VEGETATION-SOIL MAP

of

NORTHERN RHODESIA

with accompanying

MEMORANDUM

Price 5*s.*

1948

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NOTE

Owing to difficulties of shortage of materials the Map has had to be reproduced on paper inferior to that originally intended and the sheets will consequently require careful handling. It is hoped that a second impression on stronger paper will become possible at a latter date.

Northern Rhodesia

VEGETATION - SOIL MAP

OF

NORTHERN RHODESIA

By
C. G. TRAPNELL, J. D. MARTIN, W. ALLAN, O.B.E.
and other members of the
Department of Agriculture and the Forestry Branch
with an explanatory memoir by
C. G. TRAPNELL

1948
PRINTED BY THE GOVERNMENT PRINTER
LUSAKA

2nd Printing
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CONTENTS

	Paragraphs
INTRODUCTION	1–4
SOURCES :	
Topographic	5
Ecological surveys	6–10
ACKNOWLEDGMENTS	11–13
REFERENCES	14
SOIL CLASSIFICATION :	
Climatic series	15
Red Earths and Related Soils	16
Lake Basin Soils	17
Plateau Soils	18
Kalahari Sands	19
Upper Valley Soils	20
Lower Valley Soils	21
Grey and Black Swamp Soils	22
Escarpment Hill Soils	23
VEGETATION CLASSIFICATION :	
Introductory	24–29
Evergreen and Semi-deciduous types	30–31
Brachystegia-Isoberlinia Woodlands	32–38
Other Deciduous Woodlands and Forests	39–43
Deciduous Thicket types	44–45
High Grass-Woodland or " Chipya " types	46–48
Bush-Group, Tree-Grassland and Scrub-Grassland types	49–53
Grassland types	54–56
COLOURING AND NOTATION	57–60
APPLICATION TO LAND USAGE :	
Types of land usage	61–64
Index of land resources	65
Principal agricultural assets	66
Principal forestry assets	67
Conclusion	68

A Vegetation - Soil Map of Northern Rhodesia

INTRODUCTION

1. An attempt to produce a map on a Territorial scale to show both vegetation and soil types calls for some explanation. In the first place it should be made clear that the title " Vegetation-Soil Map " is intended to denote a vegetation map with supplementary indications of the types of soil occupied by each vegetation type. The vegetation types are represented as fully as practicable for a map on a 1 : 1,000,000 scale. Indications of soils, however, are confined to major soil groups such as would find a place in a general African classification. Thus various *Brachystegia-Isoberlinia* types of woodland are differentiated according as they are found on Kalahari Sands, Plateau Soils or Red Earths, but no attempt is made to represent the various subdivisions of which the Plateau Soils, in particular, are capable. This treatment of the soils is necessary as their classification has for the greater part been worked out from field traverses and profile observations without soil analyses, although invaluable help concerning them was received from the late G. Milne of the East African Agricultural Research Station, Amani. Apart from this, the incorporation of sub-groups in combination with the various vegetation types would entail a multiplicity of mapping units which would be beyond the compass of ordinary colour printing. In their general outline the soil groups are believed to be pedologically sound, as although originally independently determined they agree closely with those of Milne's East African Soil Map—but they will no doubt be found to require amplification and modification of their limits at some future date.

2. At the same time, thanks probably to the influence of climatic factors on the development of the major soil groups and to the parallel evolution of soil and vegetation types through long periods of time, there is a considerable degree of correlation in their respective distribution in this Territory. The correlation is far from being an absolute one, as the map itself will show—a single vegetation type, while generally predominantly associated with one class of soil, may extend, with minor changes, on to two or three different soils. But the fact remains that a predominant association with one soil group is frequently found, and this fact materially assists the representation of soil and vegetation in a single notation.

3. From a practical point of view, for the satisfactory assessment of the land resources of any large tract of country, it is desirable to have a representation of vegetation as well as soil type. Apart from the obvious direct applications of vegetation survey in indicating forestry and pastoral potentialities, the nature of the vegetation cover is of great importance to the native agriculture of the Territory and is used by many tribes as an indicator of the soil's potentialities. The use of vegetation as an indicator of soil fertility has been much studied in this country and the vegetation-soil unit has become the basis of a method of land survey which, whatever its shortcomings from the soil scientist's point of view, is of considerable practical value to the Agricultural and Forest Officer. It is for the use of these officers that this map has primarily been designed. Numerous areas remain in which the information represented is incomplete or partially conjectural, but it is to be hoped that these defects will be remedied in the future by more detailed investigational work.

4. Scientific work in this Territory suffered a severe loss in the death of J. D. Martin in 1941, when serving with the Royal Air Force. He was responsible for a considerable area of the map and his hitherto unpublished vegetation maps of Barotseland, unrivalled for thorough botanical study and careful workmanship, are reproduced in it with little modification. Certain simplifications of them have been necessary for the purposes of a more general classification, and they will in any case need to be retained on their full scale for the use of future Forest Officers in Barotseland. Their publication, however, in the present form will at least make more generally available a major portion of his work.

SOURCES

5. The map is based on the official 1 : 1,000,000 topographic map of the Territory, produced by the Department of Lands, Mines and Surveys in 1939, and should be used in conjunction with it. A large amount of the detail of the official map has, however, been suppressed in order to allow the vegetation data to be superimposed, while a certain number of additions or revisions have been introduced. These have been derived from various sources, including hitherto unpublished road traverses, original plottings preserved among old records on Administrative Stations, the 1 : 633,600 Geological Map of the Territory lately produced by the Mining Concession Companies and topographic revisions made in the course of Departmental surveys. By similar means considerably fuller representations

than hitherto have been compiled of the great flood-plains and swamps of the Zambezi, Kafue and the Chambezi–Luapula river systems together with those of the Mweru Marsh of the extent of the escarpment hill systems flanking the great Luangwa–lower Zambezi and Lunsemfwa–Lukusashi troughs and of the limits of the floors of these valleys. The data for the determination of these features of the land surface have been derived largely from the Geological Maps of the Concession Companies and the aerial maps of North-Western Rhodesia made by the Aircraft Operating Company, but also from J. D. Martin's Barotse surveys and from traverse observations made on the Ecological Survey of Northern Rhodesia.

6. The main framework of the vegetation and soil types represented is the skeleton of reconnaissance traverses made by the writer in the course of the Ecological Survey. A provisional vegetation-soil map of North-Western Rhodesia on the scale of 1 : 2,000,000 was published in 1937 in the Report of the Survey on that half of the Territory. This combined the results of the Survey with more detailed work in Sesheke and Livingstone Districts by J. D. Martin, Assistant Conservator of Forests in the Machili region. A 1 : 1,000,000 sheet of North-Eastern Rhodesia north of the 13th parallel was prepared (but not published) in 1940 in connection with the Report of the Survey on North-Eastern Rhodesia, while traverses south of this line were retained on larger scale maps. Upon these outlines have now been superimposed extensive detailed surveys made by various members of the Agricultural Department and its Forestry Branch in the Barotse, Eastern and Western Provinces, together with an interpretation of aerial photographs in conjunction with the Geological Map in the Kaonde-Lunda Province. While the original traverses of the Ecological Survey remain the chief sources of information for the Northern, Central and Southern Provinces these additional surveys have added greatly to the mapping of the rest of the Territory and require fuller mention.

7. In the first place extensive and detailed surveys of the vegetation of a great part of Barotseland were carried out by J. D. Martin in the course of his investigations of forests and forestry in Barotseland. Mongu, Mankoya, Sesheke and eastern Senanga Districts were covered by him with a network of compass and mileometer traverses, checked by astronomical observations, which incidentally resulted in considerable revisions of the topographic maps of these districts. Further mileometer traverses of vegetation types in Kalabo and north-west Senanga Districts were made under his direction by the Head Forest Ranger, Machili. From this material he produced a series of District vegetation maps on the scale of 1 : 250,000 together with a general 1 : 500,000 vegetation map of Barotseland, which contained numerous revisions of the previous reconnaissance work of the Ecological Survey and was accompanied by a very complete Report on Forests and Forestry in Barotseland. Details of this map were discussed with Martin in 1941, and pantograph reductions from it, checked from the larger-scale sheets and added to or modified in minor points, constitute the Barotse sector of the present map.

8. Subsequently, between 1941 and 1944 a systematic detailed survey of the vegetation-soil types of the North Charterland Concession area of Fort Jameson and Petauke Districts in the Eastern Province was carried out under the direction of W. Allan, Assistant Director of Agriculture, as a basis for the resettlement of the population of the overcrowded Native Reserves in the Concession. This survey, probably unique of its kind, employed a series of parallel traverse lines from south to north, generally at two-mile intervals, along which the recurrences of eighteen standardised vegetation-soil units were recorded. The traverse work was carried out by a team comprising W. Allan, W. B. van Wyk, J. R. E. Hindson and W. V. Morony. The results were plotted on sheets on the scale of 1 : 50,000. These sheets were subsequently reduced to two 1 : 250,000 maps, on which previous reconnaissance traverses of the Ecological Survey were included to fill in the Reserve areas. These maps in turn have been simplified and reduced by pantograph to constitute the present map of the Concession area.

9. Two further similar surveys have provided detailed maps of large parts of the Western Province. A survey on the Charterland model was made under Allan's direction by Messrs. B. C. Wills, D. U. Peters and W. B. van Wyk for the Crown Land portion of the Province south of the Kafulafuta, traverses in this case being arranged in the form of a grid with lines at two-mile intervals from east to west and one-mile intervals from north to south. With this survey has been combined results from a forest enumeration survey of selected portions of the Copperbelt conducted by C. E. Duff, Senior Assistant Conservator of Forests at Ndola, in which changes in timber and forest types were recorded along lines cut 30 to 60 chain intervals. This and the preceding survey were reduced from 1 : 50,000 sheets to a scale of 1 : 125,000 before incorporation into the present map.

10. Certain additional traverses in North-Western Rhodesia, principally in the Kaonde-Lunda Province, were made by the writer in 1943. Following these tours an examination was made of vertical and oblique aerial photographs of Mwinilunga, Balovale and west Kasempa Districts together with the northern border of Mankoya. The vegetation data shown by the photographs were transposed to the 1 : 250,000 aerial maps made from them by the Aircraft Operating Company. A pantograph reduction to 1 : 1,000,000 was then made of the limits of the Kalahari Sands in this quarter from the Geological Map

of the Concession Companies and the vegetation data were superimposed on the same scale. By this means a fairly complete vegetation-soil map of this area has proved possible, although the information it shows is necessarily inferential away from traverse lines. It should be observed that the limits of the Kalahari Sands in west Kasempa District have been altered in the light of traverses made by the writer.

ACKNOWLEDGMENTS

11. The map has been drawn for publication by the Trigonometrical Survey Department, Pretoria, and printed by the Government Printer, Pretoria. It is desired here to express appreciation of the ready help and advice given by the Trigonometrical Survey in the final stages of its preparation and of the willingness of this Department and the Government Printer, Pretoria, to undertake the colour reproduction. Owing to the distortion of the original drawings on tracing paper the sheets were redrawn in full by the Trigonometrical Survey and the very large task of lettering, arrangement and preparation of the colour layers was carried out by them. The care and thoroughness which have been devoted to the work are gratefully acknowledged.

12. In addition to the detailed surveys cited above, acknowledgment is due to the help of a number of others who assisted in the work of field investigation, particularly to Lady Gore-Browne for several traverses made by her in Mpika District and to C. M. N. White and J. M. Winterbottom for traverses in west Balovale and Kalabo Districts respectively. Full use has also been made of the vegetation and soil maps of the Kafue–Chisamba sector of the railway line which were published by C. R. Robins in the *Journal of Ecology*, Vol. XXII, No. 1, 1934.

13. Thanks are also due to the Mine Superintendent and Survey Department of the Roan Antelope Mine, Luanshya, for the provision of prints at a time when suitable materials were practically unobtainable, and to the Department of Lands, Mines and Surveys at Livingstone and Ndola for help in various stages of the preparation of the map. The section of the memoir dealing with soil classification was kindly read by Dr. C. R. van der Merwe and I am greatly indebted to him for his comments on probable relationships between Northern Rhodesian and South African soils, and also to Mr. C. Gillman for advice concerning Itigi Thicket soils in Tanganyika.

REFERENCES

14. This map is intended to be used in conjunction with the Reports of the Ecological Survey on North-Western and North-Eastern Rhodesia and with J. D. Martin's Report on Forestry in Barotseland. In the notes on it which follow paragraph citations from these Reports are indicated by the following abbreviations :

NW : *The Soils, Vegetation and Agricultural Systems of North-Western Rhodesia*, by C. G. Trapnell and J. N. Clothier. (Government Printer, Lusaka, 1937.)

B : *Report on Forestry in Barotseland* by J. D. Martin : Appendix I. (Government Printer, Lusaka, 1941.)

NE : *The Soils, Vegetation and Agriculture of North-Eastern Rhodesia*, by C. G. Trapnell. (Government Printer, Lusaka, 1943.)

In the outline of soil types page references are also made to the two principal authorities on East and South African soils as follows :

EA : *A Provisional Soil Map of East Africa*, by G. Milne. (Amani Memoir, Crown Agents for the Colonies, 1936.)

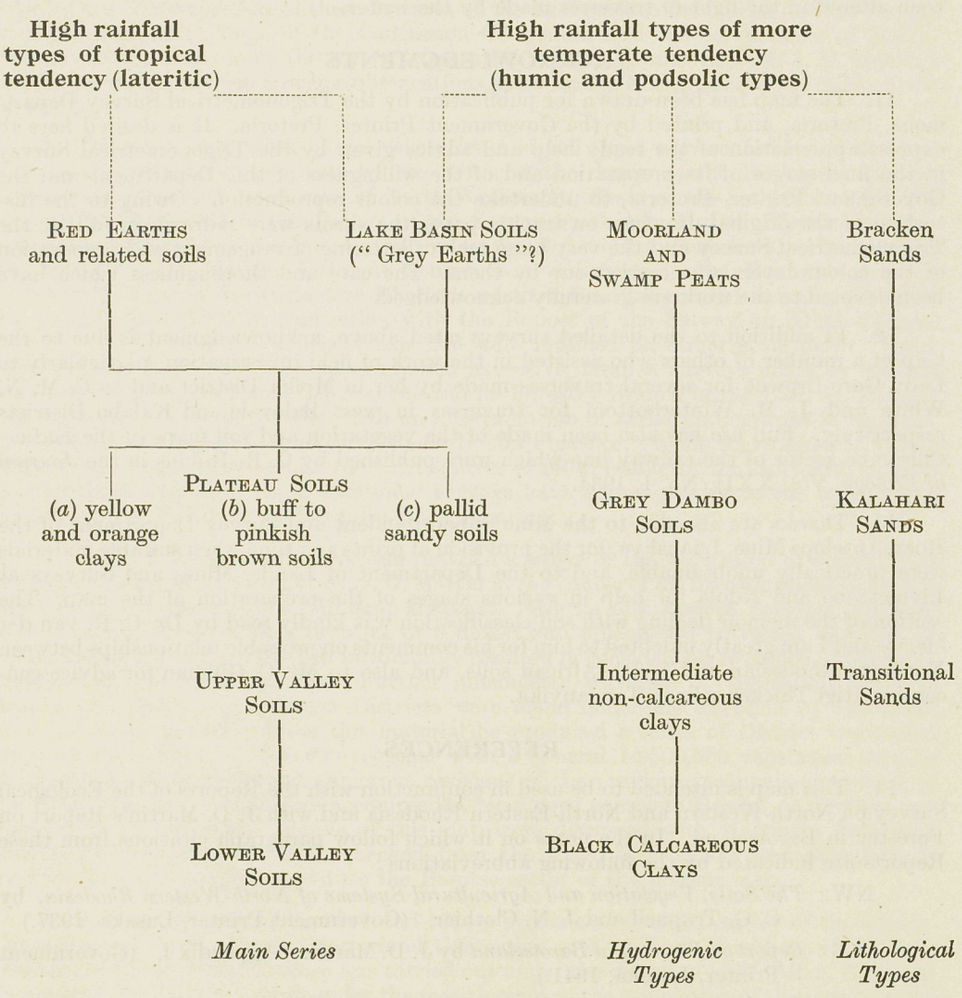
SA : *Soil Groups and Sub-groups of South Africa*, with map, by C. R. van der Merwe. (Government Printer, Pretoria, 1941.)

The vegetation units on the map should be compared with those of the pioneer Vegetation Map of Southern Rhodesia by J. S. Henkel (*Types of Vegetation in Southern Rhodesia*, Proc. Rhod. Sci. Ass., 30, 1931).

SOIL CLASSIFICATION

15. In view of the descriptions of the soils and vegetation of the Territory already provided by the Reports of the Ecological Survey it is not necessary here to give more than a recapitulation of their classification. The analytical work necessary to reach full conclusions concerning the nature of the soils has been lacking, but a classification based on field characters has been arrived at which is in general accord with that employed by Milne on the East African Soil Map and is also comparable in several instances to the soil groups of van der Merwe's South African Map. While full allowance needs to be made for geological and historical factors in their development, the soils of this country seem to fall into a series grading from the pedocal types of lower and hotter levels with lesser rainfall towards two divergent moister types, the Red Earths and lateritic soils of the moister tropics and the " podsolised " or " podsolic " soils which are now recognised in more temperate and humid portions of South and East Africa (*vide* SA pp. 131–175, EA pp. 10, 14, 22, 29).

These tendencies are illustrated in the table below in which the principal groups are compared with the parallel series of " hydrogenic " types of seasonally waterlogged or swampy conditions and with corresponding variations in the " lithological " type constituted by the Kalahari Sands.



Tropical low rainfall types (pedocal)

Note.—The tendencies suggested in the diagram are in part dependent on the nature and affinities of the peculiar group of Lake Basin Soils. These soils were examined in the field by Milne and the probability of relationship to his podsolised soils, previously suggested by him in writing, was then confirmed by him. It has since been suggested by Dr. van der Merwe that they may also prove to have some affinity to his Lateritic Yellow Earths, which he compares with Milne's podsolised soils (SA p. 233). These possible relationships are indicated in the diagram.

16. *The Red Earths and related red loam soils* (NE 13–14, 84, 97, cf. NW 23).

The term " Red Earths " has been confined to deep red, orange-red and brownish red clay-loam soils which can with confidence be allocated to the Red Earths of the East African Soil Map (EA pp. 9, 13, 14, 21). These soils are in this country largely confined to crystalline limestones, a few felspathic sedimentary rocks and basic igneous rocks. There is, however, some doubt regarding the proper limits of their definition and certain pinker soils on the granites in the Abercorn highlands have been represented on the map with a striped notation as possibly related to them. Their occurrences as at present known are extremely limited, but they will no doubt be found to be more frequent with fuller survey. This applies particularly to the northern sector of North-Western Rhodesia, where a line indicating their probable approximate southern limit as inferred from geological maps has been inserted on the map to show the field for future investigation. The typical Abercorn profile shows a friable and porous soil, reddish brown at the surface but brighter red below and orange-red from the second foot, with smallish lumps of harder clay-like soil increasing in size and number from this level downwards. More southern examples, however, show basal iron nodule accumulation, in Ndola District sometimes at depths far below the normally recognised limits of the soil profile. Whether or not any of these soils can be classified as laterised has yet to be ascertained. South of their occurrences in North-Western Rhodesia and more especially in the Eastern Province are found a limited series of related red loam soils. These are clod-structured soils, of similar derivation but extend-

ing on to the Basement Complex, which may bear comparison with Milne's Non-laterised Red Earths. In their most frequent " pastel-toned " form in the Eastern Province they show an accumulation of small iron pellets in the subsoil. The Red Earth group grades into more orange-toned variants of the Plateau Soils referred to below and may also be represented in an intrazonal chocolate-red form found among the Upper Valley Soils.

17. *The Lake Basin Soils* (" Grey Earths " ?—NE 19–21, 86–88, 91).

The generally grey-toned (light pinkish-grey to darker) humic soils which have been developed on ancient alluvium in the lower Chambezi–Bangweulu basin and on other substrata elsewhere have no known African parallels except for a probable affinity to the " podsolised soils " recorded by Milne in the Dabaga–Mufindi highlands of Tanganyika Territory (EA pp. 10, 14, 29, cf. NE 87) and, in part, to the Lateritic Yellow Earths described by van der Merwe in South Africa (SA pp. 217–234). At the same time there is some divergence from the podsolised type in that these soils descend to practically 3,000 feet and show no noticeable bleached horizon. Their main occurrences are regularly associated with traces of former evergreen forest or the " Chipya " vegetation which has replaced it, and their origin may perhaps be ascribed, in view of this, to a period of rainier and more equable climate. Their surface colouring is influenced by the presence of a peculiar ash-grey film. Below this is a darker grey-brown, somewhat cocoa-toned humic soil, blackish when moist, with a sandy basis but typically so richly humic as to be termed a loam. This may extend downwards for one to two or even three feet before passing into a buff to more pinkish-ochreous structureless subsoil of very considerable depth. The clay-fraction increases with depth but the subsoil remains of a comparatively permeable and friable nature and no indications have been found of any tendency to the formation of iron concretions except in marginal profiles. Although leached and very acid these soils are of a decidedly productive character and support large populations. Owing to the incursions of fires and cultivation, various more depleted phases of them are found with colouring either paler or approaching that of the subsoil, and a considerable range of variation is consequently found, notably in the lower Luapula Valley. Pinkish-grey to pinkish-buff sandy loams under dense deciduous thicket in the Mweru–Tanganyika lowlands are tentatively regarded as soils of the Lake Basin type which have become thus depleted and deprived of their humic horizon under changed climatic conditions. From their appearance these soils would seem to bear comparison with those found under the same type of thicket in Tanganyika, although the " grey cement " which there forms the parent material is lacking (NE 91, cf. Milne, Journ. Ecol., XXV, 1, 1937).

18. *Plateau Soils* (NW 20–22, NE 15–18, 81, 83, 85, 95, 96).

This, the most extensive group of soils in the Territory, answers to the Plateau Soils of the East African Soil Map (EA pp. 10, 29, 30) and to van der Merwe's group of Ferruginous Lateritic Soils in the Transvaal (SA pp. 234–267). These soils are developed on the mature topography of the older land surfaces of this country, and they are generally held to owe their most striking characteristic, the formation of a pronounced iron nodule horizon grading into underlying rotted rock, to conditions of impeded subsoil drainage (*vide* discussions of their classification in van der Merwe's and Milne's accounts, SA pp. 248, 249, EA p. 30). The tendency to this condition is doubtless augmented by the seasonal downpours of Rhodesian rainfall as well as by the low relief and sluggish drainage of the plateau regions. The few analyses available show the soils to be of an acid and base-deficient type. Their most usual appearance in this country is that of a buff-toned to light pinkish-brown, light-textured surface soil, slightly greyer in the top few inches, grading downwards into a raw ochreous or orange-toned clay-sand subsoil in which iron nodules are increasingly found with approach towards rotted rock. Three principal sub-groups may be differentiated, the characteristic light-coloured sandy loams of this type, a distinct group of pallid grey to practically white sandy soils with a more buff-coloured subsoil which is widespread in central plateau regions (cf. van der Merwe's Grey Ferruginous Lateritic Soils) and a group of pale yellow, yellow and more orange clayey soils most extensively found in the northern plateau region of North-Western Rhodesia. Where these profiles have been truncated by denudation of the land surface, especially on the Miocene peneplane, " older ironstone " (or " ferricrete ") soils are found with continuous sheets of iron pellets or concretionary ironstone exposed through the depleted remains of surface soil (NW 21, NE 10). These " fossil " soils answer to the " Murram " soils of East Africa. Lower-lying plateau soils with very deep iron nodule accumulations which are found on the flanks of the Luangwa Valley (NE 27) are regarded as of a similarly relict character.

19. *The Kalahari Sands* (NW 15, 24–26).

A deep extension of the Kalahari Sands of the Union of South Africa (SA pp. 54–59) covers practically the whole of Barotseland and extends into Livingstone District in the south and through Balovale in the north on to the Mwinilunga highlands. These are typically pure, loose, coarse-grained sands with the surface of the grains rounded and frosted by æolian action, attaining great depth and seldom showing any clear profile characters. They are normally whitish, or greyish where the surface layers are discoloured by organic matter or ash, but pass into golden or reddish colours where stained with iron oxide. Some

proportion of clay begins to be found in the subsoil in the compacter and shallower sands of marginal uplands. Sandy ferruginous concretions are sometimes found near the edges of dambos in this zone and concretionary iron deposits occur in them, but these are not typical of the deeper sands. Two important variants are found in the Bracken Sands of the moist Mwinilunga highlands and the Transitional Sands of hotter and drier southern areas. The Bracken Sands show a marked tendency to an accumulation of organic matter in the upper horizon, with a strongly pinkish-brown to grey-brown humic sand of mixed grain which is relatively compact and becomes loamier and ultimately clayey in the subsoil. The southern Transitional Sands have the appearance of being at least partially derived from Karroo beds or from the Pipe Sandstones basal to the Kalahari Sands. They show a high proportion of fine sand with a greyish or brownish coloration and are less acid than the usual types (NW 26). The " Kalahari Contact " soils (NW 27), which were described from areas east of Barotseland from which the sands have been denuded, have now been relegated to the Plateau class.

20. *Upper Valley Soils* (NW 28–30, NE 22–24, 98, 100).

The Plateau soils give place in lower areas of younger relief to warmer-toned, pinkish-brown or cocoa-coloured to chocolate-brown and darker brown soils of greater fertility. These probably answer to the Non-calcareous Plains Soils of the East African Soil Map (EA pp. 9, 11) and may also be comparable in part to the Brown Forest Soils of the Transvaal Low Veld (SA pp. 103–117). Associated with them locally are limited belts of brownish-red to chocolate-red soils which have been indicated by lettering on the map in view of their possible affinity to the red loams, but which are best regarded as an intrazonal type. Occurrences of these soils are often partially geologically conditioned, calcareous or felspathic sedimentary rocks and basic or intermediate igneous and metamorphic rocks favouring their formation. Their texture varies from a light but coherent sandy loam of mixed grain to a stronger and heavier loam, friable in the best examples but tending towards clod-structure or a combination of a smaller " nut " structure with vertical rhomboidal cleavages. Concretions are typically lacking from the subsoil although iron-coated rock fragments may be found above bed-rock and small black softish nodules or harder pellets occur in the subsoil of heavier chocolate-brown and redder variants. The soils show a higher degree of base-saturation than neighbouring Plateau types and an increase in exchangeable bases in the subsoil. Lime nodules, however, only occur locally in brown soils in proximity to stream courses and black swamp clays. (Rust-mottling and beds of ferruginous concretions are found in a grey-buff to ochreous variant of more doubtful status in certain flat, ill-drained areas north of the Kafue). A considerable proportion of immature soils is found in areas of more broken topography, and in lower parts of Petauke District these give place to shallower, stony or " skeletal " phases as the escarpment hills are approached.

21. *Lower Valley Soils* (NW 31 sq., NE 25 sq.).

This term has been used in the Reports of the Ecological Survey to include the collective soils of a physiographic region, but refers primarily to the brown soils of pedocal (lime-accumulating) tendency which are developed on the Lower Valley floors, together with their various immature and stony or " skeletal " phases (NW 33, NE 26). In their immature phases these soils may be comparable with Milne's Non-calcareous Plains Soils (EA pp. 9, 11) and van der Merwe's Brown Forest Soils (SA pp. 103–117) but in their pedocal form they must presumably be referred to the Calcareous Plains group (EA pp. 9, 11, 22). They have been developed almost exclusively on sedimentary beds of the Karroo formation and on old colluvial and alluvial deposits derived from them. Where they have not been modified by sheet-erosion, to which they are extraordinarily liable, the typical profile passes from a rather lighter brown surface horizon of loam texture to a darker chocolate-brown clay-loam soil which fissures with a vertical rhomboidal cleavage, breaking into flat wedge-like pieces. Lime nodules are found in deep exposures and thick horizons of them emerge in the vicinity of watercourses, while very hard and intractable clay soils occur in proximity to saline river beds. Lime accumulation, however, is lacking from various immature, shallower and lighter-textured variants which are found in a wide range of colouring, and these give place in some parts to skeletal rubble soils or belts of water-worn stones. Associated with this soil group are two intrazonal types, namely (1) small belts of chestnut or orange-brown to greyer brown sandy loams and sandier, mainly residual soils from the Karroo beds (NW 32, NE 28), which bear comparison with the sandier forms of the Upper Valley Soils and the Transitional Sands of the Kalahari region, and (2) long strips of recent alluvium which follow the rivers traversing the valley floors (NW 34, NE 29, 102). This alluvium, derived from the Basement Complex rocks of the escarpments, comprises a wide range of light greyish-brown to darker brown sandy loams, silt-loams and clay-loams of exceptional fertility. A few similar occurrences are found at higher altitudes (NW 30).

22. *Grey and Black Swamp Soils* (NW 35 sq., NE 30 sq.).

The soils of the great flood-plains and other seasonally swampy grasslands fall into three separate classes, namely local accumulations of Moorland and Swamp Peat (NE 31, cf. NW 37, EA p. 15), the Grey Dambo Soils (NE 32, cf. NW 36, EA pp. 9, 11, 22–23)

and the Black Calcareous Clays (NW 37, cf. NE 33 ; EA pp. 9, 11, 12, 22–23). Various intermediates, however, are found between these main types and it has not been practicable to give them separate representation on the map. The Moorland Peats are restricted to moist dambos, chiefly in North-Eastern Rhodesia and the Mwinilunga highlands, but Swamp Peats are found extensively in the Bangweulu Swamps, where their development is controlled by fluctuations in the water level. The Grey (or brownish-grey) Dambo Soils, while especially characteristic of dambo drainages, are also extensively represented in the flood-plains of the Chambezi–Bangweulu basin. In proximity to the Moorland Peats they may show a dark humic surface horizon over a more bleached sandy to clayey horizon, but the more typical profile possesses a superficial brownish-grey sandy layer over a grey clay-sand mixture, this passing into a more buff-coloured subsoil with rust-mottling or limonitic concretions. Their clay-fraction is of a peculiar non-cracking type, quite distinct from that of the calcareous clays, although intermediate types of grey and black non-calcareous clay soil are also found in flood-plain areas, often with a humic surface horizon (NW 37, NE 33). Other sandier phases are also found and the great watershed sand plains of Barotseland probably represent an extreme form of this soil group ; their surface sand horizons seem to overlie an impermeable subsoil of sandy clay and silicrete. Allowing for these sandy variants the Grey Dambo Soils may be related to the Grey Non-calcareous Clays of the East African Soil Map (" gley " and " gley-podsol " types, EA pp. 11, 22, 23). The Black (or sometimes greyer or browner) Calcareous Clays of lower flood-plains differ in being of a highly siliceous type, forming deep cracks in the dry season and sometimes moving by alternate shrinkage and swelling into peculiar " crab-hole " formations. These soils, extensively represented in the Kafue Flats and other low-lying situations, are generally rich in bases and show a pronounced lime nodule horizon. Excesses of calcium, sodium and magnesium salts are found locally. Although in this country confined to flood-plains or seasonally wet pans they are to be associated with the Black Calcareous Clays of the East African Soil Map and the Sub-tropical Black Clay Soils of the Transvaal (*vide* EA p. 12, SA pp. 71–88, 95–101). What may be a degraded form of this soil class, altered by leaching, occurs in the grey alluvial clays of the Machili basin (NW 38).

23. *Escarpment Hill Soils* (NW 18, NE 11).

In addition to these major soil groups mention must be made of the shallow, stony soils of the steep slopes of the escarpments which occupy wide zones down the length of the Luangwa and lower Zambezi Valleys. These are all to a greater or less extent immature or skeletal soils which vary greatly with geological formation and have as yet taken on no clear profile characters. They may in part be regarded as immature phases of the Plateau Soils, although in the lower and eastern escarpment zones they tend to a rather browner coloration and pockets of soil of the Upper Valley type occur by watercourses. Other such skeletal soils are found on or about hill masses on the plateau but these have been omitted from the map in the interests of simplicity.

VEGETATION CLASSIFICATION

24. The vegetation types employed on the map may for convenience be summarised in tabular form under the following heads :

1. Evergreen and Semi-deciduous types.
2. *Brachystegia-Isoberlinia* Woodlands.
3. Other Deciduous Woodlands and Forests.
4. Deciduous Thicket types.
5. High Grass-Woodland or " Chipya " types.
6. Bush-Group, Tree-Grassland and Scrub-Grassland types.
7. Grassland types.

25. Only brief indications of the composition of the types employed are given, fuller descriptions having already been published, but a word is necessary with regard to the subdivisions employed for the very extensive *Brachystegia-Isoberlinia* woodlands. Two methods of classification of these woodlands are practicable : (1) a broad regional grouping in which the species of *Isoberlinia* associated are used as a main criterion for their differentiation—cf. NW 41, NE 48 sq. ; and (2) a more elaborate classification based on the varying proportions of the different *Brachystegia* species and subordinate elements in the woodlands. While the second method is the most satisfactory from an ecological standpoint, and has been employed in the detailed surveys previously referred to, the first is the more practicable method where it is necessary to map great tracts of country by means of reconnaissance traverses. This broad regional classification has consequently been retained for the map, but it should be borne in mind that each of the regional types is capable of subdivision and includes, e.g., *Brachystegia Hockii, B. utilis* and similar variants. Certain types of well-developed *B. Hockii* woodland which are of consequence from the soil and economic standpoints have been differentiated for separate representation on the map. Minor types, however, such as the stunted *B. Hockii–I. paniculata* woodlands occurring on the central divide in North-Eastern Rhodesia, have been subordinated to the general regional type. Similarly no attempt has been made to differentiate the southern *Isoberlinia*

globiflora–Brachystegia woodlands into *B. Hockii* and *B. flagristipulata* types as in Henkel's Vegetation Map of Southern Rhodesia. If this were done a further *Isoberlinia–Uapaca* type would need to be shown and a corresponding degree of differentiation would be entailed in the other main regional classes.

26. It will be observed that the three types of " Northern " woodland of this class described are very similar in general composition apart from the *Isoberlinia* species associated with them. They coincide approximately, however, with certain broad differences in the Plateau Soils. The Northern *Brachystegia* woodlands are predominantly associated with clayey soils derived from the Katanga System, the Northern *Brachystegia–Isoberlinia globiflora* woodlands favour sandier soils from this System and the Northern *Brachystegia–Isoberlinia paniculata* woodlands occupy a variable range of soils derived principally from older formations. They are consequently conveniently retained as units for the large tracts of land which they cover.

27. The vegetation types summarised below are those which are of sufficient extent to be represented on a 1 : 1,000,000 scale. Thus the small belts of *Uapaca* bush which are frequently found about dambos in areas of *Brachystegia–Isoberlinia* woodland are not described. Similarly the various relict evergreen types outlined in NE 43–47 and 58 have been omitted. It has lately been established that marginal zones of the islands and shores of Lake Bangweulu originally carried high evergreen forest in which *Chrysophyllum* sp. and *C. argyrophyllum* were dominant components, the forest being subsequently replaced by evergreen *Syzygium* thicket with reduced *Chrysophyllum*. These types have now very largely been destroyed by native cultivation and as they can no longer satisfactorily be mapped they have been included (with similar relics elsewhere) in the " Chipya " vegetation that is replacing them. In the same way the *Bussea–Combretum* or " Itigi " thicket of the Mweru–Tanganyika lowlands and the open *Terminalia–Diplorrhynchus–Combretum* vegetation replacing it have been treated as a single unit. One omission, however, needs to be mentioned. A *Kirkia acuminata–Commiphora* type which is found on basalts in the Zambezi Valley near Livingstone and on similarly shallow soils lower down the Zambezi Valley has been mapped together with the *Copaifera mopani* vegetation with which it is associated, but with fuller survey should be described and represented as a separate type.

28. It would not be possible without a great deal of detailed survey to provide a satisfactory representation on the map of the various grassland types found through the great systems of watershed plains, flood-plains and river valley grasslands. A rather arbitrary physiographic basis of differentiation has therefore been adopted whereby watershed grass plains and other similar grassland types on the Kalahari Sands are distinguished from the grasslands of flood-plains and river valleys. Indications of the grassland types involved in these units are given below but they should not be regarded as representing single vegetation types in themselves.

29. Since vegetation survey in this Territory was begun various changes in botanical nomenclature have taken place. The names which were employed in the Reports of the Ecological Survey have been retained here to avoid confusion but the following revisions should be noted :

Brachystegia Hockii (*B. Randii* in Southern Rhodesia) revised to *B. spiciformis*.
B. flagristipulata (*B. woodiana* in Southern Rhodesia) revised to *B. Boehmii*.
Trichopteryx spp. revised to *Loudetia* spp.

In certain cases further co-ordination of names in use here and those accepted in East Africa remains desirable.

Evergreen and Semi-deciduous Types.

30. **Cryptosepalum Low Forest and Woodland.** Impenetrably dense low forest of the virtual evergreen, *Cryptosepalum pseudotaxus*, with numerous evergreens in the understorey and a sedge or moss ground-layer ; grading towards central Barotseland into woodland phases with *Brachystegia Hockii* or *B. longifolia* and *Copaifera coleosperma* associated. Partially replaced by secondary *Burkea africana* in Balovale District west of the Zambezi.—NW 48, 52 ; B 3, 8, 10.

31. **Marquesia and Marquesia–Brachystegia Woodlands.** Stands of the evergreen *Marquesia macroura*, either pure, with *Syzygium guineense* and other evergreens in the understorey, or mixed with *Brachystegia Hockii* or *B. longifolia*. Lesser unmapped occurrences of this type are associated with " Chipya " and Northern *Brachystegia* woodlands on the Bracken Sands in Mwinilunga District.—NW 41, 44, 49 ; NE 52, 58.

Brachystegia–Isoberlinia Woodlands (NW 41, 42 ; NE 48).

32. **Northern Brachystegia Woodlands.** *Brachystegia floribunda, B. longifolia* and *B. flagristipulata* the chief dominants according to soil type, with *B. wangermeeana* associated towards Mwinilunga. On the Mwinilunga Bracken Sands these species are replaced by *B. longifolia* and *B. Hockii* with *Cryptosepalum, Copaifera coleosperma* and other characteristic sand associates.—NW 43, 49, 200.

33. **Northern Brachystegia–Isoberlinia globiflora Woodlands.** Very similar, if often shorter, woodlands of *Brachystegia floribunda, B. longifolia* of the race *glaberrima, B. wangermeeana*, etc., but with *Isoberlinia globiflora* associated. *B. Hockii* is locally common and small *Marquesia* occurs.—NE 49.

34. **Northern Brachystegia–Isoberlinia paniculata Woodlands.** A third variant of these northern woodlands with *Brachystegia floribunda, B. longifolia* and locally *B. flagristipulata* the chief species in association with *Isoberlinia paniculata*.—NW 44, NE 50. (Description in NW 44 should be corrected, although *B. Hockii* is associated in some phases).

35. **Central Isoberlinia paniculata–Brachystegia Woodlands.** *Isoberlinia paniculata* generally dominant with *Brachystegia longifolia*, or occasionally *B. flagristipulata*, its chief associate, passing locally into *B. longifolia–B. Hockii* phases. The two last named, with local *Cryptosepalum* and *Copaifera coleosperma*, are associated on Kalahari Sands.—NW 45, 51 ; B 5–7 ; NE 51.

36. **Eastern Brachystegia–Isoberlinia Woodlands.** *Brachystegia Burttii* dominant with *Isoberlinia paniculata* or with *I. globiflora* towards lower levels and in the escarpments, where *B. Allenii* becomes increasingly common. *B. stipulata* is characteristic in the understorey and *B. flagristipulata* is also associated.—NE 53, 55, 56.

37. **Southern Isoberlinia globiflora–Brachystegia Woodlands.** *Isoberlinia globiflora* the chief species with *Brachystegia Hockii* and *B. flagristipulata* associated, the latter becoming dominant south of Zimba where it corresponds with Henkel's *B. woodiana* type. *B. tamarindoides* is present in escarpment hill country.—NW 46.

38. **Brachystegia Hockii Woodlands.** Well-grown woodlands of *Brachystegia Hockii*, pure or with *Isoberlinia globiflora*, are found in various transitions from the preceding woodlands towards other types of vegetation. *Marquesia* is present in higher rainfall examples and *Copaifera coleosperma* and belts of *Brachystegia bakeriana* are associated on Kalahari Sands in central Barotseland.—B 9, 11 ; NE 52, 57.

Other Deciduous Woodlands and Forests.

39. **Baikiaea plurijuga Forests.** *Baikiaea plurijuga* dominant, typically with a dense thicket understorey of *Combretum, Acacia* or *Commiphora* spp. Certain *Baikiaea–Pteleopsis* and similar forests towards Balovale have been included for mapping purposes ; *Pterocarpus Stevensonii* enters in Sesheke and Livingstone forests.—NW 53, 54 ; B 16–19.

40. **Burkea–Copaifera–Baikiaea types.** Variable woodlands of *Burkea africana* and *Copaifera coleosperma* with scattered *Baikiaea plurijuga*, passing in south Barotseland into *Baikiaea–Copaifera* mixtures with *Pterocarpus angolensis*, etc. Mixtures with *Brachystegia Hockii* are also found.—NW 53 ; B 13, 20.

41. **Burkea africana Woodlands.** *Burkea africana* pure or with *Erythrophloeum africanum, Pterocarpus angolensis* or other trees of the Kalahari Sands. *Combretum* spp. become associated in a *Burkea–Erythrophloeum* type on Transitional Sands in Namwala and Livingstone Districts.—NW 51 ; B 14.

42. **Allied Dialium Simii Woodlands.** *Dialium Simii* becomes dominant, with *Burkea africana* and other sand species associated, in a restricted type of very open woodland related to the above which is found in southern Sesheke District.—B 25.

43. **Copaifera mopani Woodlands.** " Mupane " woodland or scrub-woodland, generally pure but sometimes mixed with spiny *Commiphora* spp., *Terminalia* spp., etc., and grading locally into *Isoberlinia globiflora* or *Brachystegia* mixtures. *Kirkia–Commiphora* mixtures near Livingstone and in the lower Zambezi Valley have been included for mapping purposes.—NW 60 ; NE 68.

Deciduous Thicket Types.

44. **Bussea–Combretum Thicket and associated open vegetation.** Impenetrable thicket belts of *Bussea massaiensis, Combretum tetrandrum, Pseudoprosopsis Fischeri*, etc., the " Itigi Thicket " of Tanganyika Territory, giving place locally to open vegetation of a *Terminalia–Diplorrhynchus–Combretum* type.—NE 62.

45. **Commiphora–Combretum–Pterocarpus Thicket or Forest.** Dense thicket of *Commiphora* spp., *Combretum* spp., etc., with associated *Kirkia acuminata* or *Pterocarpus Stevensonii*, the latter attaining to forest growth in the lower Luangwa Valley and the Machili basin. An open *Commiphora–Euphorbia* type in Namwala District has been included for mapping purposes.—NW 59 ; NE 67.

High Grass-Woodland or " Chipya " Types.

46. **Erythrophloeum–Pterocarpus, etc., " Chipya " vegetation.** Very mixed tree growth of *Erythrophloeum africanum, Pterocarpus angolensis, Parinari mobola*, etc., with *Hymenocardia, Terminalia, Combretum, Diplorrhynchus* and other small trees in very tall grass and herbs. Dense evergreen *Syzygium* belts were formerly extensive in the

Bangweulu region, *Copaifera* and *Syzygium* are present in Kalahari Sand examples, and peculiar scrub phases of Chipya vegetation are found on the Bangweulu sandbanks. "Chipya Forest" mixtures with *Brachystegia–Isoberlinia* vegetation in the Copperbelt region have been included for mapping purposes.—NE 58–60, cf. NW 200; B 12.

47. **Combretum–Afrormosia and Pterocarpus–Combretum vegetation.** Various *Combretum* spp. with *Afrormosia angolensis*, *Terminalia torulosa*, *Ostryoderris Stuhlmannii* or *Pterocarpus angolensis*, *P. rotundifolius*, etc., forming scrub-woodland in tall grass. Semi-deciduous thicket belts of a *Combretum–Dalbergia* type are associated in North-Western Rhodesia.—NW 56, 57; NE 63, 64.

48. **Acacia–Combretum and allied vegetation.** *Acacia Woodii*, *A. campylacantha*, *A. heteracantha* or *A. albida* with associated *Combretum* and other elements of the last type in tall grass; *Combretum* phases predominate in instances towards the head of the Luangwa Valley. Represented on Transitional Sands in Sesheke District by *Acacia giraffae* mixtures with *Terminalia sericea*, *Burkea*, etc.—NW 58, cf. 54, B 14 (*a*); NE 65.

Bush-Group, Tree-Grassland and Scrub-Grassland Types.

49. **Hyphaene Palm country.** Belts of grouped or scattered *Hyphaene ventricosa* with associated *Terminalia sericea*, *Burkea africana*, *Acacia giraffae*, *Combretum*, etc., in low-lying grassland on the margins of the Transitional Sands.—NW 54.

50. **Copaifera mopani-grassland mixtures.** *Copaifera mopani*, often with *Acacia hebecladoides* or *Albizzia Harveyi*, on large termite mounds in grassland (Bush-Groups, *see* below) or sparsely distributed in seasonally swampy grassland.—NW 60.

51. **Bush-Group types of vegetation.** Small circular clumps of bush, generally about termite mounds, standing in seasonally damp or swampy grassland. Various–*Cryptosepalum*, *Brachystegia*, *Uapaca–Syzygium–Parinari*, *Parinari–Burkea*, *Burkea-Erythrophloeum*, *Acacia–Terminalia* and similar types are found as transitions between related woodland types and grassland vegetation.—NW 55, cf. NE 51, B. 14 (*e*), 24.

52. **Diplorrhynchus and other Scrub-Grasslands.** Various mixtures of *Diplorrhynchus mossambicensis*, *Hymenocardia*, short *Parinari*, *Uapaca*, *Protea*, *Combretum*, etc., scattered through short grasslands. *Diplorrhynchus* Scrub-Grasslands, passing sometimes into *Burkea*-grassland mixtures, occupy great expanses of the watershed plains of Barotseland, passing locally into Bush-Group vegetation.—NW 46, 51.

53. **Philippia Scrub-Grassland.** Scrub-grassland or moorland of *Philippia milanjiensis* with *Protea* sp., *Vellozia*, etc., and short sedge or grass growth on mountain summits in east Isoka District.—NE 8.

Grassland Types.

54. **Kalahari Sand Plain and Watershed Grasslands.** The great watershed sand plains of Barotseland carry short grassland of *Trychopteryx simplex* and similar wiry species, replaced by a taller *Tristachya* type in the Siluana Plains. The smaller and wetter circular plains of central Barotseland often contain a tussock *Miscanthidium* type. Both *Trychopteryx* and *Hyparrhenia* types are found on the Kalomo watershed grasslands.—NW 65, cf. 67; NE 71.

55. **Valley and Flood-Plain Grasslands.** *Trichopteryx simplex* and similar types occupy some valley grasslands and large areas of the flood-plains of the Chambezi-Bangweulu basin. A *T. Hitchcockii* type is found in and near the central Barotse Plain. Elsewhere, *Hyparrhenia* types are common, with a marked *H. rufa–Setaria* type on the Kafue Flats and other clayey flood-plains. A *Pennisetum glaucocladum* type is found on the inundated Lunga Plain area in the Bangweulu Swamps.—NW 65–67; NE 69, 70–72.

56. **Swamp and Papyrus Sudd.** Swamp grassland of *Miscanthidium teretifolium*, *Phragmites* reed-beds, Papyrus sudd, belts of other *Cyperus* spp. and, in deep water, *Eleocharis plantaginea* are well represented in the Bangweulu Swamps. *Oryza Barthii* and *Echinochloa stagnina* occupy lagoon areas in the Barotse Plain and elsewhere.—NW 67; NE 70, 73.

COLOURING AND NOTATION.

57. The land units represented on the map and set out in the accompanying key are the preceding vegetation types subdivided according to the major soil groups with which they are predominantly associated. Thus *Brachystegia–Isoberlinia* types on Kalahari Sands are represented in different colours from those on Plateau Soils, and these again distinguished from woodlands of the same class on Red Earths and Escarpment Hill Soils. Such a representation, however, entails a great number of mapping units, for which it has not been practicable to provide separate colours in all cases. A single colour, for example, has been adopted for all occurrences of the main *Brachystegia–Isoberlinia* types on Red Earths, the vegetation class into which each falls being that of the surrounding general type with the exception that a few examples near Mpika carry *Brachystegia Burttii*. One colour,

also, has been employed for the variable phases of these woodlands occupying the Escarpment Hill Soils, and the colouring used for the central *Isoberlinia paniculata–Brachystegia* woodlands on pallid sandy Plateau Soils has been extended to include eastern *I. paniculata–B. stipulata* woodlands on soils of the same class (NE 54). In other cases single colourings have been used for soil variants of the same vegetation type, as in the case of *Marquesia, Brachystegia Hockii* and *Erythrophloeum–Pterocarpus* (Chipya) vegetation on Plateau and Lake Basin Soils. In general the combinations used are those which have seemed best calculated to make for clarity in the colouring of the map ; with thirty-four tones derived from three primary colours this has necessarily been a deciding consideration.

58. At the same time, to facilitate reference to the key, a system of lettering and numbering of mapping units has been used, which is based on the predominant soil group of each type. The significance of the lettering is as follows :

R : Red Earths and related red loam soils.

(A red R has been used to show occurrences of soils of the Red Earth class in certain Chipya belts and the intrazonal chocolate-red loams in areas of Upper Valley Soils.)

B : Lake Basin and related soils.

P : Plateau Soils.

K : Kalahari Sands.

U : Upper Valley Soils.

L : Lower Valley Soils.

S : Grey and Black Swamp Soils.

(Mixed Grey Dambo Soils and shallow Plateau Soils of the Kalomo watershed grasslands included.)

SK : Related seasonally waterlogged soils of Kalahari Sand Plains.

SP : Shallow Plateau and ironstone soils of Scrub-Grassland types.

LP : Soils of Plateau class in Lower Valley regions.

s : Sandbanks of the Bangweulu type.

59. Except in the case of the complete surveys carried out through the Eastern and Western Province resettlement areas the colouring and limits of types should be regarded as built up from the framework of traverses shown in red on the map. Solid red lines have been employed for road traverses with the car mileometer and thinner red lines superimposed on broken lines for foot traverses by experienced observers. Thin red lines superimposed on dotted lines have been employed for other traverses on which information is less complete. Complete certainty, of course, is only attainable along the lines of full traverses. Solid colouring, however, is used in the representation of vegetation-soil types wherever proximity of traverses, supplementary native information or other evidence from topography, aerial maps, photographs, etc., allows the type to be represented with reasonable confidence. Other areas for which positive information is lacking but which allow of reasonable conjecture are covered by alternate coloured and white stripes. In certain cases, as with occurrences of Chipya based on unconfirmed native report, the area is too small to carry the stripes. In these cases, however, the intermittent broken line which is used to show conjectural limits of types has been used to provide the same indication. Much of the information so represented, notably in the Northern Province, will no doubt require revision at some future date when more complete survey is undertaken, but it has been felt of more value to indicate what may be expected to be found and should be looked for by such surveys than to adhere to a rigid principle of complete exclusion of partial evidence and inference generally.*

60. A number of stretches of country are occupied by combinations of two, or occasionally three, distinct types of vegetation which, owing to lack of detailed information, to the small size of the units involved or in certain cases to a simple admixture of two recognised types, cannot be given separate representation on the map. Combinations of grass plains with *Burkea* and *Diplorrhynchus* types of vegetation in west Barotseland, the various Bush-Group types of country referred to above, mixtures intermediate between certain of the major types of *Brachystegia–Isoberlinia* woodland and alternations of *Kirkia* (or *Copaifera mopani*) and *Brachystegia flagristipulata* vegetation north of Livingstone are examples of these cases. Such combinations of types are represented by alternate stripes of the appropriate colours. The stripe notation is also used for the scrub-grassland types. Only the latter are listed in the key, as with the combined types the colour combinations used are held to give sufficient indication of their nature. It is possible that the Kalomo watershed grasslands should have received a similar notation as having originally contained caps of scrub-grassland.

* Realignment of the Great North Road north of Mpika has lately revealed a large *Brachystegia Hockii* forest lying to the east of the old road, between points 11 and 4 miles south of the new junction with the Shiwa Ngandu road. A large tract of Bush-Group country has been observed from the air between the Kafue and the Barotse border, and *Hyphaene* Palm country has been detected near the north end of the Barotse Plain.

APPLICATION TO LAND USAGE

61. While the map is far from complete as a soil map, and makes no pretence to be so, it provides a means of land classification which may be applied directly to native agricultural practice and to the determination of agricultural and forest potentialities generally. It is not necessary to repeat the evidence for this here ; summary reviews of the potentialities of the great majority of the types of land depicted have already appeared in the sections on land utilisation and land resources in the Reports of the Ecological Survey. Reference may also be made to discussions of this aspect in *Kew Bulletin* No. 1, 1937, and NE 34–41, to the varying durations of native cultivation instanced in NE 95–103, to the results of yield-sampling in native maize gardens in the Southern Province and to the extensive practical application of the vegetation-soil unit in the estimation of land-carrying capacity which has been carried out by Allan in the resettlement schemes in the Eastern and Western Provinces.

62. The land units employed are therefore simply tabulated below with references to the relevant paragraphs in the Ecological Survey Reports. In the case of the earlier North-Western Report some revision or amplification of the potentialities of certain types is now desirable in the light of fuller knowledge, but in these cases it has generally been possible to make supplementary reference to the later Report on North-Eastern Rhodesia and to Martin's Barotseland Report. References to the latter are to paragraphs in the main body of the text. In order to provide a partial indication of the value and utilisation of the various types the references are preceded by abbreviations denoting the categories into which the land is considered to fall for purposes of traditional native land usage. These abbreviations are as follows :

Wst. : *Useless land*, which owing to shallowness of soil, seasonal waterlogging or in certain cases sheer poverty or intractability of soil, does not normally admit of cultivation.

Par. : *Partial cultivation land*, which is largely unsuitable for cultivation but may be used in native agriculture for either short or longer periods in restricted belts or patches of better soil.

Shf. : *Shifting cultivation land*, which is cultivated more extensively for short periods of three or four years or so, followed by a long rest of about twenty years for regeneration of the woodland.

Rec. : *Re-cultivation land*, which allows of cultivation for rather longer periods of four to six years or so in the first instance, after which it may be left for partial regeneration only while one or two other sites are cultivated. It is then returned to for further cultivation, after which a longer rest is needed.

Perm. : *Semi-permanent or permanent land*, which is generally cultivated for long periods of, e.g., eight to ten years at a time, separated by rests of corresponding duration, or is kept under a continuous alternation of cultivations and brief fallows.

63. These categories are of a relative character, for it will be obvious that, e.g., shifting cultivation land may be subjected to re-cultivation under conditions of congestion of population, or might be brought to a more permanent status by suitable treatment such as manuring. They depend, moreover, for their significance on the staple crop of the region concerned—the duration of cultivation is, properly speaking, a measure of the length of time for which the land is found productive for a particular crop. The distribution of staples, however, has already been set out in the Reports of the Ecological Survey (NW 89 sq., NE 112–122) and provided it is understood that the terms carry this implication they may be used to provide an approximate indication of the quality of the soil for native purposes.* In certain cases, in regions of *chitemene* agriculture, where the land is not used to its full capacity, the higher category has been employed.

64. In addition the following two abbreviations are used :

For : Land of present forestry importance or containing timbers of potential commercial value.

Pas : Land of present or potential pastoral importance. (Only wholly or partially fly-free types considered.)

Brackets are used where these aspects are of lesser promise or of local importance only. References to occurrences of certain minor forest products are also included.

* The three main categories of shifting cultivation, re-cultivation and semi-permanent or permanent land correspond with three determinable soil classes, namely (1) soils of a light and sandy (or locally, a raw clayey) type, of intrinsically low fertility, (2) light soils of a more favourable texture, with a higher organic content or of rather greater general fertility and (3) intrinsically fertile or productive soils of a " strong " texture with considerable staying power under cultivation.

Index of Land Resources.

EVERGREEN AND SEMI-DECIDUOUS TYPES.

65. *Cryptosepalum* Low Forest and Woodland on Kalahari Sands ... ... Shf.—NW 80, 129, 212; B 216, 338.

Marquesia and *Marquesia–Brachystegia* Woodlands:
(*a*) on Plateau Soils ... ... Shf.—NW 212; cf. NE 85.
(*b*) on marginal Lake Basin Soils ... ... Rec.—cf. NE 86, 87, 334.

BRACHYSTEGIA–ISOBERLINIA WOODLANDS.

Northern *Brachystegia* Woodlands:
(*a*) on Plateau Soils ... ... Shf.—NW 20–22, 74.
(*b*) on Kalahari Bracken Sands ... ... Shf. For.—NW 71, 72, 78, 200, 212.

Northern *Brachystegia–Isoberlinia globiflora* Woodlands on Plateau Soils ... ... Shf.—NE 76, 77, 81, 82, 389.

Northern *Brachystegia–Isoberlinia paniculata* Woodlands on Plateau Soils ... ... Shf. (For. Pas.)—NW 20–22, 72, 75, 212; NE 76, 77, 81, 82, 124, 125, 389.

Central *Isoberlinia paniculata–Brachystegia* Woodlands:
(*a*) on Plateau Soils ... ... Shf.—NW 20, 21, 76, 79, 212; NE 83, 95, 270, 389.
(*b*) on Kalahari Sands ... ... Shf. For.—NW 24, 25, 72, 80, 212.

Eastern *Brachystegia–Isoberlinia* Woodlands:
(*a*) on Plateau Soils ... ... Shf. (Pas.)—NE 75, 95, 96, 124, 125, 389.
(*b*) on allied Lower Valley Soils ... ... Wst.
(*c*) on Escarpment Hill Soils ... ... Wst./Par. — NE 256 sq., 389.

Southern *Isoberlinia globiflora–Brachystegia* Woodlands:
(*a*) on Plateau Soils ... ... Shf. (Pas.)—NW 20–22, 77, 109, 111.
(*b*) on Kalahari Sands ... ... Shf. (For.)—NW 77, 128.
(*c*) on Escarpment Hill Soils ... ... Wst./Par.—NW 77, 127.

Brachystegia Hockii Woodlands:
(*a*) on Plateau Soils ... ... Shf./Rec. (For.)—NE 85, 334.
(*b*) on marginal Lake Basin Soils ... ... Shf./Rec. For. (Pas.)—NE 86, 124, 125, 334, 389.
(*c*) on Kalahari Sands (including *B. bakeriana*) Shf. For.—NW 24, 25; B 11, 12, 122, 133, 247.
(*d*) on marginal Upper Valley Soils ... ... Rec./Perm. (For.)—NE 98, 99, 332, 415.

Undifferentiated *Brachystegia–Isoberlinia* Woodlands:
(*a*) on Red Earths and allied red loams... ... Rec./Perm. (For.)—NW 23, 71, 74, 200; NE 13, 14, 84, 97.
(*b*) on Escarpment Hill Soils ... ... Wst./Par.—NW 127; NE 256.

OTHER DECIDUOUS WOODLANDS AND FORESTS.

Baikiaea plurijuga Forests on Transitional Kalahari Sands ... ... Shf. For.—NW 26, 72, 82, 200, 212, 423, 426; B 12.

Burkea–Copaifera–Baikiaea types on Kalahari Sands Par./Shf. For.—NW 24, 25, 72, 81, 200; B 11 (*b*), 133, 178, 256.

Burkea africana Woodlands on Kalahari Sands ... Wst./Par. For.—NW 24, 72, 81, 141; B 11 (*c*), 266.

Allied *Dialium Simii* Woodlands on Kalahari Sands Wst.

Copaifera mopani Woodlands

(*a*) on brown Lower Valley Soils, skeletal soils, etc. ... ... Wst.—NW 31, 33, 85.

(*b*) on grey alluvial clays ... ... Wst.—NW 38, 85.

DECIDUOUS THICKET TYPES.

Bussea–Combretum Thicket and associated open vegetation on soils of Lake Basin type ... ... Shf.—NE 91.

Commiphora – Combretum – Pterocarpus Thicket or Forest :

(*a*) on Transitional Kalahari Sands ... ... Shf. For.—NW 26, 82 ; NE 423, 426.

(*b*) on Lower Valley Karroo Sands ... ... Shf.—NW 32, 85 ; NE 422–426.

HIGH GRASS-WOODLAND OR " CHIPYA " TYPES.

Erythrophloeum–Pterocarpus, etc., Chipya vegetation:

(*a*) on Lake Basin and allied soils ... ... Rec./Perm. For. (Pas.)—NE 77, 78, 87–90, 125, 333, 334, 399, 400, 415–417, 421, cf. NW 200.

(*b*) on Bracken and allied Kalahari Sands and sandbanks ... ... Shf. Pas. For.—NW 71, 78, 111, cf. NE 89 ; B 12, 122, 180 ; NE 78.

(*c*) on soils of Red Earth class ... ... Perm. For. (Pas.)—NW 75, 200 ; NE 13.

Combretum–Afrormosia and *Pterocarpus–Combretum* vegetation :

(*a*) on Upper Valley Soils ... ... Rec./Perm. (For.) Pas.—NW 28, 29, 83, 84, 109 ; NE 75, 100, 101, 270, 332, 408, 410, 415.

(*b*) on allied chocolate-red loams ... ... NE 75, 100, 101, 270.

Acacia–Combretum and allied vegetation :

(*a*) on Upper Valley Soils ... ... Rec./Perm. Pas.—NW 30, 83, 84, 109, 110.

(*b*) on Transitional Kalahari Sands ... ... Shf./Rec. (Pas.)—NW 26, 82, 109, 161, 172.

(*c*) on Lower Valley and other alluvium ... Perm. (Pas.)—NW 34, 85, 109, 111, 179, 210 ; NE 102, 103, 396, 397, 407–412, 415, 420.

BUSH-GROUP, TREE-GRASSLAND AND SCRUB-GRASSLAND TYPES.

Hyphaene Palm country on marginal Transitional Sands ... ... Wst./Par. (Pas.)—cf. NW 109.

Copaifera mopani-Grassland mixtures on grey alluvial clays ... ... Wst.—NW 85.

Bush-group types of vegetation :

(*a*) on Grey Dambo Soils ... ... Par.—NW 114, 122 ; NE 158, 270.

(*b*) on Kalahari Sand Plains ... ... Wst./Par.

(*c*) on Transitional Sand Plains ... ... Par.—NW 159.

Diplorrhynchus and other Scrub-Grasslands :

(*a*) on Plateau and ironstone soils ... ... Wst. (Pas.)

(*b*) on Kalahari Sand Plains ... ... Wst.—NW 15 ; B 11 (*c*), 227, 256.

Philippia Scrub-Grassland on mountain summits ... Wst.

GRASSLAND TYPES.

Kalahari Sand Plain and Watershed Grasslands ... Wst./Par. (Pas.)—NW 15, 24, 86, 111, 143 sq. ; B 11 (*c*), 265.

Valley and Flood-Plain Grasslands ... ... Par. Pas.—NW 35–37, 71, 86, 109, 110, 143 sq., 172, 219–221, 229 ; NE 92–94, 104, 228 sq., 360, 394.

Swamp and Papyrus Sudd ... ... Wst.

66. The abbreviations used in the preceding table do not, of course, provide a full indication of the possibilities of the various types of land, particularly with regard to the development of new or specialised European crops. For these reference should be made to the paragraph citations from the reports concerned and to the sections in them dealing with economic crops. Having regard to soil qualities and general productivity, the following may be regarded as the principal land assets represented on the map :

R : *Brachystegia–Isoberlinia* Woodlands on Red Earths and allied soils on the Northern Plateau in North-Western Rhodesia and to a lesser extent on the Abercorn plateau—certain plantation crops.

R : *Brachystegia–Isoberlinia* Woodlands on red loams and adjoining soils in the Fort Jameson sector of the Eastern Plateau—maize soils, also used for flue-cured tobacco.

B 1, 4 : *Erythrophloeum–Pterocarpus*, etc., Chipya vegetation, with adjoining *Marquesia* belts, on Lake Basin Soils in the Chambezi–Bangweulu basin, in the lower Luapula Valley and elsewhere—various plantation crops.

K 11 : *Erythrophloeum–Pterocarpus* Chipya vegetation and adjoining land on the Bracken Sands of the north Mwinilunga highlands—pastoral and certain plantation crops.

U 2, 3 : *Combretum–Afrormosia* and *Acacia–Combretum* vegetation on Upper Valley Soils in the lower Kafue Basin and south of Broken Hill, the *Acacia* type being the more fertile of the two—pastoral and maize soils.

U 1, 2 : *Pterocarpus–Combretum* vegetation and adjoining *Brachystegia Hockii* belts on Upper Valley Soils in Petauke and Fort Jameson Districts—maize, Burley tobacco, etc.

L 3 : *Acacia–Combretum* and allied vegetation on Lower Valley alluvium in the Luangwa, Lunsemfwa–Lukusashi and lower Zambezi Valleys—cotton, certain cereals, sun-cured tobacco, etc.

S 5 : Certain Valley and Flood-Plain Grasslands, notably the Kafue Flats and the Barotse Plain—pastoral and locally cereal crops. (If capable of reclamation from inundation, the Lunga Plain area of the Bangweulu Swamps would be included.)

With these, of much lower fertility but of present importance, must be included :

P 5, 7 : Southern *Isoberlinia globiflora–Brachystegia* Woodlands on Plateau Soils, and probably portions, at least, of the Central *Isoberlinia paniculata–Brachystegia* Woodlands where the rainfall is not too high—flue-cured or Turkish tobacco.

P 6 : Eastern *Brachystegia–Isoberlinia* Woodlands on Plateau Soils in Fort Jameson and Petauke Districts—flue-cured or Turkish tobacco.

The map does not, of course, show the intricate system of small dambo grasslands which follow the courses of lesser rivers and streams. Some of these, together with the seepage zones of plain margins in the Kalahari region, are of considerable agricultural value, particularly for dry-season cultivation (*vide* NW 143–150, 219–221 ; NE 92–94, 341, 342).

67. Land of potential forestry importance has a different distribution, the following types on the whole being the best stocked with indigenous timbers :

K 2 : Northern *Brachystegia* Woodlands on Kalahari Bracken Sands in north Mwinilunga District (*Pterocarpus*, *Erythrophloeum*, *Faurea*, *Albizzia*, etc. ; well-grown *B. Hockii* and *I. tomentosa*).

B 2 : *Brachystegia Hockii* Woodlands on Lake Basin Soils in several Districts in the Northern Province (*Pterocarpus*, *Erythrophloeum*, *Afrormosia*, *Albizzia* ; well-grown *B. Hockii* and *I. tomentosa*).

K 5 : *Brachystegia Hockii* Woodlands and mixtures with adjoining types on Kalahari Sands in central Barotseland (*Pterocarpus*, *Copaifera*, *Parinari*, *Erythrophloeum*, though now much depleted).

R, etc. : *Brachystegia–Isoberlinia* Woodlands and adjoining " Chipya Forest " types on Red Earths and associated soils in the Copperbelt and Solwezi regions (*Faurea*, *Albizzia*, *Pterocarpus*, *Erythrophloeum*, *Syzygium*, etc. ; well-grown *B. Hockii* and *I. tomentosa*).

K 6 : *Baikiaea plurijuga* Forests on Transitional and allied Kalahari Sands in south Barotseland and Livingstone and Balovale Districts (*Baikiaea*, largely exploited).

K 7 : *Burkea–Copaifera–Baikiaea* types on Kalahari Sands in central and south Barotseland and Livingstone District (*Pterocarpus*, *Baikiaea*, *Copaifera*, *Ricinodendron*, *Afzelia*, etc.).

B 4 : *Erythrophloeum–Pterocarpus*, etc., Chipya vegetation on Lake Basin Soils in the Chambezi–Bangweulu basin, the lower Luapula Valley and elsewhere (*Pterocarpus*, *Erythrophloeum*, *Albizzia*, *Afrormosia*, *Afzelia*, etc.).

K 11 : *Erythrophloeum–Copaifera–Syzygium* " Sikone " forests of the Chipya type on Kalahari Sands in central Barotseland (*Syzygium, Copaifera, Erythrophloeum, Parinari, Pterocarpus, Afzelia*).

The following types, also, while generally of lesser value, are of local importance :

K 3 : Central *Isoberlinia paniculata–Brachystegia* Woodlands on Kalahari Sands in Balovale District and locally in south Barotseland (*Pterocarpus, Erythrophloeum, Copaifera,* etc.).

K 8 : *Burkea africana* Woodlands on Kalahari Sands in north Kalabo District and on Transitional Sands in Namwala District (*Pterocarpus, Erythrophloeum,* etc.).

To these must be added the ordinary Northern *Brachystegia–Isoberlinia paniculata* Woodlands of the Copperbelt (P 4), which, although containing inferior species, provide the bulk of the timber used by the Mines. A restricted but valuable type, not represented on the map, is also found in the strips of Evergreen Fringing Forest (Mushitu, Litu) which are distributed along streams and dambos in North Eastern and northern parts of North-Western Rhodesia (NW 201, NE 45–47, 335 ; *Syzygium, Xylopia, Mitragyna, Khaya,* etc.).

68. Development of land resources in the Territory hitherto has largely been confined to the better agricultural areas and tobacco lands adjoining the railway line and towards Fort Jameson and to the Livingstone–Sesheke and Copperbelt forests. It is hoped that this map will serve to draw attention to a wider range of possibilities in the future. Mention may, for example, be made of the potential value of the remarkable forest and agricultural land of the Chipya tracts of the Chambezi–Bangweulu basin, similar if less extensive possibilities in the insufficiently known Red Earth areas of the Solwezi region and the forestry importance of various woodland types on the Kalahari Sands of Barotseland, Balovale and Mwinilunga. At the same time it should be made clear that many of these areas are at present wasting assets which are deteriorating under the influence of late fires, uncontrolled cultivation and destruction of their more valuable timbers. Extended measures for their conservation and proper utilisation will be necessary if the country is to obtain the benefit of its resources.

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