data there is available indicates that yields of maize may be doubled by an application of 200 lb./acre of sulphate of ammonia, and that if 200 lb./acre of superphosphate is also added a further 2 or 3 bags may be obtained. Rice is also likely to respond markedly to applied nitrogen, provided that uncontrolled flood conditions do not destroy the crop.

Suitable crops.
Maize subsistence (Mlonda).
Cassava.
Rice.

LILONGWE SERIES

DESCRIPTION

Genetic type. Ferruginous latosol.

Parent material. Basement Complex rocks, mainly hornblende rich gneisses, of intermediate to basic composition; including: 1. Hornblende-biotite-gneiss. 2. Hornblende-gneiss, with garnet. 3. Amphibolite.

Site. Crest areas and convexities, 0°- 1°, of gently undulating plains; less commonly on upper valley sides, 1°–2°; 3,500–4,000 ft.

Vegetation. *Combretum-Acacia-Piliostigma* cultivation savanna; *Combretum guenzii, C. ghazalense, Piliostigma thonningii, Erythrina tomentosa, Strychnos spinosa,* and *Ficus capensis* common.

Occurrence. Lilongwe Plain, the upper member of the Lilongwe catena (*see* p. 41); natural areas 28a–e.

Morphology. A dark red clay or sandy clay, having characteristics typifying a ferruginous soil. The topsoil is dark reddish brown sandy clay loam, or occasionally sandy clay, the surface appearance of cultivated areas being distinctly reddish. The subsoil is dark reddish brown (2·5 YR hue), becoming dark red or red in the lower subsoil and in depth; bright red termite mounds exhibit this latter colour. There is a marked structural B horizon; the subsoil structure is moderate or strong medium blocky with moderate ped cutans; below *c.*36 in. the structure becomes weaker and there is a characteristic change to a soft, easily friable consistency. This is often, but not invariably, associated with a change to a lighter texture in depth. Weatherable minerals are common in the subsoil and abundant in depth, but the profile is deep, with no weathered rock patches present above 60 in.

Lateritic and shallow phase, the latter due to stone lines of quartz gravel, occasionally occur, but the majority of such profiles are more satisfactorily classified with the Nathenje series.

For the relationship of the Lilongwe, Nathenje and Mkwinda series, see the description of the Nathenje series.

AGRONOMIC DATA

Type sites. Parts of Chitedze, notably Blocks D North, D South and F. Agricultural Instructors' gardens at Njonja (Dedza), Madzonga, Kabudula, Matanda, Mbang'ombe, Chiponde, Katunga, Chilowa, Kumalindi, Kachawa and Matondolozi (Lilongwe).

Potential. A ferruginous soil of high potential for annual arable crops.

Nutrient status of topsoil. The dark reddish brown sandy clay loam topsoil is but slightly acid, and in its virgin state has moderate levels of nitrogen and adequate levels of phosphate and potash. However this series is intensively cropped and usually overcropped, and on the farms which have been cultivated for over seven years the soil phosphate status may become limiting as well as the nitrogen.

Agricultural characteristics. This is a deep, free draining profile with a fairly easily worked topsoil on gentle slopes. There are considerable reserves of weatherable minerals and the cation exchange capacity is good. Soil structure is fairly well maintained and the soil is resilient and well buffered. With regular small dressings of organic manure (or ley) and adequate application of inorganic fertilizer, it is possible to maintain this soil in a high state of productivity even under more or less continuous cultivation. Unfertilized maize of local varieties should give yields of 10–15 bags/acre, groundnuts 800–1,000 lb./acre seed and tobacco 600 lb./acre cured leaf.

Response to fertilizers. (Data from Chitedze, Mbang'ombe '59 and yield records from farmers' gardens Lilongwe '62.) On soils in good heart, the main requirement will be for nitrogen, though on over-cropped soils good responses may only be obtained if both N and P are added. On fields in good heart (giving yields of 15 bags/acre) only small dressings of 100 lb./acre sulphate of ammonia are likely to be economic, giving returns of 2–3 bags/acre grain. On overcropped fields, responses to 200 lb./acre sulphate of ammonia may rise to 10 bags/acre where it is combined with 200 lb./acre single superphosphate. Yields of 20–25 bags/acre grain should be obtained from well cultivated and fertilized fields of hybrid maize.

Groundnuts do not normally respond to fertilizer, but on the poorer phases of the series, responses to 100 lb./acre of single superphosphate may be economic. It is however better to fertilize maize and tobacco well and let the nuts use the residues.

Tobacco responds in the same manner as maize, but it is more important to have adequate phosphatic fertilizer, as quality suffers from an excess of applied nitrogen. Applications of 200 lb./acre sulphate of ammonia plus 100 lb./acre single superphosphate may give increases of the order of 200-300 lb./acre cured leaf. Use of farmyard manure is a good insurance policy, though unless it is well made, or applied with nitrogen, it may depress maize yields in the year of application.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde).
Soya beans (medium term types such as Pelican).
Western tobacco.
Sweet potatoes.
Most annual crops except bush beans and certain legumes which suffer severely from pest and disease.
Grass.
Perennial fruit trees under irrigation.

This soil is very similar indeed to the Nambuma series and may be treated as identical from the agricultural point of view.

LOUDON SERIES

DESCRIPTION

Genetic type. Weakly ferallitic latosol.

Parent material. Basement Complex rocks; including: 1. Feldspathized hornblende-gneiss, with microline, quartz, hornblende, and biotite. 2. Biotite-granite, with quartz, microline, and biotite.

Site. Level crest areas, mainly 0°–1°, 4,000–4,400 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Ochna schweinfurthiana* common.

Occurrence. Southern part of the Upper South Rukuru Valley, natural area 16d, frequently in catena above the Bulala series; possibly present in the Phazi area, 23e.

Morphology. The topsoil is a dark reddish brown sandy clay loam or sandy loam, below which there is a textural B horizon of sandy clay or clay, with a weak fine-medium blocky structure. The lower subsoil is red or dark red, with the structure remaining weak.

The colour increases in redness downwards but this change is gradual, the profile having a uniform appearance. All horizons have moderate or rapid permeability, and the profile is deep.

A laterite phase has been recorded at Mbawa Agricultural Research Station.

AGRONOMIC DATA

Type sites. Mbawa station, the garden of the Agricultural Instructor at Chimsolo and the upper slopes of the garden of the Agricultural Instructor at Kanyanje.

Potential. A soil of high arable potential given suitable management. Widely cultivated.

Nutrient status of topsoil. Reddish brown sandy clay loams to sandy loams in which acidity is normally no problem. Total nitrogen is low (·09 or less). Available phosphate is adequate in newly opened soil (50 p.p.m.), but reserves are limited and phosphate will become limiting after a number of years' cultivation. Potash levels are adequate for normal farming practice, though under continuous and intensive cultivation they will need to be bolstered up. Sulphur may be limiting for groundnuts on worn out soils.

Agricultural characteristics. The profile is deep and offers no hindrance to root growth. Drainage is free, though water may stand for some time after heavy storms. The soil is easy to work either by hand, ox or tractor. Owing to its friable nature it is liable to erode easily unless effective measures are taken to conserve the soil. Fortunately slopes are very gentle. Well cultivated local maize without fertilizer or manure should give 7–8 bags/acre on recently opened land and groundnuts 1,000–1,200 lb./acre. The nutrient reserves of the soil are soon dissipated however and without the use of fertilizer the land should be returned to a resting crop or ley after three or four years arable cultivation. Groundnuts have a markedly beneficial effect as a rotation crop. Improved varieties can also markedly increase yields, e.g. Hybrid maize.

This soil is very responsive to treatment, showing up in no uncertain terms both good and bad management.

Responses to fertilizers. (Data from Mbawa 1951–61.) Any practice that will return nitrogen and organic matter in that order will show great benefits. Sulphate of ammonia may be expected to give increases of 4 bags, 3 bags, 2 bags and 1 bag/acre maize for successive increments of 100 lb./acre sulphate of ammonia up to 400 lb./acre on open pollinated maize. The increases may be more on suitable hybrids. After four or five years' cultivation, if soil analysis shows low phosphate status, single superphosphate may be expected to give increases of 2½ bags, 2 bags, 1½ bags and 1 bag/acre for successive increments of 100 lb. superphosphate up to 400 lb./acre. Farmyard or khola manure, if rich in nitrogen will also give increases of about 7 bags of maize from a 5 ton dressing, 4 bags of maize from a 2½ ton dressing.

On worn out soils nitrogen is essential. Green manures give excellent increases in yield if a small dressing of nitrogen is applied to the following maize crop. Broken fallows also greatly benefit from added nitrogen. On worn soils sulphur may become limiting to the growth of both maize and groundnuts. This can be remedied by the application of gypsum, but the indisposition should not arise if sulphur containing sources of nitrogen and phosphorus are regularly used.

The residual effects of fertilizers have not been carefully studied, but evidence points to benefits lasting at least two seasons after that in which phosphate, sulphur or farmyard manure have been applied. Nitrogen as such shows little residual effect.

It has been shown that this soil can be continuously cultivated with maize for at least 6 years using annual application of 5 tons/acre farmyard manure, 200 lb./acre sulphate of ammonia and 125 lb./acre single supers. Maize yields currently stand at 20–25 bags/acre.

Suitable crops for the area.

- Maize (open pollinated, e.g. Namlenga and Askari or hybrid, e.g. Mthenga).
- Groundnuts (long term varieties, Mwitunde, Dixie Runner, Chalimbana).
- Turkish tobacco.
- Ground beans (Northern Rhodesian or Mbawa).
- Soya beans (medium term, e.g. Pelican).
- Grass leys (Napier, Rhodes, Makarikari, possibly with Stylosanthes).
- Finger millet.

LUZIWA SERIES

DESCRIPTION

Genetic group. Weakly ferruginous latosol.

Parent material. Basement Complex rocks.

Site. Crest areas and valley sides on gently undulating plains, 0°–2°, 3,500–4,200 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Afromorsia angolensis* common.

Occurrence. Kasungu Plain, in association with Kasungu and Chamama series; natural areas 23a–c, e; the majority of profiles observed were in north-west Kasungu District.

Morphology. A reddish brown or yellowish red soil with the reddest horizon in the 5 YR hue. The topsoil is a dark brown sandy loam, and the heaviest horizon sandy clay. The subsoil has a moderate medium blocky structure, with clear but not strong cutans.

This soil is less ferruginous than the Chamama series, in which the subsoil is red, with a strong blocky structure.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Luziwa, Chambalekani and Gwesere (Kasungu).

Potential. A weakly ferruginous soil with a moderate potential for arable cropping. The series occurs in areas where droughts may occur in mid season and reduce yields.

Nutrient status of topsoil. The dark brown sandy loam topsoil is moderately acid with all nutrients on the low side.

Agricultural characteristics. A relatively deep soil with an easily worked topsoil and free profile drainage. As it occurs in very level country, site drainage may be imperfect and conservation measures should take this into consideration. Because of the fine nature of the sand, the surface tends to cap badly when exposed to heavy rain.

There is no recorded information on this soil series as to yields and responses to fertilizer.

Suitable crops.
Maize (Askari or Mthenga).
Groundnuts (Chalimbana or Mwitunde).
Turkish tobacco.
Grass.

MANKHAMBIRA SERIES

DESCRIPTION

Genetic group. Ferallitic latosol developed from sandy parent materials.

Parent material. Lacustrine sands, dominantly coarse; also developed on sands of alluvial origin.

Site. Level depositional plains.

Vegetation. Specialized vegetation of sands, *Terminalia sericea* common.

Occurrence. Close to the Lake Nyasa shore, natural regions 21, 25, and 30.

Morphology. The texture is predominantly loamy sand or sandy loam, possibly with a topsoil of sand. The heaviest horizon is sandy loam, or less commonly a light sandy clay loam. There is at least a slight increase of clay with depth. The structure is single grain to weakly massive throughout. The colour is brown, dark brown, or greyish brown, with no horizon redder than 7·5 YR hue. Permeability is very rapid and profile drainage excessive; site drainage may be free but is frequently impeded, with a mottle appearing in the lower subsoil or in depth.

The soil defined in the bulletin on northern Nyasaland as the Florence Bay phase of the Mankhambira series has been re-defined as the Senga series, *q.v.*

For the relationship of the Kashata, Mankhambira, and Senga series, see the description of the Kashata series.

AGRONOMIC DATA

Type sites. N.A. Mankhambira's Court and at the garden of Master Farmer near Deep Bay.

Potential. A soil of moderate potential for arable crops.

Nutrient status of topsoil. Dark grey brown sandy loams or loamy sands which are decidely acid (pH 5·0–6·0). Total nitrogen is borderline (·09 or less), available phosphate very high (150 p.p.m.) and potash borderline (·15 m.e.). Base exchange capacity of the soil is fairly good for so light a soil, but the saturation percentage is very low (20).

Agronomic characteristics. The profile is moderately deep and the profile drainage is excessive, accounting for the very leached character of the soil, which is nevertheless easily worked. Unfertilized yields of maize recorded are of the order of 9 bags/acre. Cassava is widely grown yielding about 6 tons/acre at 12 months and 12 tons/acre at 24 months, and groundnuts may do well. Unless heavily manured and fertilized this soil should not be cultivated for more than two or three years at a stretch.

Response to fertilizers. (Banga '57.) In the one experiment recorded sulphate of ammonia gave increases of 4 bags/acre maize for each 100 lb./acre fertilizer applied up to the limit of 200 lb./acre. It would appear that this soil is very responsive to nitrogen and possibly also to farmyard manure. There was no response to phosphate.

Crops suited to the area.
Maize.
Groundnuts.
Cassava.

MAONDE SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol with impeded site drainage.

Parent material. Sandy colluvium derived from, and overlying, Basement Complex rocks.

Site. Concavities, lower valley sides, and valley heads, on gently undulating plains, ½°–2°, 3,500–4,000 ft.

Vegetation. The series occupies a transitional belt between *Combretum-Acacia-Piliostigma* cultivation savanna and marsh grassland; *Acacia campylacantha* is very common.

Occurrence. Lilongwe Plain, the fourth number of the Lilongwe catena (*see* p. 41), and also in catena below the Nambuma, Nathenje, and Mkwinda series; natural areas 28a–f.

Morphology. A sandy soil, with coarse sand dominant, and impeded site drainage. A mottle commences at between 12 and 40 in.; the degree of prominence of mottling varies, from faint and in depth only, to clear in the subsoil. The topsoil is a very dark brown or very dark greyish brown loamy sand or sandy loam; the subsoil is dark brown and the heaviest horizon sandy clay loam or sandy loam. The structure is massive in all horizons. Permeability is very rapid, but site drainage is impeded.

Lateritic phase. This is more frequent than profiles without iron concretions; massive laterite normally commences below 24–48 in.

Very sandy phase. In this phase, which is common at valley heads, the topsoil is a sand or loamy sand, and the heaviest horizon loamy sand.

AGRONOMIC DATA

Type sites. At Chitedze, the north west corner of field A North and Agricultural Instructors' gardens at Kalulu (Dedza), Chingambe (Dowa) and Mpingu and Chileka (Lilongwe).

Potential. A strongly ferallitic soil with a moderate to low potential for arable cropping, best left to grass unless it can be really well fertilized and manured.

Nutrient status of topsoil. The very dark brown or greyish brown loamy sand or sandy loam topsoil is moderately acid, and is low in all nutrients and organic matter. Potash however usually suffices for the size of crop grown.

Agricultural characteristics. A moderate profile found on dambo edges with impeded site drainage. Root room may be limited to 2–3 ft. The topsoil is easily worked and eroded, and as it is, from its position in the catena, likely to receive considerable wash from higher up the slope, it must be well conserved if used for cultivation. Steps must also be taken to get rid of surplus water. Unfertilized yields of maize of the order of 5–10 bags may be expected, 800–1,000 lb./acre of groundnut seed and 300–400 lb./acre of cured tobacco.

Response to fertilizers. (Data from Chitedze.) Responses by maize have been recorded to nitrogen, phosphate and farmyard manure, but not to potash. A 200 lb./acre dressing of sulphate of ammonia is likely to give increases of the order of 4–5 bags/acre, and a 200 lb./acre dressing of single superphosphate may give increases of 2–3 bags/acre where the soil has been cultivated for some years and the soil phosphate analysis is low. Farmyard manure at 2–3 tons/acre is also likely to give increases of 2–3 bags/acre maize, unless it is very long and leached. Tobacco responds in a similar sort of way. Groundnuts are best not fertilized, but left to use residues of fertilizer applied to previous crops. There are likely to be marked residual effects from applied fertilizer and manure, especially combined ND or NP.

Suitable crops.
Maize (Askari).
Groundnuts (Mwitunde).
Western tobacco (if well fertilized).
Cassava.
Grass.

MBABZI SERIES

DESCRIPTION

Genetic group. Hydromorphic soil.

Parent material. Alluvial clays derived from, and overlying, Basement Complex rocks.

Site. Broad, gently concave, valley floors, 0°–1°, 3,500–4,000 ft.

Vegetation. Marsh grassland.

Occurrence. Lilongwe Plain, the lowest member of the Lilongwe catena (*see* p. 41), and also in catena below the Nambuma, Nathenje, and Mkwinda series; natural areas 28a–f.

Morphology. A black plastic clay, with poor site and profile drainage. All horizons are black, with a variable amount of olive brown or strong brown mottling. The topsoil may be clay, sandy clay, or clay loam; all other horizons are clays. These have a very strong coarse angular blocky structure, with a slight prismatic tendency; a typical ped size is 3 in. × 4 in. × 8 in. high. In some cases the main peds break down into subsidiary peds of 1–3 in. dimensions. The ped surfaces carry very strong, shiny ped cutans, sometimes exhibiting slickenside marks caused by differential expansion and contraction of adjacent peds. The colour may be blacker than Munsell colour N2/, and is at times slightly bluish black. Grass roots in the topsoil are stained reddish brown.

The clay minerals are predominantly montmorillonitic, resulting in a clay that is plastic and sticky when wet, very hard when dry, and with very slow permeability. A few scattered iron concretions are normally present.

AGRONOMIC DATA

Type sites. The floors of most dambos of the North Lilongwe area.

Potential. Good potential as dry season grazing once a system of management has been worked out. Can be used for dimba crops of maize, beans, pumpkins and sugar cane. Rather too heavy for good tobacco seed beds.

Nutrient status of topsoil. The black clay or sandy clay topsoil is neutral or possibly acid, and has a high organic matter content, moderate to high nitrogen and potash status and moderate to low phosphate status.

Agricultural characteristics. This soil is very sticky and heavy when wet and cracks into hard blocks when dry. During the rains it should not be cultivated or heavily trampled as it is largely waterlogged. If opened as the moisture recedes in the dry season, it can give good crops of dimba maize and vegetables, but it is a difficult soil to work and is best left under grass.

There are no records of yield potentials or responses to fertilizers.

Suitable crops.
Grass for dry season grazing.

MKWINDA SERIES

DESCRIPTION

Genetic group. Weakly ferallitic latosol.

Parent material. Basement Complex rocks.

Site. Level crests and upper valley sides on gently undulating plains, 0°–2°, 3,500–4,100 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Afrormosia angolensis, Julbernardia paniculata, Parinari mobola*, and *Acacia campylacantha* common.

Occurrence. Nsaru and Kampini-Sinyala areas of the Lilongwe Plain (28e, f), in the latter case in catena above the Sinyala series, also on the Upper Bua Plain, 27a, b.

Morphology. A red, weakly structured soil, with a profile of uniform appearance. The topsoil is a dark brown or dark reddish brown sandy clay loam; the subsoil may be sandy clay loam or sandy clay, and the heaviest horizon is normally sandy clay. The subsoil is dark reddish brown or dark red, and the colour in depth dark red or red (2·5 YR hue). The subsoil has a weak fine to medium blocky structure, with cutans just distinguishable; in depth the structure is frequently massive.

The Mkwinda series has similar characteristics to the Tembwe series except that the former is predominantly red and the latter yellowish red. For the relationship of the Lilongwe, Nathenje, and Mkwinda series, see the description of the Nathenje series.

AGRONOMIC DATA

Type sites. The deeper soils north east of Mkwinda Market, Agricultural Instructors' gardens at Kudzala and Kadzangazika (Lilongwe).

Potential. A weakly ferallitic soil of moderate to good potential for arable crops if well manured.

Nutrient status of topsoil. The dark brown or reddish brown sandy clay loam topsoil is moderately acid with soil nitrogen levels that are moderate to low and normally adequate phosphate and potash.

Agricultural characteristics. The profile is deep and free draining, though shallower lateritic phases are frequent.

There is little recorded information on soils identified as this series and it should for the time being be treated like the Kandiani series from an agricultural point of view.

MNGWANGWA SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol.

Parent material. Basement Complex rocks, probably of acid and intermediate composition; including a hornblende-perthite-gneiss.

Site. Crest areas and valley sides on gently undulating plains, 0°–2°, 3,700–4,800 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Brachystegia longifolia* and *Julbernardia paniculata* common.

Occurrence. Mainly recorded near Mngwangwa, in the southern part of North Lilongwe Plain, 28b, also observed in the Mphunzi area, 32c, and probably present in the Nsaru area, 28e.

Morphology. A profile characterized by a sharp textural change at approximately 18 in. depth. The topsoil is a very dark brown loamy sand or sandy loam; the subsoil has a similar texture and massive structure. The two horizons are completely ferallitic, with ped cutans and weatherable minerals absent. Coarse sand usually exceeds fine. Below *c.*18 in. this changes to a sandy clay loam lower subsoil, yellowish red in colour; the structure in this horizon is normally weak blocky, but may vary from massive to moderate blocky. The profile may be of moderate depth or deep.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens just north and south of Mngwangwa Market (Lilongwe) and at Mfutso (Dedza).

Potential. A strongly ferallitic group with a moderate to low potential for arable cropping.

Nutrient status of topsoil. The very dark brown loamy sand or sandy loam topsoil is moderately acid and is moderate to low in all nutrient, and organic matter. Nitrogen is the main limiting factor.

Agricultural characteristics. A moderate to deep profile with an easily worked and free draining topsoil. Site drainage is usually fairly good and conservation measures are necessary.

There are no records of yields or responses to fertilizer on this soil series, and for the moment these soils should be treated like those of the Sinyala series from an agricultural point of view.

MWANJEMA SERIES

DESCRIPTION

Genetic group. Ferallitic latosol with imperfect site drainage.

Parent material. Basement Complex rocks.

Site. Lower valley sides on gently undulating plains, $1°–1\frac{1}{2}°$, 3,500–4,000 ft.

Vegetation. *Combretum - Acacia - Piliostigma* cultivation savanna; *Acacia campylacantha, Piliostigma thonningii*, and *Terminalia sericea* common.

Occurrence. Lilongwe Plain, the third member of the Lilongwe catena (*see* p. 41), and also in catena below the Nambuma, Nathenje, and Mkwinda series; natural areas 28a, e.

Morphology. The topsoil is a very dark brown sandy clay loam. Below this is a dark brown (7·5 YR hue) subsoil; the dark brown colour continues to a depth of at least 20 in., before giving place to yellowish red or reddish brown. The heaviest horizon is a clay or sandy clay, normally with a weak fine to medium blocky structure. Site drainage is imperfect.

For the relationship of the Mwanjema and Kandiani series see the description of the latter.

Lateritic phase. This was more frequently recorded than profiles without iron concretions. The laterite horizon is frequently deep, commencing at 42–54 in.

Mottled phase. This has a slightly poorer site drainage than the normal phase, and occurs in catena below it. In it a mottle commences in the lower subsoil or in depth.

AGRONOMIC DATA

Type sites. Parts of Chitedze, notably A North and the northern edges of B North and C North. Agricultural Instructors' gardens at Chintuta and Mwanza (Lilongwe), Kasalika and the lower parts of Mponela Market plot (Dowa) and Lobe and Nyombe (Dedza).

Potential. A ferallitic soil of moderate potential for arable cropping.

Nutrient status of topsoil. The very dark brown sandy clay loam topsoil is moderately acid to acid, and has a moderate nitrogen and phosphate status and adequate potash for present needs.

Agricultural characteristics. This is a moderately deep profile limited usually by laterite at about 4 ft. depth. The topsoil has a reasonable structure and is easily worked and free draining except where site drainage is imperfect. Maize well cultivated but without fertilizer should yield 10 bags/acre and groundnuts 800 lb./acre of shelled seed.

Responses to fertilizers. (Data from Chitedze only.) Records are scanty for this series, and those that are available indicate that it reacts in very much the same way as the Kandiani series, except that responses may be limited by waterlogging. Reference should be made to the Kandiani series.

Suitable crops.
Maize.
Groundnuts.
Tobacco.
Grass.

MWERA HILL SERIES

DESCRIPTION

Genetic group. Ferruginous latosol, high altitude type.

Parent material. Basement Complex rocks, mainly of intermediate and basic composition, frequently micaceous; including: 1. Graphitic mica-schist, with muscovite and biotite; 2, Muscovite-schist; 3. Quartz-feldspar-biotite-gneiss, with garnet; 4. Biotite-pyroxene-gneiss; 5. Garnetiferous amphibolite, with pyrite.

Site. Moderately undulating country with broad valleys, broad convexities on interfluve crests, and moderate to highish relief; 0°–15° slopes, 4,600–5,300 ft.

Vegetation. Montane grassland and low montane grassland; *Cussonia kirkii* very common, *Erythrina tomentosa* common.

Occurrence. Extensive in the Mwera Hill area of the Dowa Hills, 29b; possibly also of limited extent in the Dowa area, 29a, and the North Visanza area, 24c.

Morphology. A ferruginous soil in which dull colours predominate (Munsell chroma /2 and /3), with reddish browns rather than reds present. The topsoil is a dark brown or dark reddish brown sandy clay loam, and the heaviest horizon is normally clay. The subsoil is reddish brown, dusky red, or with the unusual colour of weak red (2·5 YR 4/2), and the lower subsoil has a similar colour; in depth the colour may remain reddish brown or may change to red. There is a moderate or strong, often angular, fine blocky structure in the subsoil; ped cutans are clearly seen, and in some profiles exceptionally strongly developed cutans have been observed. Many weatherable minerals remain in the lower subsoil. The depth is usually moderate, weathered rock commencing at 36–48 in., but deep profiles are also common.

Although kaolinitic clay minerals predominate, the montmorillonitic group is also present in substantial quantities, resulting in a sticky clay.

AGRONOMIC DATA

Type sites. Mwera Hill station, Dzeleka Prison Farm and Agricultural Instructors' gardens at Mbiya, Chilopola and Mpanila (Kota Kota).

Potential. A high altitude ferruginous soil with moderate to good potential for arable crops adapted to the rather cool climate, for grass, for fruit trees and on the deeper phases for coffee.

Nutrient status of topsoil. The dark brown or dark reddish brown sandy clay loam topsoil is acid with moderate nitrogen status and adequate potash, but the level of soil phosphate is often low.

Agricultural characteristics. A moderate profile, limited by weathered rock, with fairly free drainage. The topsoil has fair natural structure, but when wet becomes very sticky and difficult to work. The sites are usually steep and full soil conservation measures are essential. Well cultivated but unfertilized maize should yield about 10 bags/acre if stem borer is controlled. Groundnuts may give 600–800 lb./acre seed. Potatoes give 2–3 tons/acre and wheat and beans about 600 lb./acre seed.

Responses to fertilizers. (Data from Mwera Hill and Dzeleka Prison Farm '61 and '62.) Response to sulphate of ammonia varies with the degree of stem borer damage, but in a good year should be of the order of 3–4 bags/acre maize for 200 lb./acre fertilizer. No response to single superphosphate has yet been recorded in spite of the frequent low soil analyses. Farmyard manure in this area gives good returns in the year of application, often increasing the yield by 50 per cent. even when no artificial nitrogen is added.

Suitable crops.
Maize (Askari) (beware stem borer).
Beans.
Groundnuts (borderline).
Potatoes.
Fruit.
Coffee (if carefully mulched and tended).
Grass.

NAMBUMA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol.

Parent material. Basement Complex rocks, mainly of intermediate and basic composition.

Site. Crest areas and valley sides on gently undulating plains, 0°–2°, 3,600–4,400 ft.

Vegetation. *Combretum-Acacia-Piliostigma* cultivation savanna; *Acacia campylacantha, Combretum guenzii, C. ghazalense, Strychnos spinosa, Erythrina tomentosa,* and *Kigelia pinnata* common.

Occurrence. North Lilongwe Plain, natural area 28b, in catena above the lower members of the Lilongwe catena (*see* p. 41).

Morphology. The topsoil is a dark reddish brown sandy clay loam or sandy clay, the surface appearance of cultivated fields being distinctly reddish. The subsoil is dark reddish brown or dark red, and the colour in depth dark red. Dark shades (Munsell value 3/ or 2/) occur throughout the profile. The subsoil and lower subsoil are normally clays, with a moderate fine to medium blocky structure and moderate or weak ped cutans. In depth the structure becomes weaker and the consistency softer. The profile is normally deep. This soil has many similarities with the Lilongwe series, the main morphological difference being the predominance of dark colours.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Mphako and Mabwera (Lilongwe), Mponela, Mphonde, Kanchere, Chimundi, Mititi and Kabanga (Dowa).

Potential. A ferruginous soil of high potential for annual arable crops.

Nutrient status of topsoil. The dark reddish brown sandy clay loam topsoil is slightly or moderately acid and has moderate levels of nitrogen and adequate potash though phosphate may be low.

Agricultural characteristics. A normally deep, free draining profile with an easily worked topsoil which maintains its structure reasonably well. There are abundant reserves of weatherable minerals and the cation exchange capacity is high. It is a resilient, well buffered soil very similar to the Lilongwe series and from an agricultural standpoint may be treated as the same.

Reference should be made to the Lilongwe series for further details.

NATHENJE SERIES

DESCRIPTION

Genetic group. Weakly ferruginous latosol.

Parent material. Basement Complex rocks, including a hornblende-biotite granulite, with garnet.

Site. Crest areas and upper valley sides on gently undulating plains, 0°–1½°, 3,400–4,300 ft.

Vegetation. *Combretum-Acacia-Piliostigma* cultivation savanna; *Afrormosia angolensis, Pterocarpus angolensis*, and *Parinari mobola* common.

Occurrence. Lilongwe Plain, Nathenje and Nsaru areas, 28d, e, in catena above the lower members of the Lilongwe catena (*see* p. 41); also in other areas of the Lilongwe Plain.

Morphology. The topsoil is dark reddish brown or dark brown sandy clay loam, and the heaviest horizon is sandy clay. The colour in depth is red or dark red, in the 2.5 YR hue. The subsoil is dark reddish brown, with moderate fine to medium blocky structure and weak cutans. The profile is frequently of moderate depth, with weathered rock or a quartz gravel stone line commencing at 24–48 in.

Relationship of the Lilongwe, Nathenje and Mkwinda series. These three series all have a red or dark red colour in the lower subsoil and in depth. The subsoil structure is moderate or strong blocky, with moderate cutans, in the Lilongwe series; moderate blocky, with weak cutans, in the Nathenje series; and weak blocky, with weak or very weak cutans, in the Mkwinda series. The heaviest horizon is usually clay in the Lilongwe series, although sandy clay is permitted; it is sandy clay in the two other series. The structural B horizon is a marked feature of the Lilongwe series, the structure becoming weaker and the consistency much softer in depth than in the subsoil; this feature is weakly developed in the Nathenje series, and absent in the Mkwinda series. The Lilongwe series is normally deep, whilst the Nathenje series is frequently of moderate depth.

AGRONOMIC DATA

Type sites. F.M.B. plot at Kampini and Nathenje markets and Agricultural Instructors' gardens at Fiveways, Kumbila, Mtema, Nyenje and Malumbwe (Lilongwe).

Potential. A weakly ferruginous soil of moderate to high potential for arable cropping, the value varying with the depth of soil and steepness of topography.

Nutrient status of topsoil. The dark reddish brown or dark brown sandy clay loam topsoil is moderately acid with moderate levels of nitrogen and normally adequate levels of phosphate and potash.

Agricultural characteristics. This is a moderate to shallow profile, often gravelly but with free drainage. The topsoil has good structure and is fairly easily worked, but is often found in an exhausted condition. Slopes are often steep and full soil conservation measures are necessary in most cases. Well cultivated maize, unfertilized, may be expected to give yields of about 10 bags /acre and groundnuts about 800 lb./acre. Because of the shallow nature of many profiles the soil is likely to become exhausted fairly quickly if it is not properly farmed.

Response to fertilizers. (Data from Fiveways '58 and Nyenje '59.) Information is sparse, but responses to 200 lb./acre sulphate of ammonia may range from 2–5 bags/acre maize depending upon the depth of profile and the degree of overcultivation of the soil. With local maize varieties there appears to be an upper limit of about 15 bags/acre. Responses to phosphate are uncertain but it is as well to apply a 100 lb./ acre dressing of single superphosphate with the nitrogen on soils known to have been in cultivation a long time.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde).
Western tobacco.

NKATA BAY SERIES

DESCRIPTION

Genetic type. Ferrisol.

Parent material. Basement Complex rocks.

Site. Dissected country of gentle and moderate slopes, 0°–15°, 1,700–2,200 ft.

Vegetation. Moist *Brachystegia* woodland.

Occurrence. Nkata Bay Lake Shore Lowlands, natural areas 21b, f.

Morphology. A red soil characterized by the occurrence of 1–10 per cent. quartz gravel or stones in the lower horizons. The topsoil is a dark reddish brown sandy clay loam and the subsoil and lower subsoil are red or dark red sandy clay or clay. There is relatively little textural differentiation within the profile. Stone lines, consisting of 25–90 per cent. quartz stones, mainly 1–2 in. in diameter, frequently occur at depths of 18–30 in. The clay minerals are almost entirely kaolinitic, resulting in a soft, easily friable clay, a weak blocky structure breaking down into weak fine crumb, and moderate or rapid permeability. The profile is of moderate depth.

AGRONOMIC DATA

Type sites. Near Timbiri track in steeply undulating country.

Potential. A soil of moderate to low potential where slopes are gentle enough to make soil conservation measures reliable. Scattered cultivation.

Nutrient status of topsoil. Dark red brown sandy clay loam of moderate acidity. Total nitrogen is moderate to adequate (·10 and above). Available phosphate is inclined to be low (10 p.p.m. or less). Potash status is perfectly adequate. Base exchange capacity is fair as is base saturation percentage.

Agronomic characteristics. The depth of profile is very variable ranging from 2 to 4 ft. in depth. Root room is further restricted by the presence of stone lines of quartz stones some 4 in. thick. Commonly found between lithosols on the ridges and the dambo soils of the river valleys with patches of Chinyakula or Chombe series on their lower margins. Unfertilized maize yields are only about 5 bags/acre and fertilizer does not increase yield much. These soils are best left to afforestation or grass, being too shallow for coffee and arable crops.

Response to fertilizers. (Data from Luwazi '55.) No significant response to either nitrogen or phosphate.

Crops suited to the area.
Maize (subsistence).
Cassava (subsistence).
Grass.
Afforestation.

PEMBA SERIES

DESCRIPTION

Genetic group. Hydromorphic soil, tending towards alluvial calcimorphic soil.

Parent material. Alluvium.

Site. Level alluvial plains at altitudes only slightly above Lake Nyasa. 1,550–1,700 ft.

Vegetation. Lake shore savanna and thicket, in places transitional with marsh grassland; *Terminalia sericea, Combretum ghazalense, Hyphaene ventricosa,* and *Lonchocarpus capassa* common.

Occurrence. Salima lake shore plain, in association with Salima series; natural areas 30a and 30b, principally the latter.

Morphology. An alluvial soil with site drainage impeded to poor, but less poor than in areas of marsh grassland. The topsoil is from very dark brown to black, varying in texture from sandy clay loam to clay. All other horizons are either black or mottled, with very dark grey or greyish brown as the matrix colour. Clays predominate in the lower horizons, but depositional bedding is present, and all other textures may occur. In the sand fraction, fine sand is usually dominant over coarse. The clay horizons have a strong coarse angular blocky structure.

With better site drainage and sandier texture this soil passes into the Salima series.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Ngolome, Kachiwambo (Zidyana), and Kombedza road (Salima).

Potential. A hydromorphic soil with a moderate potential for annual crops if it can be drained.

Nutrient status of topsoil. The very dark brown to black sandy clay loam or clay topsoil is neutral and has moderate supplies of soil nitrogen and adequate phosphate and potash.

Agricultural characteristics. The profile is deep but root room is limited by a high water table in the wet season. Site drainage is poor and profile dainage slow. The topsoil is sticky cracking clay, not easy to cultivate. Yields are limited by water and weeds rather than soil nutrients and the series is avoided by cultivators if possible.

There are no records of yields or responses to fertilizer on this soil series.

Suitable crops.
Maize (subsistence on better drained sites) (Mlonda).
Cotton (on better drained sites).
Rice (on wet sites).
Grass.

SALIMA SERIES

DESCRIPTION

Genetic group. Alluvial calcimorphic soil.

Parent material. Alluvium.

Site. Level alluvial plains, 1,550–1,800 ft.

Vegetation. *Acacia-Adansonia-Hyphaene-Sterculia* cultivation savanna of the lake shore. The series probably occurs also under lake shore savanna and thicket.

Occurrence. Salima Lake Shore Plain, in association with the Pemba series; principally natural area 30c, also present in areas 30a, b and d.

Morphology. A greyish brown alluvial soil, with depositional bedding present and imperfect site drainage. The topsoil and subsoil are very dark brown to very dark greyish brown; a mottle commences in the lower subsoil or in depth, and in some cases is faintly visible in the subsoil. The majority of horizons are sandy clay loams and sandy loams, but due to depositional bedding, horizons of all textures, including gravel, may occur. Fine sand is usually but not invariably, dominant over coarse. Structure varies with texture, from massive in sandy horizons, to moderate medium or coarse blocky in heavier horizons, and strong blocky in clays.

With poorer site drainage and heavier texture this soil passes into the Pemba series, *q.v.*

It is probable that a more sandy soil with massive structure and lower fertility occurs in natural areas 30a and 30d, but no observations of this have been made during the present survey. It should be defined as a separate series, comparable with the Lughali series of northern Nyasaland (the Salima series being comparable with the Karonga series).

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Pemba and Mtonga Markets, W. Khombe and Chipoka (Salima), Ntakataka, Golomoti station and Kabulika (Dedza).

Potential. An alluvial calcimorphic soil of good potential for arable crops if well drained and weeded.

Nutrient status of topsoil. The dark brown or greyish brown topsoil varies from sandy clay loam to sandy loam and is slightly acid. Soil nitrogen status is moderate to low, but phosphate and potash are normally adequate.

Agricultural characteristics. This is a deep profile but root room is often limited to about 3 ft. by a high wet season water table. Profile drainage is usually free, but site drainage is impeded. The soil is fairly easy to work when just moist but gets hard when dry. Conservation measures should aim at getting excess water away quickly with the minimum of erosion. Owing to the hot, damp climate that prevails during the growing season, weed competition vies with waterlogging and nitrogen shortage in limiting yields. Unfertilized yields vary greatly from year to year, but maize may be expected to give 4–10 bags/acre, groundnuts 600–1,200 lb./acre shelled nuts and cotton, if sprayed, 800–1,600 lb./acre seed cotton.

Response to fertilizers. (Data from Pemba '59, '60 and '62, Mtonga '58 and '62, Ntakataka '58 and '59 and Golomoti '60.) Responses by maize to sulphate of ammonia should be of the order of 2½ and 2 bags respectively for the first and second increments of 100 lb./acre of fertilizer applied. No more than 200 lb./acre of sulphate of ammonia has been tried and it may be worth applying up to 300 lb./acre if the application is split. However with local varieties there is likely to be an upper limit on yield of about 15 bags/acre. There has been no recorded response to superphosphate from either maize or groundnuts. Cotton may respond to nitrogenous fertilizer, but no records are yet available. Farmyard manure is not likely to improve yields on these alluvial soils. Prompt weeding is essential.

Suitable crops.
Maize (Mlonda or Mthenga).
Groundnuts (Early Runner).
Cotton.
Cassava.
Castor.

SENGA SERIES

DESCRIPTION

Genetic group. Ferallitic soil developed from sandy parent materials.

Parent material. Lacustrine sands, and sandy raised beach deposits, probably of Quarternary age.

Site. Level raised beach remnants, 1,600-1,900 ft.

Vegetation. Modified *Brachystegia* plateau woodland; *Brachystegia longifolia, Afrormosia angolensis,* and *Combretum ghazalense* common.

Occurrence. Raised beaches of the Kota Kota Lake Shore Ridge and the Senga Bay area, 25b and 30e.

Morphology. A coarse sandy soil, developed from lacustrine sands, but with definite textural differentiation within the profile. The topsoil is a brown to very dark brown coarse sandy loam or loamy coarse sand; the texture is slightly heavier in the subsoil, becoming a yellowish red sandy clay loam in the lower subsoil. The coarse sand fraction exceeds the fine. The structure is normally massive in all horizons, although a very weak blocky structure may be present in the lower subsoil.

For the relationship of the Kashata, Mankhambira and Senga series, see the description of the Kashata series.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Nkhongo (Kota Kota) and soils behind the Lake Hotels at Salima.

Potential. A sandy ferallitic soil of low potential for arable crops. It should be left to grass.

Nutrient status of topsoil. The dark brown, coarse sandy loam or loamy sand topsoil is acid and low in nitrogen and organic matter. Phosphate and potash status are probably adequate for the level of yields that is normally attainable.

Agricultural characteristics. A deep, free draining massive profile with a loose, easily eroded topsoil. If opened for cultivation it will very rapidly become exhausted unless liberally supplied with manure and fertilizer. Unfertilized maize yields may be of the order of 5 bags/acre and a 200 lb./acre dressing of sulphate of ammonia may be expected to double this yield.

There is very little data recorded for this soil series.

Suitable crops.

Maize (subsistence only) (Mlonda).
Cassava.
Grass.

SINYALA SERIES

DESCRIPTION

Genetic group. Strongly ferallitic latosol.

Parent material. Basement Complex rocks.

Site. Crests, and both upper and lower valley sides of gently undulating plains, 0°–2°, 3,400–4,200 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Julbernardia paniculata* and *Uapaca kirkiana* very common.

Occurrence. A widespread series, occurring extensively on the western parts of the Kasungu Plain, natural area 23c; the Mkanda area of the Upper Bua Plain, 27b; the Sinyala-Kampini area of the Lilongwe Plain, 28f, where it is in places in catena below the Mkwinda series; and of lesser extent in the Tembwe area of the Upper Bua Plain, 27a, and in the Fort Manning pediment area, 26a.

Morphology. A yellowish red, sandy, structureless soil. The topsoil is normally dark brown or very dark greyish brown, varying in texture between loamy sand and sandy clay loam. The lower horizons are predominantly yellowish red, or less commonly dark reddish brown, in the 5 YR hue. The subsoil structure is massive, with ped cutans and weatherable minerals absent.

This soil differs from the Tembwe series in being more strongly ferallitic, with no blocky structure discernible in the subsoil.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Chitedze (Sinyala), Msenga and Malembo (Chisepo) in Lilongwe District, Madisi Market plot (Dowa), Chesa pool (Kasungu) and Tembwe (Fort Manning).

Potential. A strongly ferallitic soil of moderate to poor potential for arable crops.

Nutrient status of topsoil. The dark brown or greyish brown sandy loam or sandy clay loam topsoil is often acid with low nitrogen and organic matter status but adequate phosphate and potash.

Agricultural characteristics. A moderate to deep profile, sometimes limited by laterite at about 4 ft. with free drainage and on easily worked topsoil which is also easily eroded. There is little reserve of weatherable minerals and the soil soon becomes exhausted by cropping. Unless heavy dressings of manure and fertilizer can be applied, the soil should not be cropped for more than three years without rest. Without fertilizer, maize yields of 5–8 bags/acre may be obtained, but they will rapidly fall below this figure unless the land is rested. Groundnuts should give about 800 lb./acre shelled nuts.

Response to fertilizers. (Data from Tembwe '59, '61 and '62.) Large responses to nitrogen may be expected from maize, of the order of 4 bags and 3 bags/acre for the first two increments of 100 lb./acre sulphate of ammonia. No larger dressings have been tried. Small increases have been recorded resulting from an application of 200 lb./acre single superphosphate—of the order of 2 bags/acre of maize and 350 lb./acre of shelled groundnuts. Farmyard manure is likely to give disappointing results in the year of application unless nitrogen is applied.

Suitable crops.

Maize (Askari).
Groundnuts (Mwitunde or Chalimbana).
Bambarra groundnuts.
Cassava.
Turkish tobacco.

TANGA SERIES

DESCRIPTION

Genetic group. Ferruginous latosol, low altitude type.

Parent material. Basement Complex rocks, including: 1. Feldspathic hornblende-gneiss; 2, Quartzo-feldspathic gneiss.

Site. Gently undulating areas and moderately dissected country, 0°–7°, 1,900–2,500 ft.

Vegetation. Mixed woodlands of Rift Valley Scarp foothills; *Pterocarpus angolensis, Afrormosia angolensis, Acacia campylacantha, Sterculia africana, Sclerocarya birrea, Adansonia digitata,* and *Albizzia versicolor* common.

Occurrence. The principal series on the lower parts of the dissected zone separating the Dowa Hills from the Salima Lake Shore Plain; natural areas 29c and 30f. Above 2,500–3,000 ft. it gives place to the Dowa series, with which it has many similarities.

Morphology. The topsoil is a dark reddish brown sandy clay loam, or less commonly sandy loam; the heaviest horizon is a sandy clay. The subsoil is also dark reddish brown, in the 5 YR hue, in the lower subsoil and in depth the colour is in the 2·5 YR hue, either dark reddish brown or dark red. The subsoil structure is moderate or strongly medium blocky, with moderate or strong ped cutans.

AGRONOMIC DATA

Type sites. Agricultural Instructors' gardens at Mwanyumbu, Mwamsambo and Nthanga (Kota Kota) and at Makyoni and Mwamsangu (Salima)—also Mua Mission (Dedza).

Potential. A ferruginous soil of moderate to high potential for arable cropping.

Nutrient status of topsoil. The dark reddish brown sandy clay loam topsoil is only slightly acid with moderate levels of nitrogen, adequate potash and distinctly low phosphate levels.

Agricultural characteristics. A deep profile, free draining and with an easily worked topsoil of good structure. Because of the undulating nature of the topography soil conservation measures are necessary except on the flattest ridge crests. Reserves of soil nutrients are plentiful and the soil is fairly resilient. Unfertilized yields of maize of the order of 10–15 bags/acre may be expected, while groundnuts should give 1,000 lb./acre seed, tobacco 600 lb./acre cured leaf and cotton 1,500 lb./acre if sprayed.

Response to fertilizers. (Data from Mwanyumbu '62, Mwamsangu '60 and Mua '62.) Sulphate of ammonia may give disappointing results unless phosphate is also added. 200 lb./acre of single superphosphate should increase maize yields by some 4 bags/acre and if 100 lb./acre sulphate of ammonia is also applied an extra 2 or 3 bags may be obtained. Farmyard manure at the rate of 3–5 tons/acre should give the same results as the dressing of artificials mentioned above.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde or Early Runner).
Western tobacco.
Cotton.

TEMBWE SERIES

DESCRIPTION

Genetic group. Weakly ferallitic latosol.

Parent material. Basement Complex rocks.

Site. Crest areas, convexities, and valley sides on gently undulating plains, 0°–2½°, 3,600–4,100 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland; *Uapaca kirkiana, Parinari mobola,* and *Ochna schweinfurthiana* common.

Occurrence. The principal series in the Tembwe area of the Upper Bua Plain, 27a, and also common in the Mkanda area, 27b, and in the Fort Manning pediment area (26a); the sandier patches amid the Lilongwe Plain frequently possess this soil, particularly in natural areas 28d–f. This series was the most frequently seen during the survey, 17 profiles being recorded.

Morphology. The topsoil is a dark brown sandy loam or sandy clay loam. A yellowish red colour (5 YR hue) commences in either the subsoil or lower subsoil. The heaviest horizon is sandy clay loam or sandy clay. The subsoil structure is weak, with ped cutans very weakly developed or absent. The profile is frequently of moderate depth.

The Tembwe series has similar characteristics to the Mkwinda series except that the former is predominantly yellowish red and the latter red. It differs from the Sinyala series in being less strongly ferallitic, with a weak subsoil structure.

AGRONOMIC DATA

Type sites. The F.M.B. Market plot at Nsaru, and the Agricultural Instructors' gardens at Nsaru, Tsabango and Chikanda (Lilongwe), Madise, Nauchi and Mbangala (Dowa) and Matutu, Thako, Zulu and Walilanji (Fort Manning). Also Kochira Leprosarium.

Potential. A weakly ferallitic soil of moderate to good potential for arable cropping if it is well farmed.

Nutrient status of topsoil. The dark brown sandy loam or sandy clay loam topsoil tends to be acid, low in nitrogen, organic matter and phosphate, and moderate in potash. It is the best arable soil in its region and as such tends to be overcropped.

Agricultural characteristics. A profile of moderate depth usually limited by laterite at 4 or 5 ft. It drains fairly freely down the profile, but as the series can occur on very flat sites, care should be taken in planning conservation works that excess water is not allowed to stand for too long in the furrows. The soil is fairly easy to work, but may 'pan' if exposed to heavy rain. Unfertilized maize yields vary widely with the degree of overcropping but are normally of the order of 5–8 bags/acre. Groundnuts may be expected to give yields of 400–600 lb./acre seed and tobacco 400 lb./acre cured leaf. Fields of this soil series are frequently heavily infested with *Striga*.

Response to fertilizers. (Data from Kochira '58–'61, Walilanji '58–'61, Thako '61 and Nsaru '56–'59.) On this soil phosphate may limit the response to nitrogen and a mixture should be used unless farmyard manure is regularly applied. Sulphate of ammonia may give increases in maize yields of about 2 bags/100 lb. of fertilizer applied, at least up to the rate of 200 lb./acre. A 200 lb./acre dressing of single superphosphate will give an increase of some 2 bags/acre maize and 400–600 lb./acre of shelled groundnuts. Farmyard manure should be boosted by a small dressing of nitrogen.

Suitable crops.
Maize (Askari or Mthenga).
Groundnuts (Mwitunde or Chalimbana).
Western tobacco.
Sweet potatoes.
Grass.

VIPYA SERIES

DESCRIPTION

Genetic group. Humic ferallitic latosol.

Parent material. Basement Complex rocks.

Site. Moderately undulating high altitude plateau, 0°–15°, 5,000–6,000 ft.

Vegetation. Montane grassland; *Protea madiensis* and *Erythrina tomentosa* common.

Occurrence. High Vipya Plateau, natural area 19b.

Morphology. The topsoil is a sandy loam with a high humus content and abundant grass roots, resulting in a strong crumb structure. The subsoil is dark reddish brown. The clay percentage increases gradually downwards in the profile, the lower subsoil being a reddish brown or dark red sandy clay, with a moderate medium blocky structure. Fine sand predominates over coarse in all horizons.

Shallow phase. This phase is extensive, weathered rock commencing at between 18 and 36 in.

AGRONOMIC DATA

Type sites. Champoyo and Luwawa.

Potential. Soils of moderate potential for a specialized type of agriculture, but excellent for re-afforestation.

Nutrient status of topsoil. Black or dark red-brown sandy clay loam of moderate acidity (pH 5·5 to 6·0). Total nitrogen level is moderate to high (·175 or over), available phosphate is low (20 p.p.m. or less) and potash is high. Nutrient reserves appear to be fair and organic matter is high.

Agricultural characteristics. The profile is deep and fairly well drained. The topsoil, abounding in grass roots has a good crumb structure and is fairly easily worked. Maize is out of its element and is not expected to yield more than 6 bags/acre unfertilized. Potatoes have given yields of 3 to 5 tons/acre and temperate cereals have given yields ranging as follows:

Wheat, 600–800 lb./acre.
Rye, 200–600 lb./acre.
Oats, 1,000–1,400 lb./acre.
Barley, 800–1,000 lb./acre.

Sheep have thrived on planted pastures.

Responses to fertilizers. (Data from North Vipya and South Vipya '51–'53 and Luwafwa '55.) On these soils farmyard manure, and phosphate have increased yields. Farmyard manure has given increases of 1 to 2 tons/acre of potatoes. 200 lb./acre sulphate of ammonia has increased yields of barley and oats by 1 bag/acre and maize by 2 bags/acre but this does not always occur. 200 lb./acre superphosphate will almost certainly increase yields of barley, oats, wheat, maize and rye, by 1 bag/acre. Lime had if anything a deleterious effect in the year of application. There were no residual responses.

Crops suitable to the area.

Potatoes.
Maize (subsistence).
Barley and oats (feeding).
Grass.

VISANZA SERIES

DESCRIPTION

Genetic group. Weakly ferruginous soil.

Parent material. Basement Complex rocks; including a quartzo-feldspathic granulite.

Site. Gently to moderately undulating country, including pockets of better soil amid areas of lithosols; 0°–5°, 3,500–4,500 ft.

Vegetation. *Brachystegia-Julbernardia* plateau woodland.

Occurrence. Frequent in the North Visanza area, 24c; possibly also present in the dissected country along the eastern margin of the Kasungu Plain, 23a.

Morphology. The topsoil is a dark brown sandy loam, or less commonly sandy clay loam; the heaviest horizon is a sandy clay. The colour in the lower subsoil and in depth varies from reddish brown to dark red, in the 2·5 YR hue or slightly less red. The subsoil has a moderate or strong blocky structure, with clearly developed ped cutans. The profile is usually of moderate depth.

AGRONOMIC DATA

Type sites. The F.M.B. market plot at Visanza (Shallow) and Agricultural Instructors' gardens at Mzungu, Kazonga and Kamsonga (Visanza).

Potential. A weakly ferruginous soil of moderate potential for arable crops. Potential tends to be limited by depth and slope.

Nutrient status of topsoil. The dark brown sandy loam or sandy clay loam topsoil is moderately acid with moderate to low levels of nitrogen and phosphate and adequate potash.

Agricultural characteristics. The moderately deep profile is limited by weathered rock and is usually free draining. The topsoil is easily worked and of fair structure. Full soil conservation measures are necessary due to the rather steep slopes. The soil is only moderately resilient and should not be expected to bear more than three or four years' cultivation unless adequate dressings of manure and fertilizer are applied. Unfertilized yields of maize may be of the order of 8–10 bags/acre with groundnuts at about 800 lb./acre and tobacco at about 400 lb./acre, if these crops are well cultivated.

Response to fertilizers. (Data from M. Ndeule '62, C. Sambakunsi '62 and Visanza plot '62.) A dressing of 200 lb./acre sulphate of ammonia may be expected to increase maize yields by some 5–6 bags/acre and 200 lb./acre single superphosphate may add another 1 or 2 bags. Well made farmyard manure, rich in nutrients, may also give good increases in the year of application, but if there is any doubt as to the quality, a small dressing of nitrogen should also be applied.

Groundnuts give little response to single superphosphate.

Suitable crops.

Maize (Askari or Mthenga).
Groundnuts (Mwitunde).
Western tobacco.
Grass.

Table I.— RAINFALL CONFIDENCE LIMITS FOR 9 OUT OF 10 YEARS

Mean annual rainfall (in.)	*Lower confidence limit (in.)*	*Upper confidence limit (in.)*
64 – 72	47	89
56 – 64	40	80
48 – 56	34	70
40 – 48	27	61
32 – 40	21	52
24 – 32	14	42

Source: Jack, D. T., *et al.*, 1960. "Report on an economic survey of Nyasaland 1958–59", map No. 2.

TABLE II.— VEGETATIONAL COMMUNITIES

	Community	Dominant and characteristic species
I. Grassland	1. Montane grassland	*Protea madiensis, Protea* species, *Cussonia kirkii, Erythrina tomentosa.* Grasses: *Themeda triandra, Loudetia simplex, Exotheca abyssinica, Monocymbium cerisiiforme, Andropogon schirensis.*
	2. Low montane grassland . . .	*Brachystegia floribunda, Uapaca kirkiana, Cussonia kirkii, Parinari mobola.* Grasses: *Hyparrhenia cymbaria, H. nyassae, Themeda triandra.*
	3. Marsh grassland	Grasses: *Hyparrhenia* species, *Pennisetum purpureum, Echinochloa pyramidalis, Setaria sphacelata.* Reed: *Phragmites mauritianus.*
II. Forest	4. Montane evergreen forest . .	*Aphloia myrtiflora, Maesa lanceolata.*
III. Woodland and savanna woodland.	5. *Combretum-Acacia-Piliostigma* woodland, entirely reduced to cultivation savanna.	*Combretum guenzii, C. ghazalense, Acacia campylacantha, Piliostigma thonningii, Erythrina tomentosa, Afrormosia angolensis, Pterocarpus angolensis, Parinari mobola, Strychnos spinosa, Kigelia pinnata.* Grasses: *Hyparrhenia* species, *Andropogon amplectens, Setaria sphacelata, Panicum maximum.*
	6. Moist *Brachystegia* woodland .	*Brachystegia spiciformis, B. longifolia, Parinari mobola, Uapaca kirkiana.*
	7. *Brachystegia-Julbernardia* plateau woodland and savanna woodland.	*Brachystegia boehmii, B. floribunda, B. longifolia, B. manga, B. spiciformis, B. utilis, Julbernardia paniculata, J. globiflora, Diplorrhyncus condylocarpon, Dichrostachys glomerata, Pseudolachnostylis maprouneifolia, Flacourtia indica, Diospyros kirkii, Ochna schweinfurthiana, Monotes africanus, Xeromphis obovata, Eriosema affine.* Grasses: *Hyparrhenia* species, *Andropogon schirensis, Themeda triandra var. hispida.*
	8. Mixed woodlands on foothills of the Rift Valley scarp.	*Acacia campylacantha, Pterocarpus angolensis, Terminalia sericea, Sclerocarya birrea, Bauhinia petersiana, Adansonia digitata, Albizzia versicolor, Brachystegia* species, *Oxytenanthera abyssinica* (bamboo).
	9. *Brachystegia* hill woodland and savanna woodland.	*Brachystegia boehmii, Uapaca kirkiana,* with other species as for *Brachystegia* plateau woodland.
IV. Savanna and thicket . . .	10. *Acacia-Adansonia-Hyphaene-Sterculia* cultivation savanna of the lake shore.	*Acacia albida, A. campylacantha, Adansonia digitata, Hyphaene ventricosa* (palm), *Sterculia africana.*
	11. Lake shore savanna and thicket .	*Acacia campylacantha, A. spirocarpa, Combretum ghazalense, Sclerocarya birrea, Terminalia sericea, Lonchocarpus capassa, Adansonia digitata, Hyphaene ventricosa* (palm), *Sterculia africana, Albizzia versicolor.*
V. Specialized vegetation . . .	12. Vegetation of sands	*Terminalia sericea, Hyphaene ventricosa* (palm). Reed: *Phragmites mauritianus.*

TABLE III.— GENETIC CLASSIFICATION OF SOILS

	Group	Sub-group	Series
I. Latosols	1. Ferruginous soils . . .	(*a*) High altitude ferruginous soils . .	Dedza, Mwera Hill.
		(*b*) Medium altitude ferruginuos soils .	Chamama, Dowa, Lilongwe, Nambuma.
		(*c*) Low altitude ferruginous soils . . .	Chitala, Tanga.
		(*d*) Shallow ferruginous soils	Chimutu, Kanyama.
		(*e*) Weakly ferruginous soils	Luziwa, Nathenje, Visanza.
	2. Ferrisols	—	Nkata Bay.
	3. Ferallitic soils	(*a*) Weakly ferallitic soils	Fort Manning, Jenda, Kandiani, Loudon, Mkwinda, Tembwe.
		(*b*) Strongly ferallitic soils	Bembeke, Bulala, Kafukule, Kamenya, Kamphuru, Kombedza, Mngwangwa, Sinyala.
		(*c*) Strongly ferallitic soils with laterite .	Jalira, Kasungu, Kota Kota.
		(*d*) Humic ferallitic soils	Vipya.
		(*e*) Ferallitic soils developed from sandy parent materials.	Kashata, Mankhambira, Senga.
		(*f*) Ferallitic soils with impeded site drainage.	Maonde, Mwanjema.
II. Calcimorphic soils .	4. Alluvial calcimorphic soils	—	Salima.
III. Hydromorphic soils .	5. Hydromorphic soils . .	—	Mbabzi, Pemba.
IV. Lithosols	6. Lithosols	—	—

TABLE IV.— CORRESPONDENCE BETWEEN MAJOR RELIEF UNITS, CLIMATIC REGIONS AND NATURAL REGIONS

Major relief unit	Climatic region	Natural region
High Plateaux	I. Cold, wettish	19. Vipya Plateau.
High Altitude Hill Zones . . .	IA. Cool, wettish	22. Chimaliro Hills. 29. Dowa Hills. 31. Dzalanyama Range. 32. Dedza Hills.
	III. Warm, dryish	17. Central Mzimba Hills. 26. Fort Manning Hills.
Mid-Tertiary Surface	III. Warm, dryish	16. Upper South Rukuru Valley. 23. Kasungu Plain. 27. Upper Bua Plain. 28. Lilongwe Plain.
Rift Valley Scarp Zone	V. Warm-hot, wettish . . .	20. East Vipya Scarp Zone. 24. Kota Kota Scarp Zone. 33. Dedza Scarp Zone.
Lake Shore Plain	VI. Hot, wet	21. Nkata Bay Lake Shore Lowlands.
	VII. Hot, wettish	25. Kota Kota Lake Shore Lowlands.
	VIII. Hot, dryish	30. Salima Lake Shore Plain.

Exceptions. The two major exceptions relate to the Dowa and Dedza Hills. In the Dowa Hills, areas 29c and d are in the Rift Valley Scarp Zone and in climatic region V; in the Dedza Hills, those parts of 32b, c, and e which lie below 4,700 ft. are in climatic region III.

Minor exceptions are as follows:

Region 20, extreme north: Climatic region II.

Region 22, parts above 5,500 ft.: Climatic region I.

Region 26, parts above 4,800 ft.: Climatic region 1a.

Region 29, parts below 4,700 ft.: Climatic region III.

Region 32, summit plateaux of Dedza and Chongoni Mountains: Climatic region I.

TABLE V.— AGRICULTURAL POTENTIAL

Agricultural Potential		Natural Areas Included
A. Intensive farming; soil of moderate or high fertility.	Ai. Intensive mixed farming on latosols; maize, tobacco, groundnuts, with cattle.	16d, 16g, 23e, 26a, 28a, 28b, 28c, 28d, 28e, 29a, 32b.
	Aii. Intensive mixed farming on lowland soils, largely of calcimorphic and hydromorphic types; cotton, maize, groundnuts, rice, with cattle.	29c, 30a, 30b, 30d, 30f.
	Aiii. Intensive food farming on rich alluvial soils; largely maize	21e, 25c, 30c.
B. Extensive farming; soil of low inherent fertility; groundnuts, maize, tobacco (including Turkish and flue cured), with emphasis on livestock.		16f, 23a, 23b, 23c, 24c, 25b, 27a, 27b, 28f, 28g.
C. Perennial Crops, with summer and winter annual crops on more level areas; moderate to high rainfall.	Ci. Moderate to high altitude; coffee and tung marginal, due to exposure and thin soils; fruit, potatoes, winter cereals, and vegetables, with subsistence maize.	20b, 22b, 29b, 32a.
	Cii. Low altitude; perennial high rainfall crops, with rice and subsistence cassava and maize.	21b, 21f.
D. Livestock ranching; soils very poor or stony, but with pockets of cultivatable soil suitable for subsistence food crops. Shifting cultivation.		17d, 23d, 24b, 29d, 30g, 32c.
E. Afforestation		19b, 29e, 32d.
G. Marsh; dry season grazing, with potential for rice in some areas		Marshes, 25d.
H. Natural forest; very broken country or thin, stony soils; unsuitable for agriculture, but suitable as forest reserves or nature reserves.		17e, 20a, 20b, 22a, 24a, 24d, 25a, 26b, 30e, 31a, 32e, 33a, 33b; Hills, Scarps, Gorges, Lacustrine Sands.

TABLE VI.— MORPHOLOGICAL CHARACTERISTICS OF SOIL SERIES

Characteristics X: Normal values O: Permitted values			Bembeke	Bulala	Chamama	Chimutu	Chitala	Dedza	Dowa	Fort Manning	Jalira	Jenda	Kafukule	Kamenya	Kampuru	Kandiani	Kashata	Kanyama	Kasungu	Kombedza	Kota Kota	Lilongwe	Loudon	Luziwa	Mankhambira	Maonde	Mbabzi	Mkwinda	Mngwangwa	Mwanjema	Mrewa Hill	Nambuma	Nathenje	Nkata Bay	Pemba	Salima	Senga	Sinyala	Tanga	Tembwe	Vipya	Visanza
COLOUR	1. Mottled horizon present																				X					X	X		O						X	X						
	2. Munsell hue of reddest horizon:	10 YR		O							O			O			X				X				X		X			O					X	X						
		7·5 YR		X							X		O	X			X		O	O	O				X	X			O	X						X						
		5 YR	X			X					X		X	X	X	X		X	X	X	O			X					X	X	X						X	X		X		X
		2·5 YR	O		X	O	X	X	X	X								X				X	X					X			X	O	X	X					X		X	X
		10 R			X				X			X										X	O									X										
TEXTURE	1. Topsoil:	Loamy sand		X							X		X	X	X		O[1]		X	O	X				X[2]	X			X							O	X	O				
		Sandy loam	O	X	X	X	X				X		X	X	O	X			X	X	X		X	X		X		X	O							X	X	X	O	X		X
		Sandy clay loam	X		X	O	X	X	X	X		X				X		X		O		X	X					X		X	X	X	X	O	X	X		X	X	X	X	O
		Sandy clay					X	O	X													O					X[3]					X		X	X[3]	O						
	2. Heaviest horizon:	Sandy loam		O							O		X	X			[2]								X	X																
		Sandy clay loam	O	X		X					X		X	X	X				X	X	O				O			O	X							X	X	X		X		
		Sandy clay	X		O	X	X	O	O	X	X	X			O	X		X	X	X	X	O	X	X				X	O	X	O		X	X		X			X	X	X	X
		Clay			X		O	X	X	X		X						X				X	O				X			X	X	X		X	X	O						
	3. Depositional bedding present																O								O		O								X	X						
	4. Gravel present above 36 in.					X								O				O		X														X								
DEPTH	1. Laterite present above 60 in.										X								X		O					O																
	2. Weathered rock present above 60 in.					X		X						X				X	X	X	X													X							O	X
STRUCTURE	Strongest grade, blocky, above 36 in.	Massive		X							X		X	X	X		[4]		X	X					[4]	X			O								X	X				
		Very weak	X								O	O			X	O			X	X								O	O	O				O			O	X				
		Weak				O				X		X			O	X			O	X			X					X	X	X				X		X		O		X	X	O
		Moderate				X	X	O		X		O				O		X	O		X	X		X				O	O	O	X	X	X			X			X		O	X
		Strong			X		X	X	X												X	X					X				X				X	X			X			X
PED CUTANS	Strongest grade above 36 in.:	Absent	X	X							X		X	X	X		X		X	X					X	X			O								X	X		X		
		Very weak	X								O	O			X	X			X	X								X	X	O				O				O		X	O	
		Weak								X		X			O	X			O	X			X					X	X	X	O	X	X	X		X					X	O
		Moderate			X		X	X	X	X		O						X	O		X	X		X					O	O	X	X	O		X	X			X		O	X
		Strong			X		X		X									X			X						X				X				X	X			X			X

[1]Normally sand; [2]Loamy sand or sand; [3]Sandy clay or clay; [4]Single grain.

Table VII.— ANALYTICAL CHARACTERISTICS OF SOIL SERIES

Characteristics			Bembeke	Bulala	Chamama	Chimutu	Chitala	Dedza	Dowa	Fort Manning	Jalira	Jenda	Kafukule	Kamenya	Kampuru	Kandiani	Kashata	Kanyama	Kasungu	Kombedza	Kota Kota	Lilongwe
Reaction	pH, all horizons:	7·0 – 6·0					X	X												X		
		6·0 – 5·5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		5·5 – 5·0	X	X				X	X	X			X	X	X	X		X	X	X	X	X
		5·0 – 4·5																				
Organic Matter	Topsoil:	0·5 – 2%	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
		2 – 5%	X		X	X	X		X			X				X		X				X
		5 – 10%																				
Base Saturation	Lower horizons:	10 – 40%						X														
		40 – 60%	X					X		X	X	X	X	X	X	X	X	X	X			
		60 – 80%		X	X	X	X		X			X	X	X	X	X	X		X	X	X	X
		80 – 100%					X															
Exchange Capacity	Lower horizons, cation exchange capacity per 100g. of clay:*	5 – 15 m.e. %	X	X						X		X	X		X			X				
		15 – 40 m.e. %				X	X	X	X		X	X		X	X	X	X		X	X	X	X
		40 – 80 m.e. %															X					

Characteristics			Loudon	Luziwa	Mankhambira	Maonde	Mbabzi	Mkwinda	Mngwangwa	Mwanjema	Mwera Hill	Nambuma	Nathenje	Nkata Bay	Pemba	Salima	Senga	Sinyala	Tanga	Tembwe	Vipya	Visanza
Reaction	pH, all horizons:	7·0 – 6·0					[1]								X	X			X			X
		6·0 – 5·5	X	X		X			X	X	X	X	X				X	X	X			X
		5·5 – 5·0	X	X	X	X		X	X			X	X	X			X	X		X	X	
		5·0 – 4·5			X								X	X			X			X	X	
Organic Matter	Topsoil:	0·5 – 2%	X	X	X	X		X	X								X	X	X	X		X
		2 – 5%			X		X	X		X	X	X	X	X	X	X			X	X	X	X
		5 – 10%					X				X										X	
Base Saturation	Lower horizons:	10 – 40%			X								X				X			X	X	
		40 – 60%		X	X	X		X	X	X	X		X	X			X	X		X	X	
		60 – 80%	X	X		X				X	X	X	X						X			X
		80 – 100%					X								X	X			X			X
Exchange Capacity	Lower horizons, cation exchange capacity per 100g. of clay:*	5 – 15 m.e. %	X	X				X			X		X	X			X	X		X	X	
		15 – 40 m.e. %		X	X	X		X	X	X	X	X	X				X	X	X	X		X
		40 – 80 m.e. %					X								X	X			X			

[1] 6·5 – 8·0

*This parameter indicates the nature of the clay minerals present. The exchange capacity of the principal clay minerals, in m.e. % per 100g. of clay, are (Grim[4])

Kaolinite	3 – 15
Illite	10 – 40
Montmorillonite	80 – 150

Organic matter = 1·724 x organic carbon, organic carbon determined by the Walkley-Black method, uncorrected.

TABLE VIII.— NUTRIENT STATUS OF SOIL SERIES

Nutrient (Topsoil values)			Bembeke	Bulala	Chamama	Chimutu	Chitala	Dedza	Dowa	Fort Manning	Jalira	Jenda	Kafukule	Kamenya	Kampuru	Kandiani	Kashata	Kanyama	Kasungu	Kombedza	Kota Kota	Lilongwe
NITROGEN	Low:	0·04 – 0·1 %	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	
	Medium:	0·1 – 0·2 %	X				X	X	X			X				X						X
	High:	0·2 – 0·4 %																				
AVAILABLE PHOSPHORUS	Low:	0 – 20 p.p.m.		X	X	X	X		X	X		X	X	X	X	X					X	X
	Medium:	20 – 50 p.p.m.		X				X			X	X		X	X	X	X	X	X		X	
	High:	50 – 100 p.p.m.	X					X			X					X			X	X	X	
EXCHANGEABLE POTASSIUM	Low:	0·03 – 0·2 m.e. %		X				X			X		X	X	X		X		X		X	
	Medium:	0·2 – 0·4 m.e. %	X					X	X	X	X	X						X	X	X	X	
	High:	0·4 – 0·8 m.e. %			X	X	X		X							X		X		X	X	X

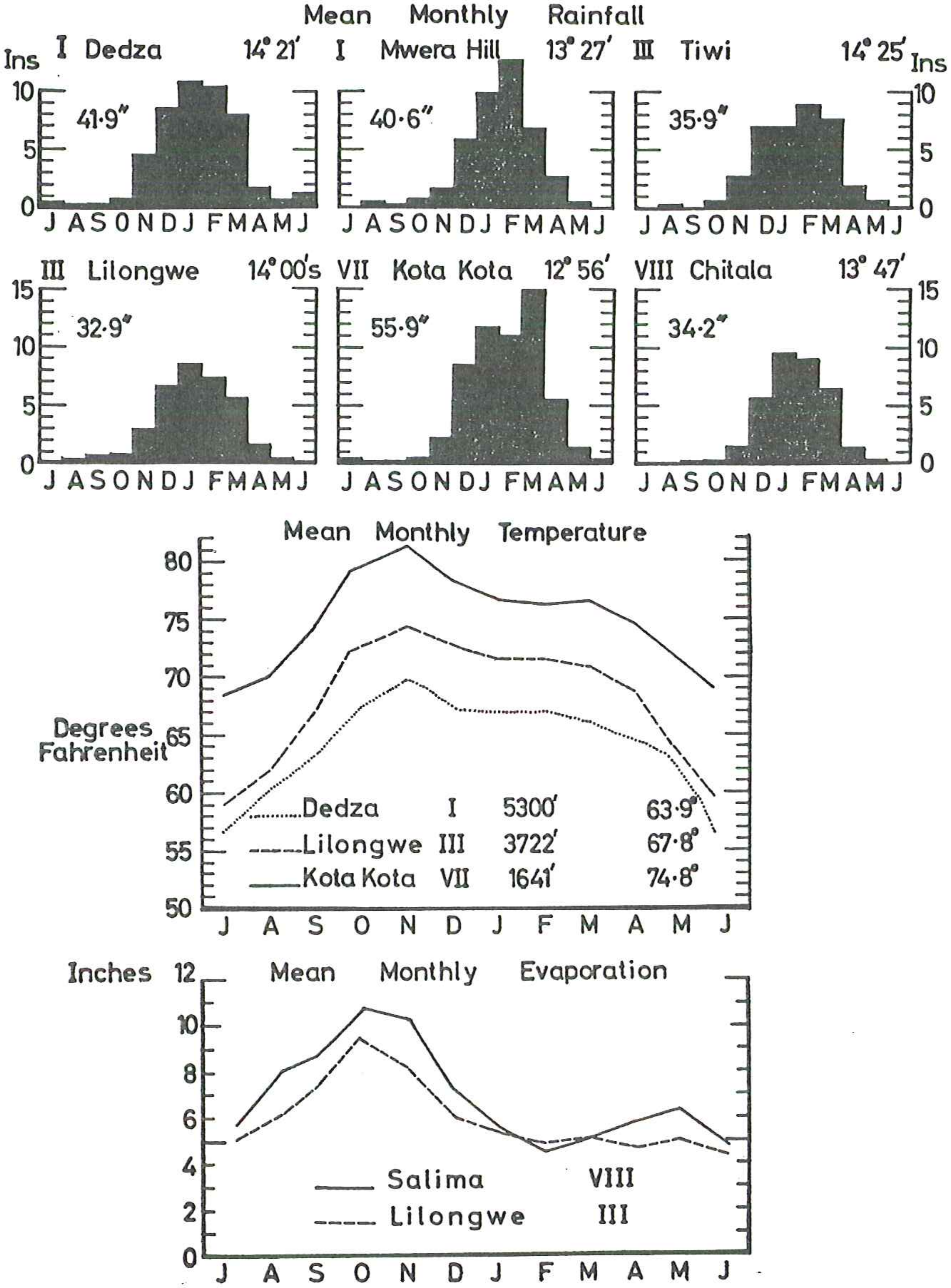
Nutrient (Topsoil values)			Loudon	Luziwa	Mankhambira	Maonde	Mbabzi	Mkwinda	Mngwangwa	Mwanjema	Mwera Hill	Nambuma	Nathenje	Nkata Bay	Pemba	Salima	Senga	Sinyala	Tanga	Tembwe	Vipya	Visanza
NITROGEN	Low:	0·04 – 0·1 %	X	X	X	X		X	X				X		X	X	X	X	X	X		X
	Medium:	0·1 – 0·2 %					X	X		X	X	X	X	X	X	X			X		X	
	High:	0·2 – 0·4 %									X										X	
AVAILABLE PHOSPHORUS	Low:	0 – 20 p.p.m.		X		X	X	X		X	X	X	X	X					X	X	X	X
	Medium:	20 – 50 p.p.m.	X		X			X	X				X									X
	High:	50 – 100 p.p.m.			X			X							X	X	X	X				
EXCHANGEABLE POTASSIUM	Low:	0·03 – 0·2 m.e. %	X	X	X	X	X		X								X			X		
	Medium:	0·2 – 0·4 m.e. %	X	X	X	X	X	X	X	X	X	X	X	X			X	X			X	
	High:	0·4 – 0·8 m.e. %			X					X	X	X	X		X	X			X		X	X

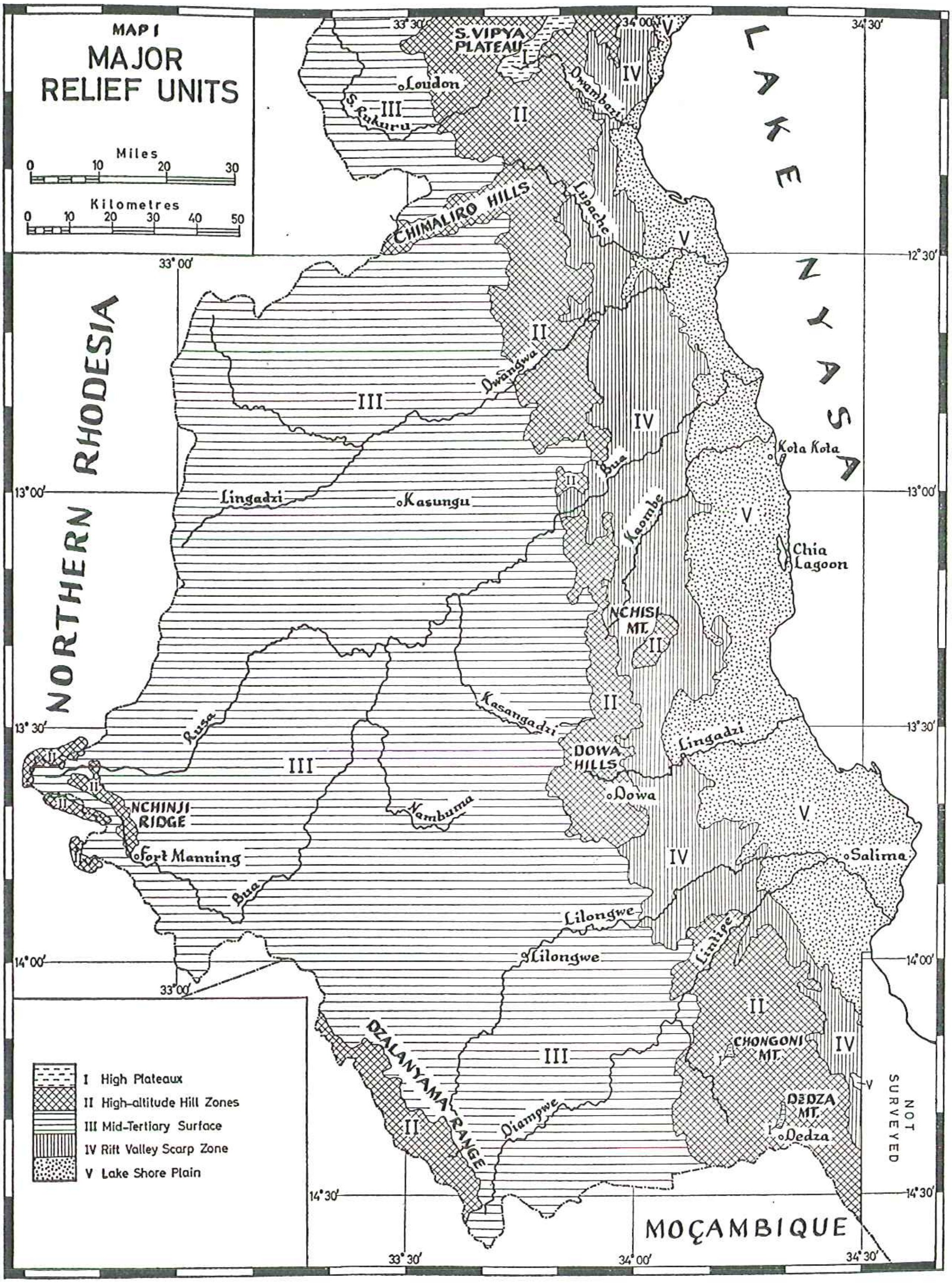
It should be noted that phosphorus and potassium values in some cases vary considerably within a single series: the above table shows the range of values recorded, but should not be taken to imply that other values will not be encountered.

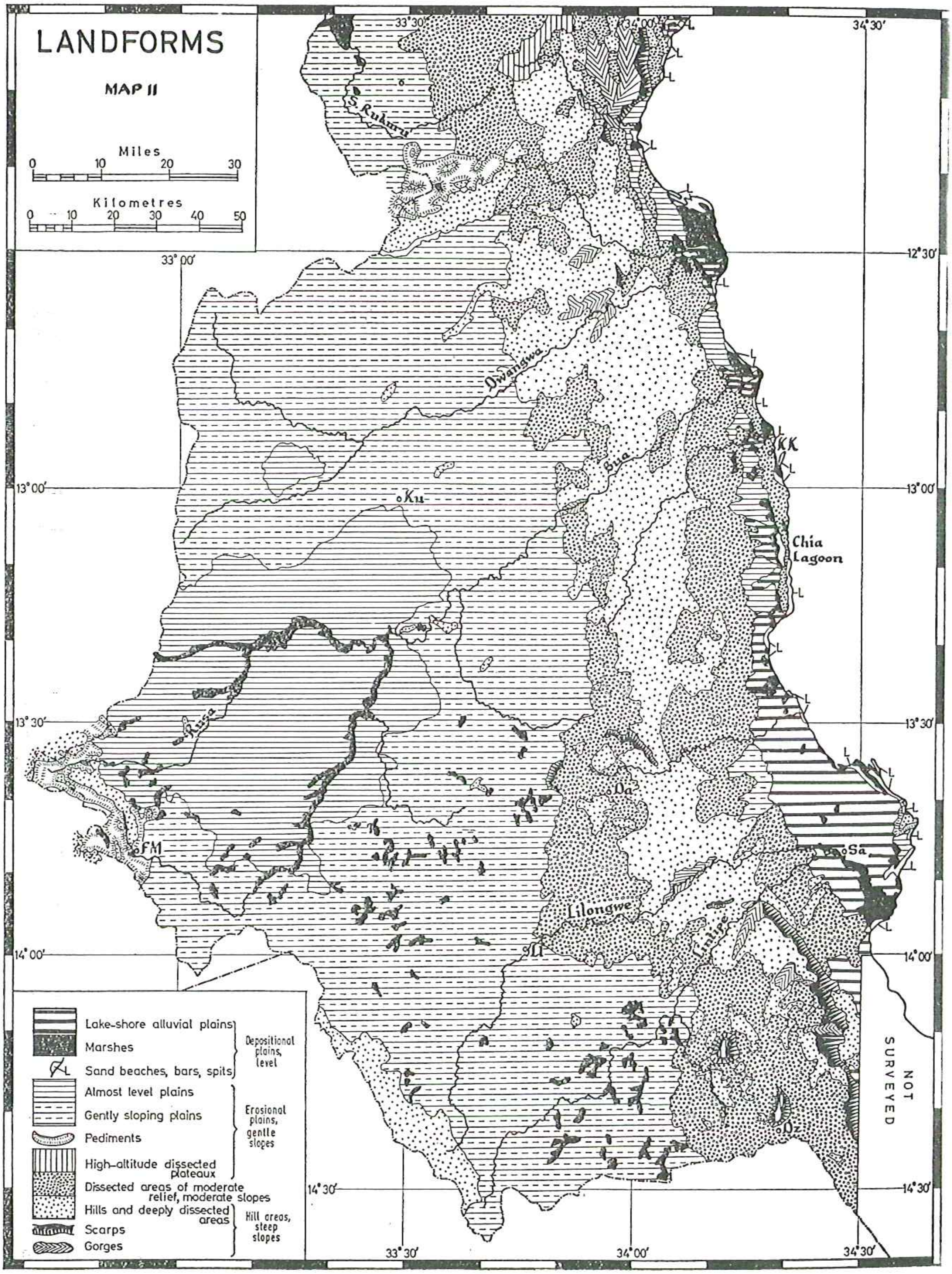
Available phosphorus determined by Bray's method (NH_4F extract).

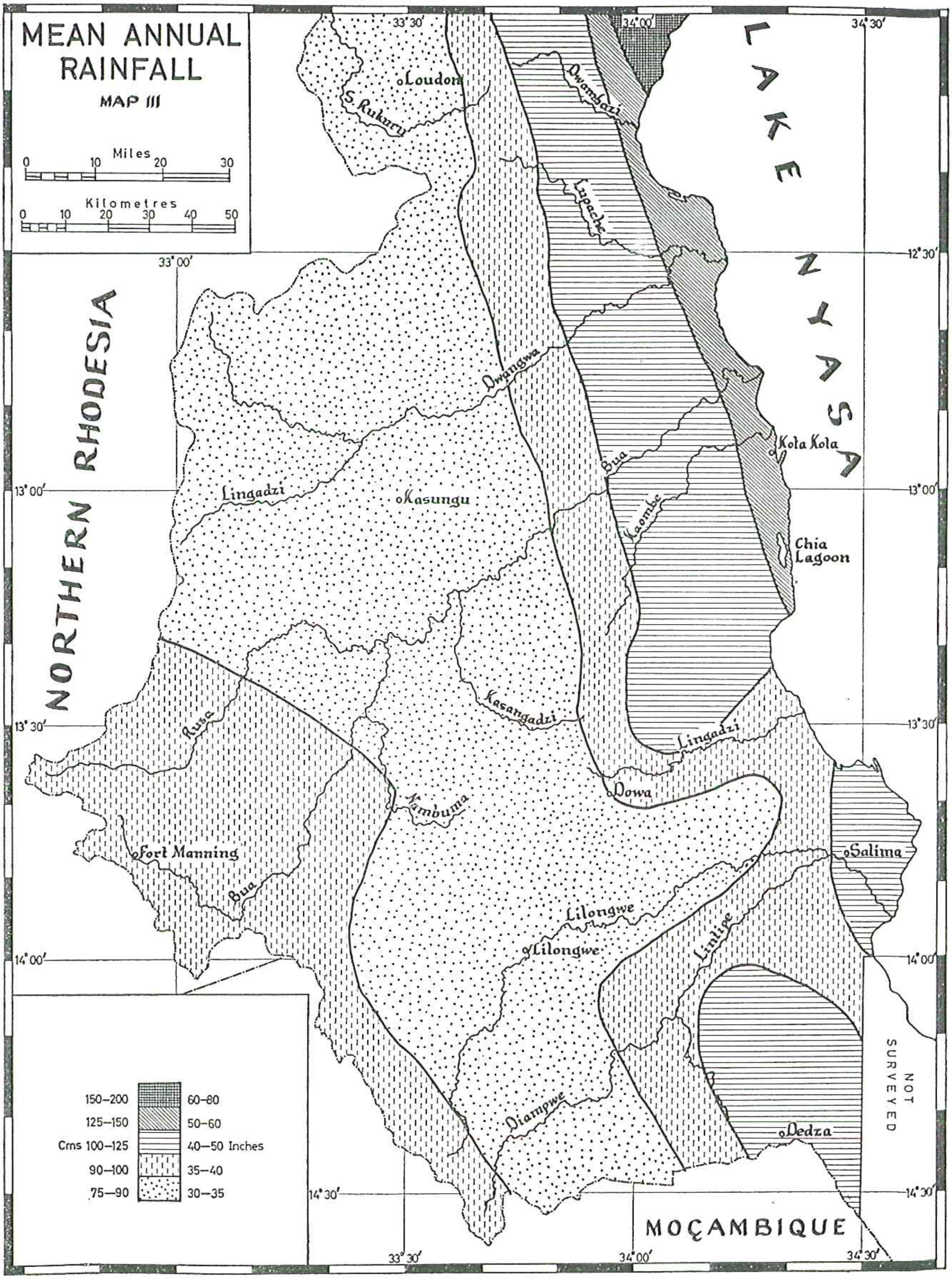
Total nitrogen determined by Kjeldhal's method.

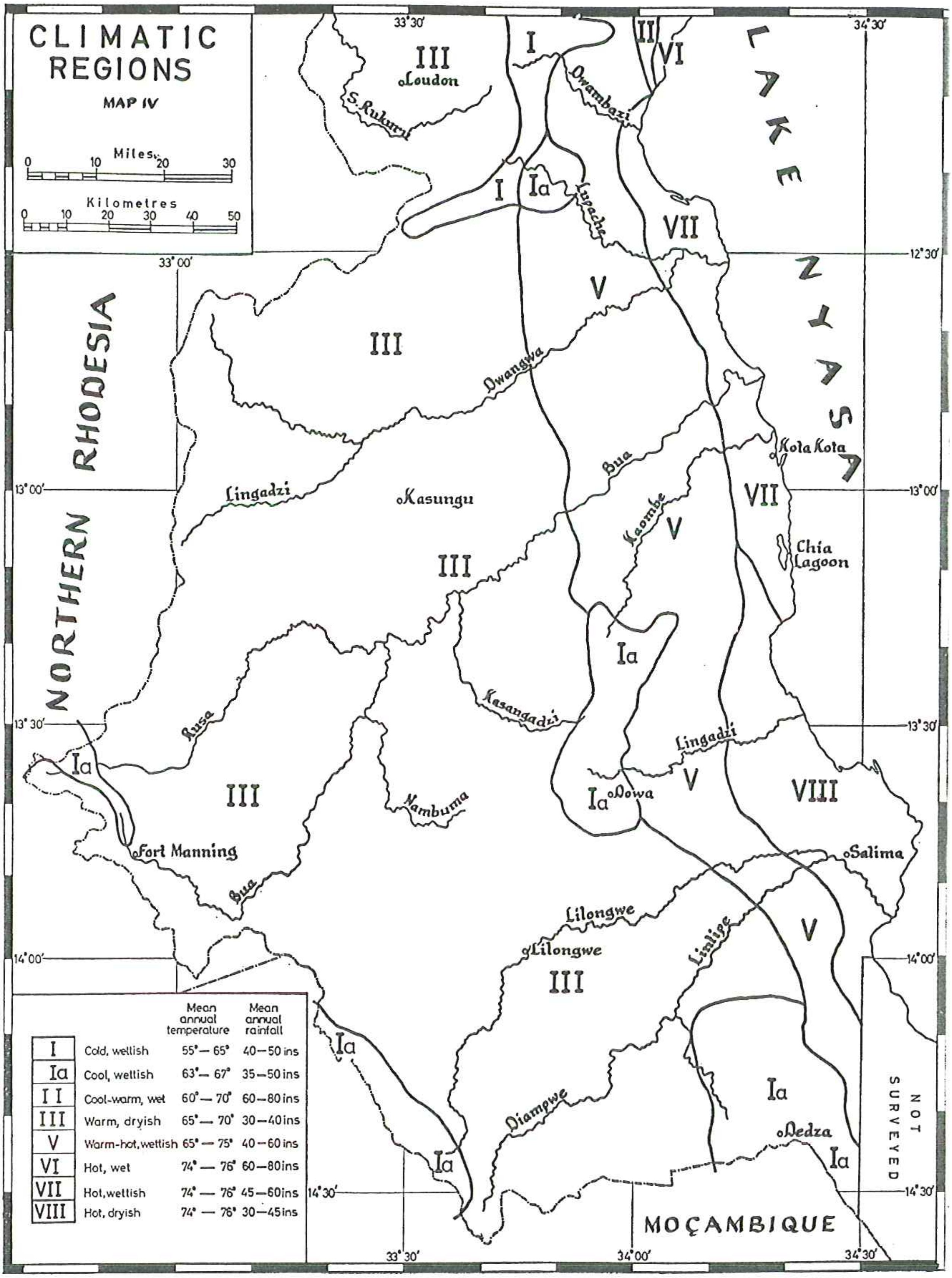
Fig. 1.—RAINFALL, TEMPERATURE AND EVAPORATION FOR SELECTED STATIONS



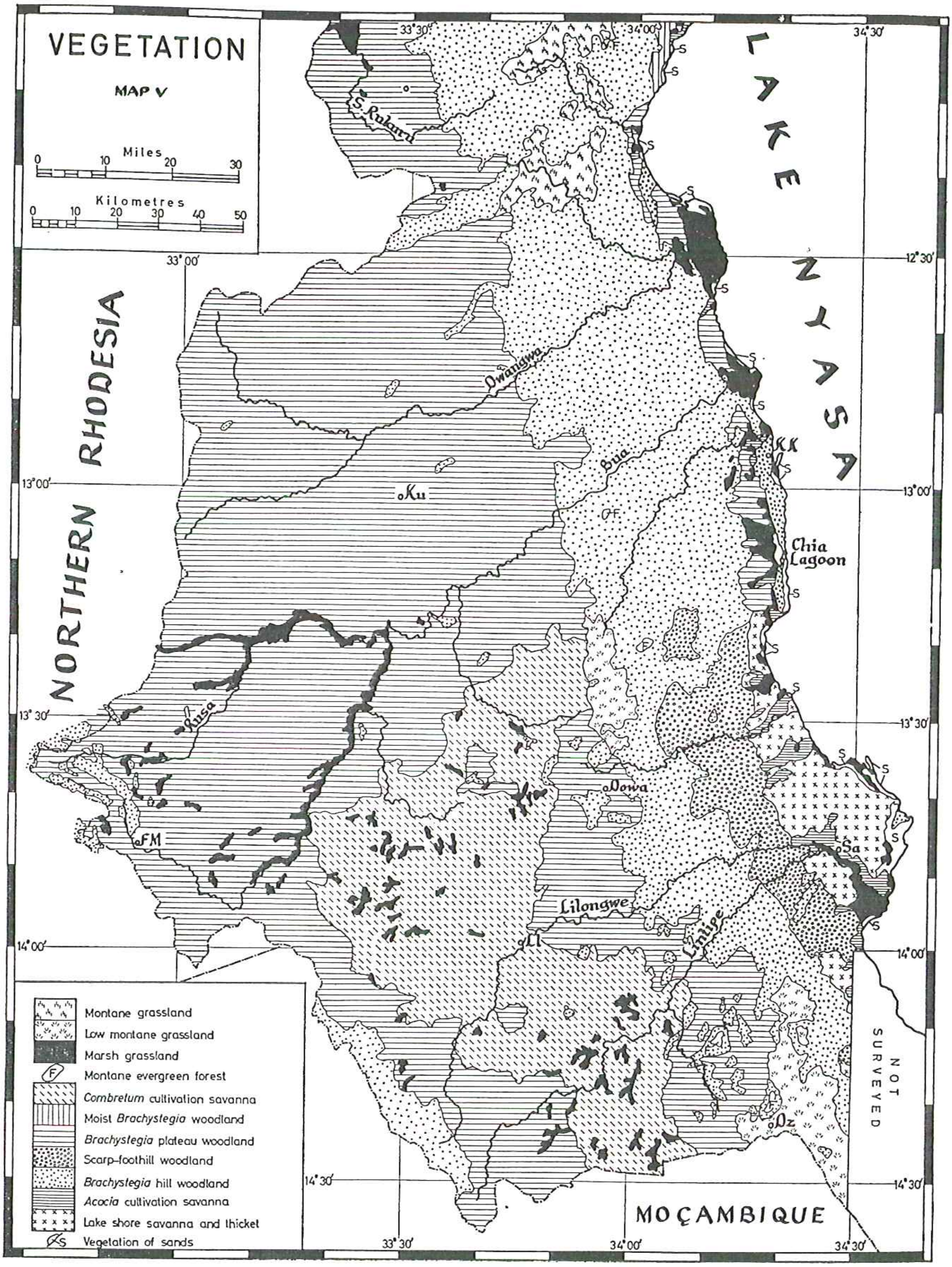

MAP I
MAJOR RELIEF UNITS
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
S. VIPYA PLATEAU
Loudon
S. Rukuru
Dwambazi
LAKE NYASA
CHIMALIRO HILLS
Lupache
NORTHERN RHODESIA
Dwangwa
Kota Kota
Bua
Lingadzi
Kasungu
Kaombe
Chia Lagoon
NCHISI MT.
Kasangadzi
Rusa
Lingadzi
DOWA HILLS
Dowa
NCHINJI RIDGE
Namkuma
Fort Manning
Salima
Bua
Lilongwe
Lilongwe
Linthipe
DZALANYAMA RANGE
CHONGONI MT.
DEDZA MT.
Dedza
Diampwe
NOT SURVEYED
MOÇAMBIQUE
I High Plateaux
II High-altitude Hill Zones
III Mid-Tertiary Surface
IV Rift Valley Scarp Zone
V Lake Shore Plain
33° 00'
33° 30'
34° 00'
34° 30'
12° 30'
13° 00'
13° 30'
14° 00'
14° 30'

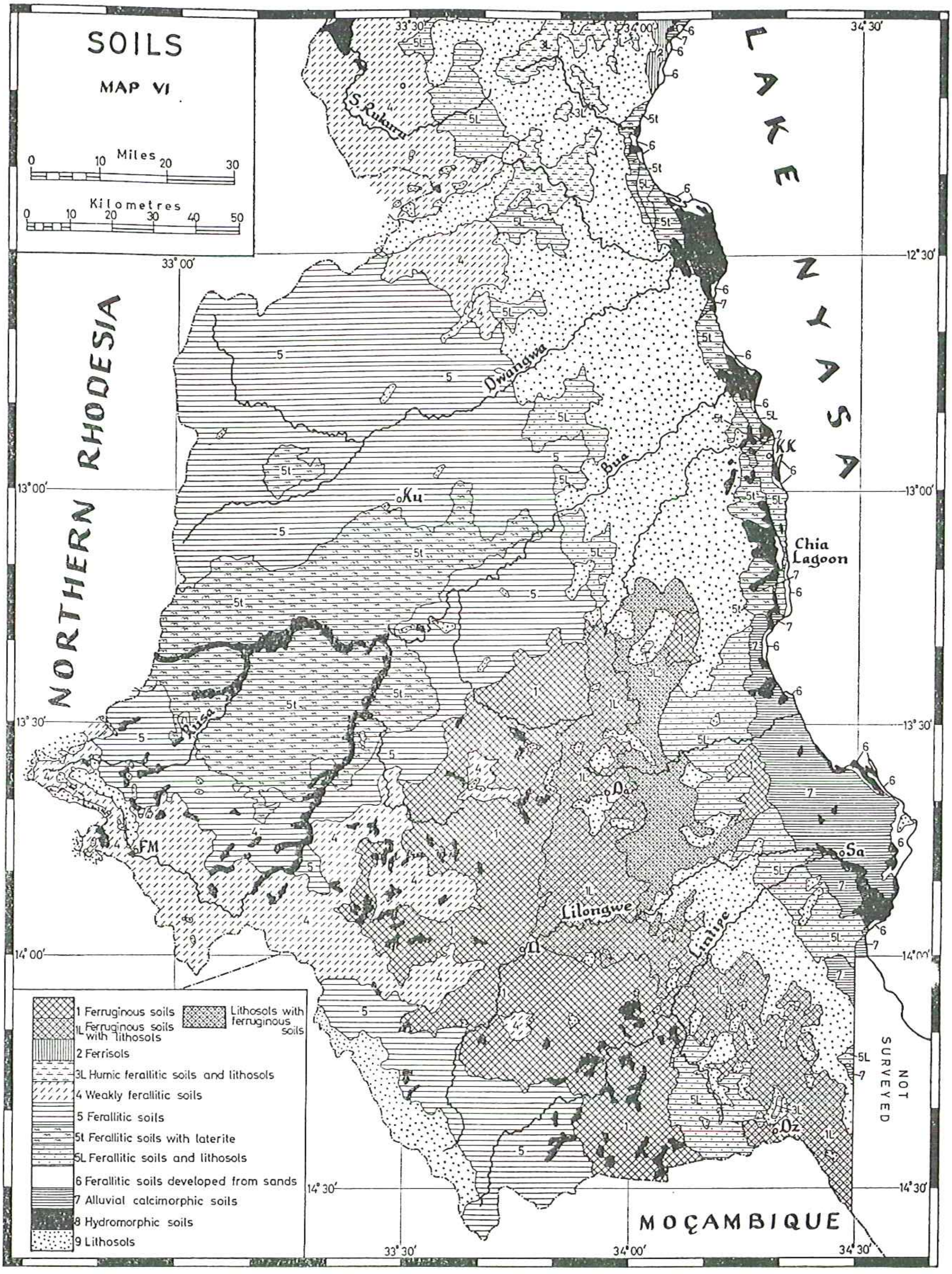

LANDFORMS
MAP II
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
33°30'
34°00'
34°30'
33°00'
12°30'
13°00'
13°30'
14°00'
14°30'
S. Rukuru
Dwangwa
Bua
Rusa
Lilongwe
Linthipe
Ku
KK
Chia Lagoon
Da
FM
Sa
Li
NOT SURVEYED
Lake-shore alluvial plains
Marshes
Sand beaches, bars, spits
Depositional plains, level
Almost level plains
Gently sloping plains
Pediments
High-altitude dissected plateaux
Erosional plains, gentle slopes
Dissected areas of moderate relief, moderate slopes
Hills and deeply dissected areas
Scarps
Gorges
Hill areas, steep slopes

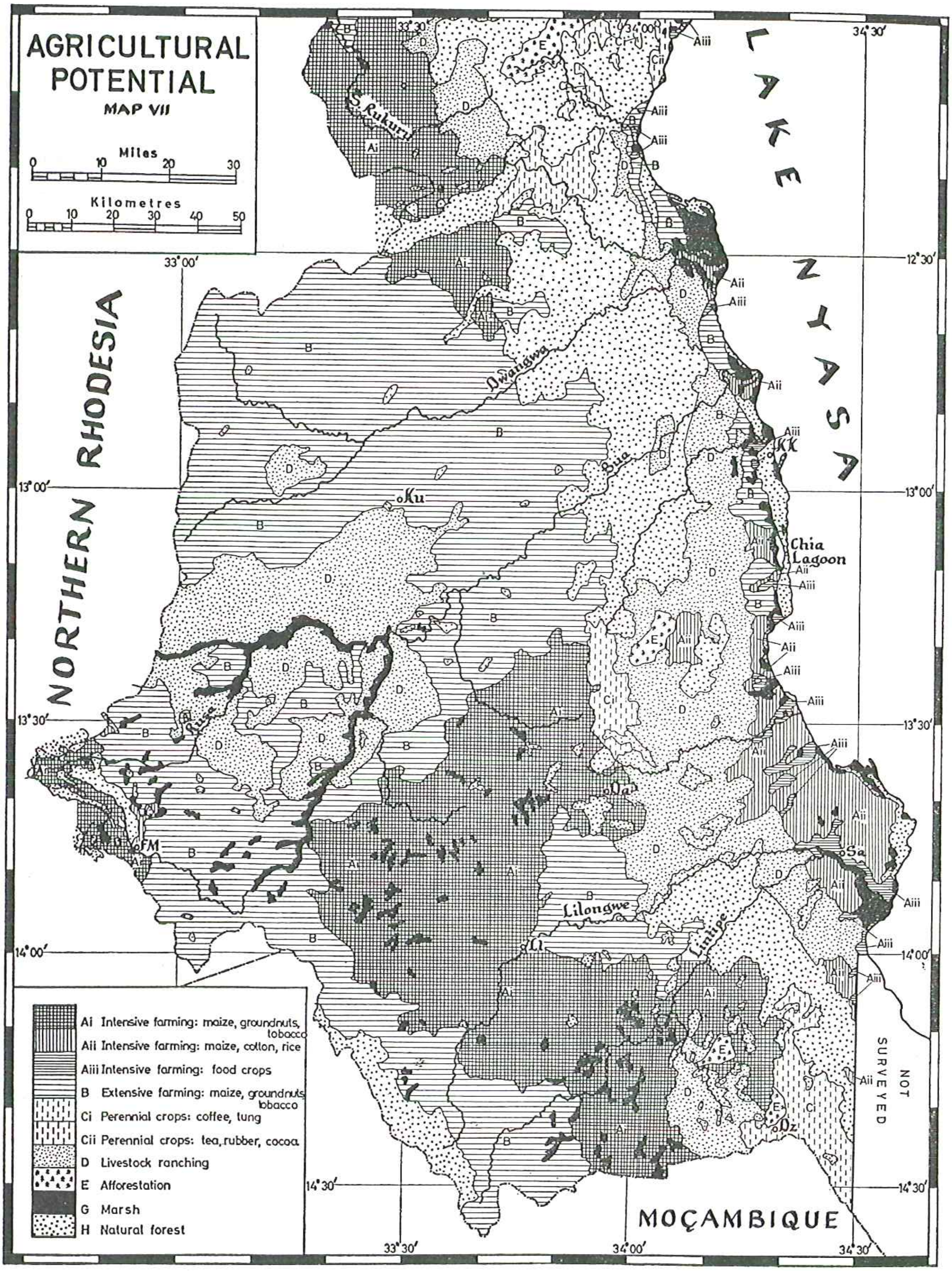

MEAN ANNUAL RAINFALL
MAP III
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
LAKE NYASA
NORTHERN RHODESIA
MOÇAMBIQUE
NOT SURVEYED
33°00′
33°30′
34°00′
34°30′
12°30′
13°00′
13°30′
14°00′
14°30′
Loudon
S. Rukuru
Dwambazi
Lupache
Dwangwa
Bua
Kota Kota
Kaombe
Chia Lagoon
Lingadzi
Kasungu
Kasangadzi
Rusa
Nambuma
Dowa
Fort Manning
Salima
Lilongwe
Linthipe
Diampwe
Dedza
150–200 60–80
125–150 50–60
Cms 100–125 40–50 Inches
90–100 35–40
75–90 30–35



CLIMATIC REGIONS
MAP IV
Miles 0 10 20 30
Kilometres 0 10 20 30 40 50
NORTHERN RHODESIA
LAKE NYASA
MOÇAMBIQUE
NOT SURVEYED
Loudon
S. Rukuru
Ozwambazi
Lupache
Dwangwa
Lingadzi
Kasungu
Bua
Kaombe
Kota Kota
Chia Lagoon
Kasangadzi
Rusa
Nambuma
Fort Manning
Dowa
Salima
Lilongwe
Linlige
Diampwe
Dedza
33°30'
34°30'
33°00'
12°30'
13°00'
13°30'
14°00'
14°30'
34°00'
I
Ia
II
III
V
VI
VII
VIII
Mean annual temperature
Mean annual rainfall
I Cold, wellish 55°—65° 40—50 ins
Ia Cool, wettish 63°—67° 35—50 ins
II Cool-warm, wet 60°—70° 60—80 ins
III Warm, dryish 65°—70° 30—40 ins
V Warm-hot, wettish 65°—75° 40—60 ins
VI Hot, wet 74°—76° 60—80 ins
VII Hot, wettish 74°—76° 45—60 ins
VIII Hot, dryish 74°—76° 30—45 ins


VEGETATION
MAP V
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
LAKE NYASA
NORTHERN RHODESIA
MOÇAMBIQUE
NOT SURVEYED
S. Rukuru
Dwangwa
Bua
Ku
Chia Lagoon
KK
Dowa
Rusa
FM
Lilongwe
Li
Linthipe
Sa
Dz
33°30'
34°00'
34°30'
33°00'
12°30'
13°00'
13°30'
14°00'
14°30'
Montane grassland
Low montane grassland
Marsh grassland
Montane evergreen forest
Combretum cultivation savanna
Moist Brachystegia woodland
Brachystegia plateau woodland
Scarp-foothill woodland
Brachystegia hill woodland
Acacia cultivation savanna
Lake shore savanna and thicket
Vegetation of sands


SOILS
MAP VI
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
NORTHERN RHODESIA
LAKE NYASA
MOÇAMBIQUE
NOT SURVEYED
Chia Lagoon
S. Rukuru
Dwangwa
Bua
Rusa
Lilongwe
Linthipe
Ku
KK
Da
Sa
Dz
FM
33°00′
33°30′
34°00′
34°30′
12°30′
13°00′
13°30′
14°00′
14°30′
1 Ferruginous soils
1L Ferruginous soils with lithosols
Lithosols with ferruginous soils
2 Ferrisols
3L Humic ferallitic soils and lithosols
4 Weakly ferallitic soils
5 Ferallitic soils
5t Ferallitic soils with laterite
5L Ferallitic soils and lithosols
6 Ferallitic soils developed from sands
7 Alluvial calcimorphic soils
8 Hydromorphic soils
9 Lithosols


AGRICULTURAL POTENTIAL
MAP VII
Miles
0 10 20 30
Kilometres
0 10 20 30 40 50
LAKE NYASA
NORTHERN RHODESIA
MOÇAMBIQUE
NOT SURVEYED
S. Rukuru
Dwangwa
Bua
Rusa
Lilongwe
Linthipe
Ku
KK
Chia Lagoon
Sa
Li
Dz
FM
33°00′
33°30′
34°00′
34°30′
12°30′
13°00′
13°30′
14°00′
14°30′
Ai Intensive farming: maize, groundnuts, tobacco
Aii Intensive farming: maize, cotton, rice
Aiii Intensive farming: food crops
B Extensive farming: maize, groundnuts, tobacco
Ci Perennial crops: coffee, tung
Cii Perennial crops: tea, rubber, cocoa
D Livestock ranching
E Afforestation
G Marsh
H Natural forest