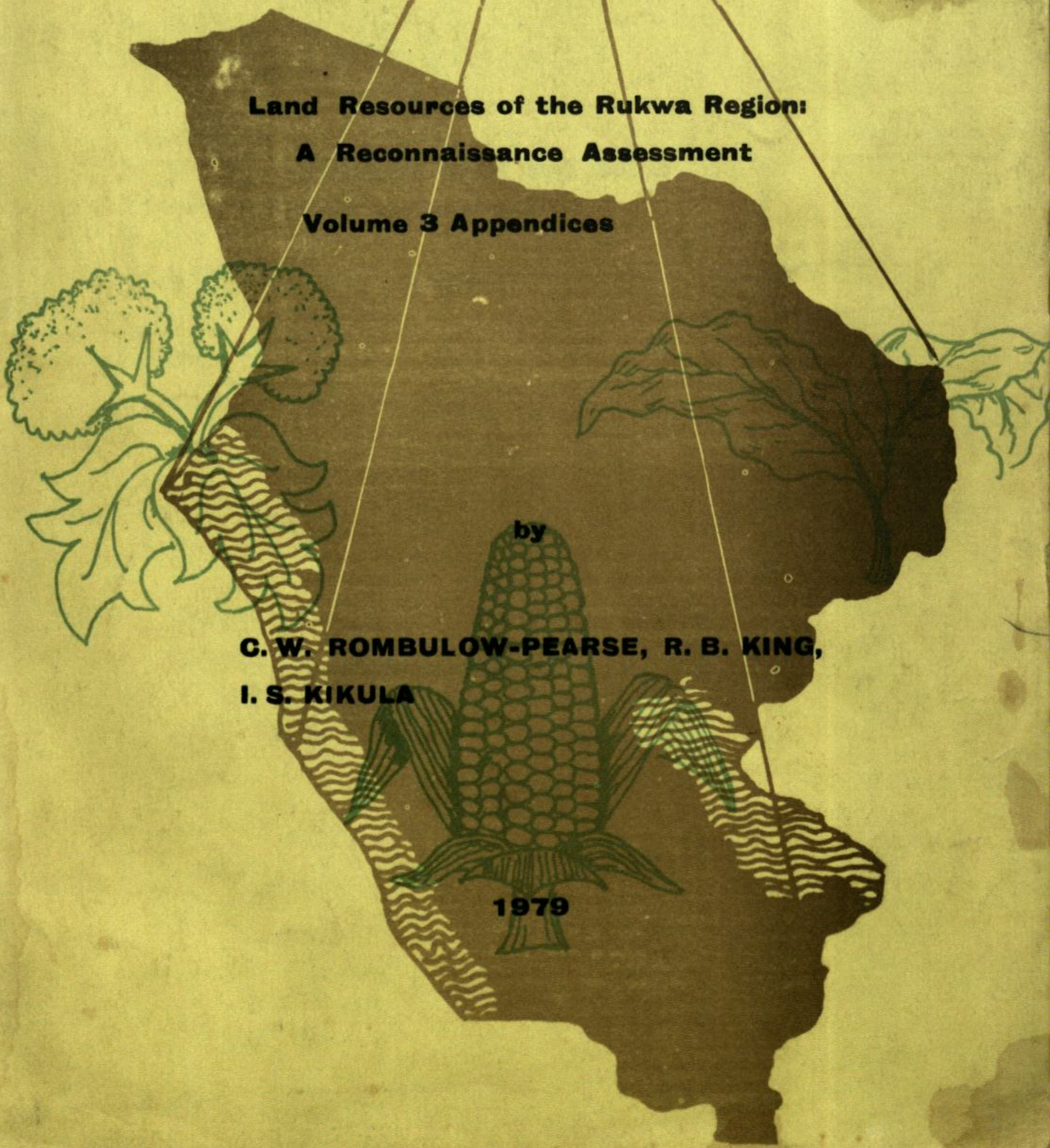
Bureau of Resource Assessment
and Land use Planning
University of Dar es Salaam

Land Resources of the Rukwa Region: A Reconnaissance Assessment

Volume 3 Appendices



by

C. W. ROMBULOW-PEARSE, R. B. KING,
I. S. KIKULA

1979

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LAND RESOURCES OF THE RUKWA REGION: A RECONNAISSANCE ASSESSMENT.

VOLUME 3 APPENDICES

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CONTENTS

Page

APPENDIXES

FIGURES

APPENDIX 1

FURTHER METHODS OF SURVEY

FURTHER DESCRIPTIVE ITEMS

(a) Vegetation: The units for classifying East African Rangeland after Pratt and coworkers (1966).

(b) Gilgae: the terms used by Harris (1959).

(c) Plant indicators: the conditions indicated by individual plant species after Lind and Morrison (1974), Napper (1965) and Brenan and Greenway (1949).

METHODS OF LABORATORY ANALYSIS (unless otherwise indicated)

The Buoyoucos hydrometer method of particula· size analysis; Walkely and Black for organic C%; Kjeldahl for total N%; NH_4F and HCl for available P; 1 in 5 soil water mixtures for PH and conductivity measurements; NH_4O Ac extraction for exchangeable bases and the exchange capacities by summation.

METHODS FOR ESTIMATING LAND SUITABILITY

Each soil unit was graded into the following four classes (FAO, 1976): highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) for the intensive production of specific arable crops. Guides to crop requirements were Acland (1971), Agricultural Division (undated), Jakobsan (1979) and Akehurst (1961): and guides to relative soil productivity were CCTA (1964), Young (1976) and Anderson (1973).

In addition to these guides, the following standard land qualities were used for the grading (FAO, 1976): erosion potential (limitation e), available soil moisture (limitation m), available soil nutrients (limitation n), available oxygen in the root zone (limitation o), rooting depth (limitation r) and soil temperature (limitation t.). Additional limitations were used for Map 11 (Suitability for rice): moisture excess (limitation m") and ease of levelling or land shaping (limitation l (replacing limitation e). Map 12 (Suitability for irrigation) limitations were reduced to: depth to sand, gravel, hardpan, water table or slowly permeable clay (limitation d), moisture holding capacity (limitation m) and slope (limitation s (replacing limitation e). Limitations e and t are discussed under "Land Suitability Maps (Maps 8-12)" in the 'Soils and Land Suitability' section. Limitations r,n,o and m are discussed below:

1. Rooting depth

The effective soil depth classes limited by the materials, which prevent root development after Sir W Halcrow and Partners (1962) including saline and sodic materials.

(a) Saline materials: highly saline horizons graded from conductivity measurements after Sir W Holdrow and Partners (1962).

(b) Sodic materials: horizons with exchangeable sodium percentages (ESPs) exceeding 15% (Young, 1976; Anderson, 1963). ESPs of 6-15% (Szaboles, 1971) or sodium and magnasium saturation exceeding a total of 25% were included with other indicators of slow permeability (Rembulow-Pearse, 1978).

The restriction of traditional cultivation to finger millet production with the "chitemene" system (Young, 1976) was used as evidence of a shallow rooting depth.

2. Available nutrients

The following weighted averages in the surface 30 cm of soil were calculated from the laboratory analytical data (details in Appendix 5):

TABLE 1 SOIL AVAILABLE NUTRIENT GRADING

Grade	CEC me/100g	K me/100g	aBase saturation%	P ppm	Clay %
3	< 9		NO		<15
2	9-14	L I M I T A T I O N S			
1	> 14	> 0.4	> 70%	7^+	> 15

+ NH_4F + HCl. The equivalent values for other methods of p extraction were 10 ppm (Olsen), 100 ppm (Bray and Kurtz No. 4) and 31 (0.3 N. HCl).

The "Land use factor" (Appendix 2) was also used as evidence of grade 4 (Alllan, 1965). The restriction of cultivation to finger millet production was used as an indicator of marginal fertility.

~~For flue-cured tobacco production a grade 3 soil for available nutrients was grade~~ 1 if the soil was an Albic Arenosol and grade 2 another arenosol or a Ferralsol (adapted from Akehurst, 1961).

3. Oxygen availability in the root zone

The standard effective depth classes limited by waterlogged material as indicators of drainage conditions (adapted from Federal Department of Conservation and Extension, 1963 and Soil Survey Staff, 1961): grade 1, well drained; grade 3, imperfectly drained with waterlogged material within the depth interval 50-100 cm; grade N, poorly drained. Waterlogged material was as defined for hydromorphic properties after FAO/UNESCO (1974).

4. Available soil mositure

A drought index adapted from Dagg (1972): the percentage of years, in which the ratio of R/E_o is less than 0.5 in months critical for local maize varieties (Papadakis, 1970). "R" is the total of the monthly rainfall and the moisture store in the preceding month and "E" is Penman E_o (Woodhead, 1970). The critical months were the month of planting (December), the month of tasselling (March on the Ufipa Plateau and February elsewhere) or the month following it. The index was used for grading the climate as follows in relation to areas, which are known to be liable to drought; some consideration also being given to freely drained soils, vegetation and the ecological zones of Kenya (Pratt and coworkers, 1966; Anon., 1974):

Grade 3 (marginal): the drought index is equal to or exceeds 20%. Vegetation generally grassland with scattered *A.albida* trees, or dry forms of woodland,+

Grade 2 (moderately available): the drought index is less than 20%. Vegetation generally *Brachystegia-Julbernardia* type woodland.

Grade 1 (very available): drought index 0, assumed to occur with "moist forest", not found in the region.

In addition these potential grades were modified as follows for actual soil moisture availability: Soil-physiographic unit 3.1 was assumed to have a good moisture holding capacity and to make use of a moisture store during dry months (Young, 1976). It was allocated grade 2. Well drained alluvial soils, influenced by groundwater with usually giant grass in the vegetation were assumed to be grade 1. The grasses were often *Penisetum* and trees were *A. polycantha* subsp. *campylacantha* or

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+ *A. tortilis* subsp. *spiracarpa* woodland or *Sterculia-Sclerocarya-Lonchocarpus* woodland.

A. albida. If the drought index was grade 3, the trees Combretum and the grasses Hyparrhenia, the soil moisture availability was assumed to be S2. These tree species seem to occur in moister situations in the region.

APPENDIX 2

LAND USE FACTOR

The land use factor was defined by Allan (1965) as follows:

> "The relationship between the duration of cultivation on each of the land or soil units used in classification and the period of subsequent rest required for the restoration of soil fertility".

It is experessed as the number of areas in cultivation at any one time, and may be used in connection with the following classes of "cultivation land".

1. "Permanent cultivation land"; the strongest and most fertile soils with a land use factor of 2 or less, and a brief fallow often interposed after 3 or 4 years of cropping to control weeds and preserve structure.

2. "Semi-permanent cultivation land"; the cropping period is followed by a short fallow of similar duration, a further period of cultivation and a longer period of fallow at least twice the cultivation period. A land use factor of 2.5-3.

3. "Recurrent cultivation land"; the cultivation period is 2-6 years with a fallow of 6-30 years. The land use factor is 4-10, and respectively 3-5, 5-7 and 7-10 for short, medium and long term recurrent cultivation lands.

4. "Shifting cultivation land"; the land use factor is over 10. The soil is so poor that one, two, or at the most three years of cultivation must be followed by a very long fallow period of the order of 20-30 years for the regeneration of woodland or the restoration of fertility.

APPENDIX 3

SOIL PROFILES

The soil profiles shown in Map 7 are listed and classified according to soil-physiographic unit, FAO/UNESCO Units for the Soil Map of the World (FAO/UNESCO, 1974) and the Soil Taxonomy Ststem (Soil Survey Staff, 1975). The land system in which the profile is found is also indicated. Typic Ustorthents, which are not agriculturally suitable, have not been given a soil-physiographic unit.

Profile number	Soil-physiographic unit	Soil Map of the World Unit	Soil Taxonomy System	Land system
SA 1	3.5	Cambic Arenosol	Typic Ustipsamment	A11d
SA 2	3.2	Orthic Ferralsol	Typic Eutrustox	A11d
SA 3	3.1	Ferric Luvisol	Typic Haplustalf	A11d
SA 4	3.2	Orthic Ferralsol	Typic Eutrustox	A10i
SA 6	3.2	Orthic Ferralsol	Typic Eutrustox	A10i
SA 7	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A10n
SA 8	3.2	Orthic Ferralsol	Typic Eutrustox	A10o
SA 9	3.8	Medium Ferralic Cambisol	Oxic Ustropept	A10p
SA 10	3.2	Orthic Ferralsol	Typic Eutrustox	A11d
SA 11	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A10l
SA 12	3.2	Orthic Ferralsol	Typic Eutrustox	A11d
SA 13	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A11b
SA 14	3.2	Orthic Ferralsol	Typic Eutrustox	A9e
SA 15	3.5	Cambic Arenosol	Typic Ustipsamment	A11b
SA 16	-	Lithosol	Typic Ustorthent	A11c
SA 17	3.5	Cambic Arenosol	Typic Ustipsamment	A11b
SA 18	3.5	Cambic Arenosol	Typic Ustipsamment	A11a
SA 19	3.5	Cambic Arenosol	Typic Ustipsamment	A11b
SA 21	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A10o
SA 22	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A11h
SA 23	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A9f
SA 24	3.1	Ferric Luvisol	Typic Haplustalf	A9f
SA 25	2.3	Fine Eutric Fluvisol	Typic Ustifluvent	A13a
SA 26	3.2	Orthic Ferralsol	Typic Eutrustox	A9j
SA 27	3.2	Orthic Ferralsol	Typic Eutrustox	A10n

Profile number	Soil-physiographic unit	Soil Map of the World Unit	Soil Taxonomy System	Land system
SA 28	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A9f
SA 29	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A9f
SA 30	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A9g
SA 31	3.2	Gleyic Orthic Ferralsol	Typic Eutrustox	A11f
SA 32	3.5	Cambic Arenosol	Typic Ustipsamment	A11f
SA 33	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A11f
SA 34	3.2	Orthic Ferralsol	Typic Eutrustox	A9o
SA 35	3.2	Orthic Ferralsol	Typic Eutrustox	A9o
SA 36	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A13m
SA 37	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A10o
SA 38	3.2	Orthic Ferralsol	Typic Eutrustox	A11i
SA 39	3.5	Cambic Arenosol	Typic Ustipsamment	A11i
SA 40	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A11k
SA 41	3.2	Orthic Ferralsol	Typic Eustrustox	A11m
SA 42	3.2	Orthic Ferralsol	Typic Eutrustox	A11o
SA 43	3.2	Orthic Ferralsol	Typic Eutrustox	A11o
SA 44	3.2	Orthic Ferralsol	Typic Eutrustox	A11l
SA 45	3.7	Coarse Eutric Gleysol	Tropaquent	A11p
SA 46	3.2	Orthic Ferralsol	Typic Eutrustox	A11q
SA 47	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A9s
SA 48	3.2	Orthic Ferralsol	Typic Eutrustox	A9l
SA 49	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A11j
SA 50	3.7	Medium Eutric Gleysol	Tropaquent	A11j
SA 51	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A11j
SA 52	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A9g
SA 53	3.8	Medium Ferralic Cambisol	Oxic Ustropept	A11f
SA 54	3.2	Orthic Ferralsol	Typic Eutrustox	A9r
SA 55	3.2	Orthic Ferralsol	Typic Eutrustox	A9r
SA 56	3.3	Xanthic Ferralsol	Tropeptic Eutrustox	A11f
SA 57	3.7	Coarse Eutric Gleysol	Tropaquent	A9e
SA 58	3.3	Xanthic Ferralsol	Tropeptic Eutrustox	A9e
SA 59	3.3	Gleyic Xanthic Ferralsol	Tropeptic Eutrustox	A9e
SA 60	3.2	Orthic Ferralsol	Typic Eutrustox	A9e
SA 61	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A9b
SA 62	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A9b

Profile number	Soil-physio-graphic unit	Soil Map of the World Unit	Soil Taxonomy System	Land system
SA 63	3.8	Medium Ferralic Cambic	Typic Fluventic Ustropept	A9e
SA 64	3.3	Xanthic Ferralsol	Typic Eutrustox	A9e
SA 65	3.5	Cambic Arenosol	Typic Ustipsamment	A11a
SA 66	3.5	Cambic Arenosol	Typic Ustipsamment	A13f
SA 67	-	Eutric Gleysol	Typic Ustorthent	A13a
SA 68	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A13a
SA 69	2.1	Fine sodic Eutric Gleysol	Tropaquent	A13a
SA 70	2.1	Medium sodic Eutric Gleysol	Tropaquent	A13a
SA 71	2.1	Medium sodic Eutric Gleysol	Tropaquent	A13a
SA 72	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A13a
SA 73	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A13a
SA 74	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A13a
SA 75	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A13a
SA 76	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A13a
SA 77	3.8	Coorse Ferralic Cambisol	Oxic Ustropept	A13j
SA 78	1.1	Coarse Eutric Regosol	Mollic Ustipsamment	A7o
SA 79	1.3	Sodic Eutric Regosol	Typic Ustipsamment	A7o
SA 80	1.1	Coarse Eutric Regosol	Mollic Ustipsamment	A7o
SA 81	1.2	Medium eutric Fluvisol	Mollic Ustifluvent	A7o
SA 82	1.1	Coarse Eutric Fluvisol	Mollic Ustipsamment	A7o
SA 83	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
SA 84	1.3	Gleyic Solonetz	Natric Aqualt	A7o
SA 85	1.3	Gleyic Solonetz	Natric Aqualt	A7o
SA 86	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A7o
SA 87	1.4	Cambic Arenosol	Typic Ustipsamment	A7o
SA 88	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
SA 89	1.4	Cambic Arenosol	Typic Ustipsamment	A7o
SA 90	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7y
SA 91	1.4	Cambic Arenosol	Typic Ustipsamment	A7y
SA 92	1.1	Medium Eutric Fluvisol	Mollic Ustipsamment	A7y
SA 93	1.4	Cambic Arenosol	Typic Ustipsamment	A7o
SA 94	1.3	Gleyic Solonetz	Natric Aqualt	A7x
SA 95	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7y
SA 96	1.3	Sodic Eutric Regosol	Typic Ustipsamment	A7y
SA 97	1.3	Gleyic Solonetz	Natric Aqualt	A7x
SA 98	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
SA 99	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
SA 100	1.1	Coarse Eutric Regosol	Mollic Ustipsamment	A7o

Profile Number	Soil-physiographic unit	Soil Map of the World Unit	Soil Taxonomy System	Land System
SA 101	2.1	Medium sodic Eutric Gleysol	Tropaquent	A7o
SA 102	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A7o
SA 103	1.3	Gleyic Solonetz	Natric Aqualt	A7y
SA 104	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A11d
SA 106	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A11d
SA 107	3.5	Cambic Arenosol	Typic Ustipsamment	A11f
SA 108	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A11f
SA 109	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A9e
SA 110	3.7	Medium Eutric Gleysol	Tropaquent	A11e
SA 111	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A9e
SA 112	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A11k
SA 113	2.1	Fine sodic Eutric Gleysol	Tropaquent	A11k
SA 114	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A11l
SA 115	2.3	Coarse Eutric Fluvisol	Typic Ustifluvent	A11l
SA 116	2.1	Fine sodic Eutric Gleysol	Tropaquent	A11k
SA 117	3.2	Orthic Ferralsol	Typic Eutrustox	A11i
SA 118	3.2	Orthic Ferralsol	Typic Eutrustox	A11i
SA 119	2.3	Fine Eutric Fluvisol	Typic Ustifluvent	A13a
SA 120	3.2	Orthic Ferralsol	Typic Eutrustox	A13m
SA 121	3.2	Orthic Ferralsol	Typic Eutrustox	A13m
SA 122	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A13a
SA 123	2.3	Fine Eutric Fluvisol	Typic Ustifluvent	A13a
SA 124	3.2	Orthic Ferralsol	Typic Eutrustox	A11d
SA 125	3.8	Coarse Ferralic Cambisol	Fluventic Ustropept	A11o
MP 1	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A4i
MP 2	3.1	Ferric Luvisol	Oxic Haplustalf	A4i
MP 3	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A5b
MP 4	3.2	Orthic Ferralsol	Typic Eutrustox	A2i
MP 5	3.7	Medium Eutric Gleysol	Tropaquent	A2i
MP 6	3.8	Chromic Cambisol	Fluventic Ustropept	A13a
MP 7	3.8	Chromic Cambisol	Fluventic Ustropept	A13a
MP 8	2.2	Fine Eutric Fluvisol	Aeric Ustifluvent	A13a
MP 9	2.1	Fine sodic Eutric Fluvisol	Vertic Fluvaquent	A13a
MP 10	2.1	Fine sodic Eutric Fluvisol	Vertic Fluvaquent	A13a
MP 11	2.1	Fine sodic Eutric Fluvisol	Vertic Fluvaquent	A13a
MP 12	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A13a
MP 13	2.1	Fine sodic Eutric Fluvisol	Vertic Fluvaquent	A13a
MP 14	2.2	Pellic Vertisol	Typic Pellustert	A13a
MP 15	2.3	Medium Eutric Fluvisol	Typic Ustifluvent	A13a
MP 16	2.1	Fine sodic Eutric Fluvisol	Vertic Fluvaquent	A13a
MP 17	3.5	Cambic Arenosol	Typic Ustipsamment	A4o

Profile number	Soil-physiographic unit	Soil Map of the World Unit	Soil Taxonomy System	Land System
MP 19	3.8	Chromic Cambisol	Fluventic Ustropept	A7f
MP 20	3.8	Medium Ferralic Cambisol	Fluventic Ustropept	A7f
MP 21	2.3	Fine Eutric Fluvisol	Aquic Ustifluvent	A4c
MP 22	2.4	Sodic Eutric Cambisol	Aquic Ustropept	A7b
MP 23	2.2	Fine Eutric Fluvisol	Vertic Ustifluvent	A7a
MP 24	3.5	Cambic Arenosol	Typic Ustipsamment	A5b
MP 25	3.2	Orthic Ferralsol	Typic Eutrustox	A5d
MP 26	3.2	Orthic Ferralsol	Typic Eutrustox	A5d
MP 27	3.3	Xanthic Ferralsol	Typic Eutrustox	A5d
MP 28	3.5	Cambic Arenosol	Typic Ustipsamment	A2e
MP 29	3.6	Gleyic Cambic Arenosol	Aquic Ustipsamment	A1b
MP 30	3.2	Orthic Ferralsol	Typic Eutrustox	A1c
MP 31	2.1	Medium sodic Eutric Gleysol	Tropaquent	A7e
MP 32	3.7	Coarse sodic Eutric Gleysol	Tropaquent	A7c
MP 33	3.2	Orthic Ferralsol	Typic Eutrustox	A7c
MP 34	3.5	Cambic Arenosol	Typic Ustipsamment	A5b
MP 35	3.3	Xanthic Ferralsol	Typic Eutrustox	A5d
MP 36	3.2	Orthic Ferralsol	Typic Eustrustox	A2i
MP 37	3.5	Cambic Arenosol	Typic Ustipsamment	A2j
MP 38	3.2	Orthic Ferralsol	Typic Eutrustox	A2e
MP 39	3.5	Cambic Arenosol	Typic Ustipsamment	A4i
MP 40	3.1	Ferric Luvisol	Oxic Haplustalf	A4i
MP 41	3.8	Medium Ferralic Cambisol	Oxic Ustropept	A4i
MP 42	3.1	Ferric Luvisol	Oxic Haplustalf	A4i
MP 43	3.2	Orthic Ferralsol	Typic Eutrustox	A4i
MP 44	3.2	Orthic Ferralsol	Typic Eutrustox	A5e
MP 45	1.4	Cambic Arenosol	Typic Ustipsamment	A7l
MP 46	3.3	Xanthic Ferralsol	Typic Eutrustox	A6j
MP 47	3.9	Pellic Vertisol	Typic Pellustert	A6j
MP 48	3.1	Ferric Luvisol	Oxic Haplustalf	A6l
MP 49	3.2	Orthic Ferralsol	Typic Eutrustox	A5e
MP 50	3.5	Cambic Arenosol	Typic Ustipsamment	A5e
MP 51	1.3	Eutric Regosol	Typic Ustipsamment	A7l
MP 52	1.4	Cambic Arenosol	Typic Ustipsamment	A7l
MP 53	1.3	Gleyic Solonetz	Tropaquent	A7l
MP 54	3.5	Cambic Arenosol	Typic Ustipsamment	A4i
MP 55	3.2	Orthic Ferralsol	Typic Eutrustox	A5c
MP 56	3.3	Xanthic Ferralsol	Tropeptic Eutrustox	A5c
MP 57	2.3	Medium Eutric Fluvisol	Aquic Ustifluvent	A4h
MP 58	3.5	Cambic Arenosol	Typic Ustipsamment	A4h

Profile number	Soil-physiographic unit	Soil Map of the World Unit	Soil Taxonomy System	Land system
MP 59	3.3	Xanthic Ferralsol	Eutrustox	A7d
MP 60	3.2	Orthic Ferralsol	Tropeptic Eutrustox	A7d
MP 61	3.8	Chromic Cambisol	Fluventic Ustropept	A7f
MP 62	3.2	Orthic Ferralsol	Typic Eutrustox	A2i
MP 63	3.5	Cambic Arenosol	Typic Ustipsamment	A2e
MP 64	3.7	Coarse Eutric Gleysol	Tropaquent	A2e
MP 65	3.2	Orthic Ferralsol	Typic Eutrustox	A2e
MP 66	3.2	Orthic Ferralsol	Typic Eutrustox	A4i
MP 70	1.4	Cambic Arenosol	Typic Ustipsamment	A7l
MP 71	3.8	Chromic Cambisol	Fluventic Ustropept	A4f
MP 72	3.2	Rhodic Ferralsol	Typic Haplustox	A4f
MP 73	3.2	Orthic Ferralsol	Typic Eutrustox	A4f
MP 75	3.8	Medium Ferralic Cambisol	Flurentic Ustropept	A4f
MP 76	3.2	Orthic Ferralsol	Typic Eutrustox	A4f
MP 77	3.2	Orthic Ferralsol	Typic Eutrustox	A4b
MP 78	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
MP 79	2.1	Medium sodic Eutric Gleysol	Tropaquent	A7o
MP 80	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
MP 81	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7o
MP 82	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7l
MP 83	1.3	Eutric Regosol	Typic Ustipsamment	A7p
MP 84	1.3	Eutric Regosol	Typic Ustipsamment	A7p
MP 85	1.3	Eutric Regosol	Typic Ustipsamment	A7p
MP 86	1.3	Gleyic Solonetz	Natric Aqualt	A7e
MP 87	1.3	Gleyic Solonetz	Natric Aqualt	A7e
MP 88	1.2	Medium Eutric Fluvisol	Mollic Ustifluvent	A7e
MP 89	1.4	Cambic Arenosol	Typic Ustipsamment	A7l
MP 90	1.3	Eutric Regosol	Typic Ustipsamment	A7l
MP 91	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7l
MP 92	1.3	Sodic Eutric Regosol	Typic Ustipsamment	A7r
MP 93	1.3	Gleyic Solonetz	Natric Aqualt	A7m
MP 94	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7l
MP 95	1.3	Sodic Calcaric Regosol	Typic Ustipsamment	A7r
MP 96	1.4	Cambic Arenosol	Typic Ustipsamment	A7t
MP 97	1.3	Sodic Eutric Regosol	Typic Ustipsamment	A7t
MP 98	1.3	Calcaric Regosol	Typic Ustipsamment	A7v
MP 99	1.3	Gelyic Solonetz	Natric Aqualt	A7v
MP 100	1.3	Gleyic Solonetz	Natric Aqualt	A7v

Profile number	Soil-physio-graphic unit	Soil Map of the World Unit	Soil Taxonomy System	Land System
MP 101	1.4	Cambic Arenosol	Typic Ustipsamment	A7v
MP 102	1.3	Coarse Eutric Fluvisol	Typic Ustipsamment	A7u
MP 103	1.4	Cambic Arenosol	Typic Ustipsamment	A7l
MP 104	1.3	Gleyic Solonetz	Natric Aqualt	A7l
MP 105	3.2	Orthic Ferralsol	Typic Eutrustox	B1b
MP 106	3.3	Xanthic Ferralsol	Tropeptic Eutrustox	B1b
MP 107	3.7	Coarse sodic Eutric Gleysol	Tropaquent	B1b
MP 108	3.5	Cambic Arenosol	Typic Ustipsamment	B1b
MP 109	3.4	Albic Arenosol	Spodic Quartzipsamment	B1g
MP 110	3.5	Ferralic Arenosol	Ustoxic Quartzipsamment	A2k
MP 111	3.2	Orthic Ferralsol	Typic Eutrustox	A2k
MP 112	3.7	Coarse sodic Eutric Gleysol	Tropaquent	B1d
MP 113	2.1	Fine sodic Eutric Gleysol	Tropaquent	B1d
MP 114	3.4	Albic Arenosol	Spodic Quartzipsamment	B1d
MP 115	3.4	Albic Arenosol	Spodic Quartzipsamment	B1d
MP 116	3.5	Cambic Arenosol	Typic Ustipsamment	B1d
MP 117	3.4	Albic Arenosol	Spodic Quartzipsamment	B1b
MP 118	3.7	Medium sodic Eutric Gleysol	Tropaquent	B1b
MP 119	3.4	Albic Arenosol	Spodic Quartzipsamment	B1b
MP 120	3.5	Cambic Arenosol	Typic Ustipsamment	B1d
MP 121	3.4	Albic Arenosol	Spodic Quartzipsamment	B1b
MP 122	3.5	Cambic Arenosol	Typic Ustipsamment	A6b
MP 123	3.7	Medium sodic Eutric Gleysol	Tropaquent	A5h
MP 124	3.4	Albic Arenosol	Spodic Quartzipsamment	A5h
MP 125	3.7	Medium sodic Eutric Gleysol	Tropaquent	A5h
MP 126	3.4	Albic Arenosol	Spodic Quartzipsamment	A5g
MP 127	3.5	Cambic Arenosol	Typic Ustipsamment	B1g
MP 128	3.4	Albic Arenosol	Spodic Quartzipsamment	B1b
MP 129	3.4	Albic Arenosol	Spodic Quartzipsamment	B1b

APPENDIX 4

FURTHER SOIL DESCTIPTIONS

Profile SA 1 (Cambie Arenosol)

Location, Kiwite, 31° 37'E, 7° 59'S; a fallow on a convex slope of abour 5% on an interfluve of a dissected piedmont; altitude 1908m; large rounded termitoria 100m apart; parent materials: sandy sediments; well drained.

Ap	0-18cm	Very dark grey (5YR 3/1) moist and dry; loamy sand; moderate very fine granular; non-sticky, non-plastic, very friable, very soft; very fine and fine herb and grass roots; wavy gradual boundary.
B1	18-43cm	Reddish brown (5YR 4/3) moist and brown (10YR 5/5) dry; loamy sand; weak fine granular; consistence as above; common fine and very fine roots; wavy clear boundary.
B2	43-100cm	Colour as above; sandy loam; weak medium subangular blocky, tending to be massive; slightly sticky, slughtly plastic, friable, hard and brittle when dry, possibly reversably cemented; many fine simple tubular pores; common very fine roots; wavy gradual boundary.
at	100cm	Orange to dark red, hard, irregular nodules, black in cross-section, tightly packed; can only be chipped out with a pick.

Profile SA 9 (medium Ferralic Cambisol)

Location, Mbizi Forest Reserve, 31° 41' 30"E, 7° 53' 40"S; altitude 2168m; landform: hilly, a convex slope of 7%; vegetation: a grade of Andropogon grassland surrounded by Euphorbia sp. forest; well drained.

A	0-30cm	Dark yellowish brown (10YR 3/4) moist; sandy loam; common mica flakes; fine granular; abundant roots; diffuse boundary.
B	30-100cm (Auger)	Yellowish red (5YR 5/6) moist; sandy loam; common mica flakes; common roots; diffuse boundary.
BC	100-120cm(+) (Auger)	As above, but soft, highly weathered greiss dominant with the rock strata clearly visible and abundant mica; roots still fairly common.

Profile SA 21 (Orthic Ferralsol)

Location, 31° 40'E, 8° 8'S; fallow on a convex slope of 9% on the interfluve of a rolling plain; altitude 1814m; parent materials forming in place from gneiss; well drained.

A	0-25cm	Dark reddish brown (5YR 3/3) moist and dry; sandy loam; moderate medium granular; non-sticky, slightly plastic, very friable, slightly hard; abundant fine to very fine roots; smooth diffuse boundary.
AB	25-55cm	Dark red (2.5YR 3/6) moist and dry; sandy clay loam; moderate medium subangular blocky; slightly sticky; plastic, friable, very hard; weakly developed shiny surfaces on peds and in pore linings; common fine roots; diffuse boundary.
B	55-110cm	Red moist (2.5YR 4/6) and dry (2.5YR 4/8); sandy clay loam; moderate fine granular; slightly sticky, slightly plastic, friable, very hard; common small pisolites; ped coatings as above; very few fine roots; abrupt boundary.
R	110cm+	Massive hardened nodular ironstone.

Profile SA 45 (Coarse Eutric Gleysol)

Location, Kitete, 31° 59'E, 8° 40'S; an almost flat valley bottom on a very gently undulating plain; vegetation: grassland with scattered Parinari trees; parent materials: sandy sediments; poor drainage; altitude 1470m.

A	0-20cm	Light brownish grey (10YR 3/2) moist and grey (10YR 6/1) dry; with faint root iron stains; loamy sand; fine granular; non-sticky, non-plastic, very friable, loose; abundant very fine roots; gradual boundary.
B	20-140cm (Auger)	Light grey (10YR 7/2) moist and dry fine sand; fine strong brown (7.5YR 5/8) mottles becoming distinct with depth.

Profile SA 70 (medium Eutric Gleysol)

Location, Kirando, 30° 38"E, 7° 23"S; altitude 770m; landform: foodplain; microtopography: the surface covered by small mounds of alluvium collecting round grass tussocks; slope 1/2%; vegetation; Echinocloa seasonally flooded and waterlogged tall grassland; parent materials: river alluvium overlying a lake depost; drainage: very poor.

A1	0-20cm	Colour as below; loam with low bulk density; mounds of debris about 1/2m high collecting round grass tussocks; wavy gradual boundary.
A2r	20-35cm	Very dark grey (10YR 3/1) moist and grey (10YR 5/1) dry; root iron stains; sandy clay loam; moderate medium granular structure; slightly sticky, slightly plastic, friable, slightly hard; numerous fine root holes; common opaque whitish fragments in the sand fraction; abundant fine roots; abrupt to clear wavy boundary.
AG	35-60cm	Brown (7.5YR 5/3) wet and pinkish grey (7.5YR 7/3) dry; the colour being dominated by the colours of the sand grains; coase to medium sand; single grained; common roots; clear wavy boundary.
AC2	60-120cm	Colours as above; medium sand, becoming coarse with depth; few roots.
AC3	120-160cm	Colours as above; faintly mottled; fine sand; very few roots; water table at 150cm.

<u>Profile SA 76</u> (Eutric Cambisol, sodic phase)

Location, 30° 37' E 7° 20' S; a grass fallow, common weeds being <u>Hyparrhenia</u> sp. and <u>Imperata cylindrica</u>; altitude 770m; landform: a flat lacustrine terrace; parent materials: riverine alluvium overlying lacustrine sediments; imperfect drainage.

A	0-45cm	Black (10YR 2/1) moist and grey (10YR 5/1) dry; loam; moderate medium granular; sticky, slightly plastic, friable, hard; common fine tubular pores, abundant fine mica flakes; abundant roots, clear smooth boundary.
2B	46-90cm (Auger)	Very dark grey (10YR 3/1) moist, unmottled; dark grey (10YR 4/1) dry with common, fine, distinct and clear reddish brown (5YR 4/4) mottles along root holes; sandy clay; coarse strong subangular blocky; very sticky, very plastic, firm, extremely hard; common fine tubular pores, abundant fine mica flakes; common roots.
3BC	90-120cm (Auger)	Very dark greyish brown (10YR 3/2) moist, unmottled; greyish brown (10YR 5/2) dry with common, fine, distinct and clear yellowish brown (10YR 5/4) mottles; texture and consistence as above; few weathered black and red rock fragments; few fine roots.

Profile SA 79 (Eutric Regosol, sodic phase)

Location, 31° 48' E, 7° 47' N; altitude 811m; landform: floodplain on a lacustrine plain; slope 0%; vegetation: Cynodon short grassland with scattered patches of A. tortilis subsp. spiracarpa and Hyphaene; parent materials: lacustrine underlying riverine alluvium.

A	0-7cm	Very dark grey (10YR 3/1) moist and grey (10YR 5/1) dry; loamy sand; fine granular; non-sticky, non-plastic, very friable, loose; abundant roots; clear boundary.
AC	7-110cm	Very dark brown (10YR 2/2) moist and very dark greyish brown (10YR 4/2) dry with grey (10YR 6/1); loam; medium moderate subangular blocky; sticky, slightly plastic, firm, hard; few fine tubular pores; whitish deposit in cracks and on ped surfaces; common roots; diffuse boundary.
3C	110-150cm+	Dark yellowish brown (10YR 4/4) moist and yellowish brown (10YR 5/4) dry; single grained, non-sticky, plastic, loose.

Profile SA 82 (coarse Eutric Fluvisol)

Location, Mtoisa, 32° 46' 30 E, 7° 48' 10 N; altitude, 871m; landform: lacustrine terrace; vegetation: a fallow derived from A. tortilis subsp. spiracarpa-A. polyacantha subsp. campylacantha-Lonchocarpus woodland with a ground cover of giant Panicum; parent materials: lacustrine alluvium with some hillwash from the escarpment nearby; drainage: good probably influenced by goundwater, the soil being still moist at the end of September.

Ap	0-20cm	Black (10YR 3/2) moist and dark greyish brown (10YR 4/2) dry; loamy fine sand; non-sticky, non-plastic, loose, slightly hard; very fine and medium granular; few mica flakes; common roots; clear boundary.
A2	20-40cm	Dark brown (7.5YR 3/2) moist and dry (7.5YR 4/2); loamy sand; non-sticky, non-plastic, loose, very hard; weak fine granular; numerous pores and opaque fragments of fine gravel size; common roots; gradual smoooth boundary.

AC 40-140cm+ Dark brown (7.5YR 3/3) moist and brown (7.5YR 5/3) dry with pale yellow (2.5YR 8/4) patches; slightly gravelly sand composed of angular quartz and opaque fragments; consistence and structure as above; roots still common.

<u>Profile SA 90</u> (coarse Calcaric Regosol, sodic phase)

Location, 32° 14' E, 8° 18' S; altitude 874m; landform: a depression on a lacustrine plain; vegetation: Gardenia (?) ("nyonganzwi") A. <u>tortilis</u> subsp. <u>spiracarpa-Cynodon</u> bushed grassland; parent materials: lake beds; poor drainage.

AC1 0-24cm Very dark greyish brown (10YR 3/2) moist and light brownish grey (10YR 6/2) dry; loamy sand; fine granular non-sticky, non-plastic, loose; abundant roots; clear boundary.

2AC2 24-110cm Dark olive grey (5Y 3/2) moist and olive grey (5Y 5/2) dry with light grey (10YR 7/1) towards the outside of the peds; sandy clay; medium subangular blocky; very sticky, very plastic, firm, hard; few small irregular whitish calcareous nodules, few fine tubular pores; calcareous; common roots; clear boundary.

3C 110-170cm Olive (5Y 4/3) moist and olive yellow (5Y 6/2) dry in the matrix with light grey towards the outside of peds; clay; medium subangular blocky; very sticky, very plastic firm, hard and difficult to dig; white snail shells common; calcareous; few fine tubular pores; few fine roots; diffuse boundary.

3C 170-230cm+ (Auger) As above, but common small whitish calcareous nodules which are red in cross-section.

<u>Profile MP II</u> (fine Eutric Fluvisol, sodic phase)

Location, Karema, longitude 30° 26' 20"E, 6° 48' 50"S; altitude 770m; landform: high floodplain bench; slope 0%; vegetation: <u>Hyparrhenia</u> tall grassland; parent materials: river alluvium.

AI 0-5cm Black (10YR 2/1) moist and very dark grey (10YR 3/1) dry; sany clay loam; strong fine and medium granular; slightly sticku, slightly plastic, friable, slightly hard; abundant fine rotts; clear smooth boundary.

A2 5-30cm Very dark grey (10YR 3/1) moist and very dark greyish brown (10YR 3/2) dry; clay; strong coarse and medium subangular blocky; plastic, sticky, friable, hard abundant fine tubular simple pores; diffuse wavy boundary.

ACI 30-47cm Very dark grey (5YR 3/1) and dark brown (7.5YR 3/2) moist with few, faint, fine yellowish red (5YR 5/6) mottles; dark (10YR 4/2) and very dark (10YR 3/2) greyish brown dry with mottles as above but 5YR 4/8; clay; strong very coarse prismatic; very plastic, very sticky, firm, very hard; shiny surfaces towards the tip and bottom of the prisms, which are probably pressure faces; many fine simple tubular pores; many fine pale specks like fine sand; common fine roots; cracked to this layer; diffuse wavy boundary.

AC2 47-120cm Mottled black (10YR 2/1) and dark brown (7.5YR 4/4) moist, and very dark grey (10YR 3/1) and yellowish brown (7.5YR 4/6) dry, the darker material filling root holes and the spaces between the peds; clay; fine prismatic; breaking into pyramidal subangular blocks; fine gravel sized quartz crystals; few fine roots.

C 120cm+ (Auger) Mottled black (5YR 2/1) and reddish brown (5YR 4/4) moist, and yellowish brown (7.5YR 4/6) and dark reddish brown (5YR 2/2) dry; slightly gravelly clay; consistence as above, no pores; abundant fine mica flakes; slightly calcareous; few fine roots.

<u>Profile MP 21</u> (fine Eutric Fluvisol)

Location, Sibwesa, 30° 44' 30"E, 6° 29' 40"S; altitude 1105m slope: 0.5%; landform: floodplain; a fallow in <u>A. polycantha</u> subsp. <u>campylacantha</u> <u>Hyparrhenia</u> wooded giant grassland; imperfect drainage.

1 0-20cm Black (5YR 2.5/1) moist and dark brown (7.5YR 4/2) dry; sandy clay; strong medium subangular blocky; sticky, plastic, friable, slightly hard; common mica flakes; cracked; abundant fine roots; wavy diffuse boundary.

2 20–78cm Black (5YR 2.5/1) moist and very dark grey (5YR 3/1) dry; clay; weak coarse prismatic, breaking into moderate subangular blocky; consistence as above but very hard; common very fine tubular pores; fewer mica flakes; common reddish brown soft nodules (2.5YR 4/4) dry; common fine roots; wavy clear boundary.

3r 78–125cm Black (7.5YR 3/1) moist and dark reddish brown (5YR 3/2) dry with yellowish red (5YR 5/6) mottles; sandy clay; medium granular; consistence as above; nodules as above; but more mica; few fine roots; water table at 125 cm.

4 125–130cm+ Dark brown (10YR 3/3) moist with reddish brown (2.5YR 4/4) mottles; sandy clay loam; slightly sticky and slightly plastic, friable; waterlogged; common fine mica flakes.

<u>Profile MP 22</u> (Eutric Cambisol, sodic phase)

Location, 30° 53'E 6° 30'S; landform: lacustrine terrace; altitude 1032m; parent materials: probably riverine alluvium overlying lake sediments; vegetation; <u>Pterocarpus</u> woodland with <u>Sclerocarya</u> and <u>Combretum</u>; imperfect drainage.

A 0–12cm Very dark grey (10YR 3/1) moist and dark grey (10YR 4/1) dry; sandy loam; weak fine and medium subangular blocky and fine granular, and smooth spherical units probably created by termites; slightly sticky, slightly plastic, very firable, hard; abundant fine roots; termites; common; smooth gradual boundary.

B 12–36cm Dark grey (10YR 4/2) moist with many faint, small, clear and yellowish brown (10YR 5/8) mottles; texture, structure and consistence as above; common fine roots; smooth gradual boundary.

2BC 36–105cm Grey (10YR 5/1) moist with many, distinct small, clear to diffuse, dark yellow brown (10YR 4/6) mottles; clay; moderate fine subangular blocky, becoming stronger with depth and the block faces shiny; stickly, plastic, firm, very hard; common fine roots; clear smooth boundary.

2C	105-125cm+	Dark brown (10YR 4/3) moist and dry faintly mottled brownish yellow (10YR 6/8); texture and consistence as above, but becoming gravelly with depth; massive and very diffuoult to dig; pisolites increasing with depth; small and large, yellow brown and very hard few very fine roots, becoming rotless with depth.

Profile MP 23 (fine Eutric Fluvisol)

Location: Iloba, 30° 30' 40"E, 6° 31' 30"S; altitude 1017m; slope 1% landform: a high floodplain bench; vegetation: Hyparrhenia giant grassland.

AI	0-5cm	Black (7.5YR 2/0) moist and dark grey (10YR 4/1) dry; clay loam; moderate medium subangular blocky; sticky, plastic, firm, hard; common termites; common fine roots; clear smooth boundary.
Ar2	5-75cm	Very dark grey (5YR 3/1) moist and grey (5YR 5/1) dry; few medium faint diffuse mottles, very dark greyish brown (10YR 3/2) moist and dark greyish brown (10YR 4/4) dry; clay; strong medium subangular blocky, aggregated into very coarse weak prisms, 10-20cm long separated by cracks, which are less than 1cm wide; very plastic, very sticky, friable, very hard; common fine and medium tubular, simple and continuous pores, possibly termite holes; ped surface and pores covered with smooth shiny clay material, possibly a termite secretion; termites and fine roots common; clear wavy boundary.
ACr1	75-100cm	Dark reddish brown (5YR 3/2) moist unmottled; and mottled light grey (7.5YR 6/1), strong brown (7.5YR 4/2) dry, faint, diffuse fine to medium; clay; strong fine to medium subangular blocky, some peds pyramidal and others almost angular blocky; very hard, firm, very sticky, very plastic; common very fine pores as above; ped and pore coatings as above; common fine roots; clear wavy boundary.

2ACr2 100cm+ Dark brown (mottled 7.5YR 3/4 and 3/4) moist; dry, colours as above, but brown (7.5YR 4/6) and light grey dominant distinct, fine, medium and clear; clay loam; slightly calcareous.

<u>Profile MP 32</u> (coarse Eutric Gleysol, sodic phase)

Location: Mpamda Prison Farm, 30° 55 E, 6° 22"S; altitude 1038m; slope 2%; landform: the lower slopes of a piedmont; parent materials: hillwash over la e beds; vegetation: rice fallow, cleared from "Brachystegia-Julbernardia" type woodland; poorly drained.

AI 0-15cm Very dark grey (5YR 3/1) moist and grey (5YR 5/1) dry; sand; fine granular; non-sticky, non-plastic, very friable, soft; abundant fine roots; clear wavy boundary.

ABr 15-50cm Dark reddish grey (5YR 4/2) moist and grey (5YR 5/1) dry, with few, distinct, fine clear yellowish brown (10YR 5/8) mottles; abundant very fine roots; coarse sand; medium granular; consistence as above; abundant very fine roots; smooth clear boundary.

2Br 50-80cm Reddish grey (5YR 5/2) moist and dry with common distinct, fine clear, yellowish brown (10YR 5/8) mottles; coarse sandy loam; coarse granular; slightly sticky, non-plastic, loose and soft; common fine roots; diffuse boundary.

2BC 80-110cm+ Reddish grey (5YR 5/2) moist and dry; many prominent medium, clear, yellowish brown (10YR 5/8), dark reddish brown (2.5YR 2.5/4) and very dusky red (2.5YR 2.5/2) mottles; sandy clay; coarse granular; sticky, plastic, friable, hard; common, soft, dark reddish brown (2.5YR 2.5/4) nodules; very few fine roots.

<u>Profile MP 71</u> (Chromic Cambisol)

Location, Mwese, 30° 19 20"E, 6° 12 20S"at an altitude of 1836m; fallow sloping at 5% on the convex crest of an interfluve on a dissected piedmont below a quartzite inselberg; parent materials: hillwash derived from a mixture of quartzite and amphibolite; vegetation in the vicinity was Acacia siebeliana-Combretum-Panicum-Penisetum wooded giant grassland.

A	0–26cm	Dark reddish brown moist (5YR 2/2) and dry (5YR 3/4) loam; medium moderate granular; non-sticky, non-plastic, friable, soft, abundant roots; clear wavy boundary.
B	26–87cm	Dark reddish brown (2.5YR 3/4) moist and dark red (2.5YR 3/6) dry; sandy loam; medium granular and weak subangular blocky; non-sticky, non-plastic, friable, soft, common fine tubular pores; common mica flakes and quartzose fragments; common fine roots; diffuse boundary.
2C1	87–107cm	Gravel and small stones made of fresh and weathering fragments of amphibolite and quartzite.
3C2	107–159cm	Dark red (2.5YR 3/6) moist and red (2.5YR 4/8) dry; gravelly sandy loam; structure and consistence as above; many fragments of weathered rock, mainly amphibolites; roots still common.

<u>Profile MP 80</u> (medium Eutric Fluvisol)

Location: Mamba, 31° 21' 30"E, 7° 20' 0"S; altitude 913m; landform: a piedmont sloping at 1/2% on an almost flat lacustrine plain; vegetation: a fallow with <u>Lonchocarpus</u> regenerating; well drained.

A1	0–20cm	Black (5YR 2/1) moist and dark greyish brown (5YR 4/2) dry; loam; fine granular; non-sticky, slightly plastic, friable, slightly hard; common fine mica flakes; abundant medium to very fine roots; clear wavy boundary.
A2	20–75cm	Dark reddish brown (5YR 3/1) moist and reddish brown (5YR 5/3) dry; sandy clay loam; slightly sticky, slightly plastic, slightly firm, very hard; moderate medium subangular blocky; common fine in-ped pores; common medium to fine roots, diffuse wavy boundary.
AC	75–110cm	Dark reddish brown (5YR 3/1) moist and reddish brown (5YR 5/3) dry; sandy clay; sticky, plastic, slightly firm, very hard; moderate medium subangular blocky; common fine mica flakes and small dark brown weathered fragments of rock; common fine in-ped pores, few fine roots.

APPENDIX 5

SOIL NUTRIENT AVAILABILITY

INTRODUCTION

The availability of soil nutrients, or "soil fertility" was a land quality, required for the grading of land suitability. Only three classes were allowed for this, as more would have been incompatable with the scale of the mapping, and trends were required rather than the precise status of certain areas of land.

The agricultural productivity of the arable units for the "Soil Map of Africa" has already been roughly graded qualitatively into about three groups (CCTA, 1964). The units have equivalent names in the "Soil Map of the World" (FAO/UNESCO, 1974). The analytical data of the soils from Rukwa Region, which represent them, can also be graded roughly as indicators of the availability of soil nutrients. They also fall into three groups, which correspond to the soil units. The latter therefore can be used as criterial for the availability of soil nutrients.

Although arable soils are the important ones for grading, those which are unsuitable or marginally suitable on account of poor drainage, alkali or salt, also need grading as a guide to their value for improvement or reclamation.

LITERATURE REVIEW

Some criteria for grading analytical data have been documented by:

Mehlich and Coworkers (1964) for available potassium;
Black and coworkers (1965) for available phosphorus;
Rijkebusch and Osborne (1965) for organic carbon;
Anon. (1974) for clay;
ibid., Young (1976) and Rijkebusch and Osborne (1965) for cation exchange capacity.

Some qualitative productivity grades for the "Soil Map of Africa" may be found in CCTA (1964). Gradings for the units for the "Soil Map of the World" do not appear to have been published (FAO/UNESCO, 1974).

MATERIALS AND METHODS

Three suitability classes were chosen for arable soils: SI, very suitable; S2n, moderately suitable; and S3n, marginally suitable (FAO, 1976).

Arenosols and Ferralsols ("Ferrallitic soils" or "Ferruginous tropical soils on loose sandy sediments") were regarded as of low productivity (CCTA, 1964). Ferric Luvisols ("Ferruginous tropical soils on materials rich in ferromagnesian minerals") were regarded as of medium productivity (CCTA, 1964; Young, 1976), and Eutric Fluvisols ("Juvenile soils on recent alluvium") as of high productivity (ibid.).

The following analytical data were extracted from the data sheets for the surface 30cm of all the Rukwa samples, as potential indicators of the availability of nutrients (Anon., 1974): clay%, base exchange capacity, available potassium and phosphorus, organic carbon% and base saturation. They were tabled under the soil unit for the Soil Map of the World to which they belonged, the unit having been already identified in the field from the standard examination of profile pits.

The selected analytical data were compared with the published productivities of the different soil units in order to establish criterial for the three classes of soil nutrient availability.

RESULTS AND DISCUSSION

The analytical data and the corresponding units for the Soil Map of the World are shown in Table 1.

One group of soils has a clay% less than about 15, exchange capacity below about 9 me/100g, and potassium and organic carbon contents respectively 2me/100g, and 1% or less. These are all low figures (Mehlich and coworkers, 1964; Anon., 1974 Rjkebusch and Osborne, 1965). The exchange capacity compares with about 8me/100g, which is the minimum for a reasonable sisal soil (Rijkebusch and Osborne, 1965). Some of the samples were base unsaturated.

The soils comprising this group were the Arenosols, and those of other units, particularly the Ferralsols, with coarse surface layers. The productivity of the units equivalent to the Arenosols and Ferralsols in the Soil Map of Africa is generally low (CCTA, 1964). The units, therefore, which comprise this group have all been graded S3n, marginally suitable, with respect to soil nutrients. The grade of some Cambic Arenosols and coarse Eutric Fluvisols may sometimes be higher, because the contents of potassium and organic carbon can be quite high (Table 1).

If the clay% was greater than 15, and the exchange capacity was below about 9me/100g, the soils were all Ferralsols. These are roughly equivalent to the Ferrallitic soils in the Soil Map of Africa, with a low productivity (CCTA, 1964; Young, 1976). The potassium and organic carbon contents in Table 1 tended to be slightly higher, the former being generally 2-4me/100g and the latter 1-2% with some lower figures. Although these are low-medium levels (Mehlich and coworkers, 1964; Young, 1976), the exchange capacities of the group were no different in the sandier soils and some were also base unsaturated. The soil unit comprising the group therefore was also graded S3n.

If clay% exceeded 15 and the exchange capacity exceeded about 9me/100g, the contents of potassium and phosphorus were higher still, the former exceeding about 4me/100g and the latter reaching some very high figures (Mehlich and coworkers, 1964; Black and cowrkers, 1965). Soils with these exchange capacities would be expected to be superior to others (Anon., 1974; Rijkebusch and Osborne, 1965).

If the exchange capacities were less than about 14me/100g, the soils were all Ferric Luvisols (Table 2). As the "Ferruginous tropical soils on rocks rich in ferromagnesian minerals "in the "Soils Map of Africa", they are of medium productivity (CCTA, 1964; Young, 1976). The group has been graded S2n, soil nutrients being moderately available.

If the exchange capacities exceeded about 14me/100g, the base saturation exceeded about 90%, phosphorus and potassium levels tended to be very high, the latter exceeding about 5me/100g. The units comprising this group were the Eutric Fluvisols and Chromic Cambisols (Table 2), the equivalent of the former in the Soil Map of Africa being "Juvenile soils on recent river alluvium", the productivity of which is often extremely high (ibid.). These units have therefore been graded S1, with good soil nutrient availability.

Organic carbon is customarily used as an indicator of soil nutrient availability (Rijkebusch and Osborne, 1965; Anon., 1974). It has not been so used here, because organic carbon levels seem to have been generally degraded in particular by the deforestation and annual burning necessary with traditional systems of cultivation. Most of the percentages are low and only 6 are fair to good (ibid., Tables 1 and 2). Many high altitude figures, which would be expected to the high (Young, 1976) were low (Table 3). Most of the very low figures were among the Arenosols and Ferralsols, but the highest figure of all come from a Cambic Arenosol (SA 93), a low altitude soil under natural woodland.

The potentially high levels to which organic matter can be raised in high altitude soils and the research programme to raise it initiated by the Uyole agricultural centre has been mentioned in the Soils and Land Suitability section. If this programme is successful, the low grade Ferralsols at high altitudes may have to be upgraded to S2n, since the exchange capacities may also be raised above 9me/100g.

The analytical data for the soils which were unsuitable or marginally suitable on account of alkalinity or drainage are shown in Table 4. Exchange capacties and available potassium and phosphorus are generally fairly high, whether or not the texture is a sand or the organic carbon contant is low; and all the soils are highly base saturated. They would therefore probably be grade S2 or S1 if reclaimed.

CONCLUSIONS

The criteria for grading soil nutrient availability in Rukwa Region were:

S3n: Arenosols, and Eutric Fluvisols, Ferralic Cambisols or Ferralsols with coarse surface soils.

S2n: Ferric Luvisols.

S1 : Chromic Cambisols and Eutric Fluvisols.

The altrenative criterial for the analytical data were:

S3n: Clay% of less than 15 or an exchange capacity of less than 9me/100g, or both; and 2me/100g available potassium. Unsaturation is common.

S2n: clay exceeding 15% and exchange capacities of 9-14me/100g, available potassium is generally between 2-4me/100g and available phosphorus should be over 7ppm (NH_4F + HCl). The soils are generally base saturated.

S1 : clay exceeds 15% and exchange capacities 14%, and potassium 5me/100g. Phosphorus levels can be very high indeed.

TABLE 1. SELECTED ANALYTICAL DATA FROM SOME MARGINALLY SUITABLE ARABLE SOILS

Profile number	Clay %	CEC/ 100g	Org. C%	Kme/ 100g	P ppm	Base sat"n%	Soil Map of the World Unit
SA 106	125	C26	0.6	0.1	5	61	Ferralic Arenosol
MP 119	7	6.1	0.8	0.1	8	61	Albic Arenosol
SA 17	4	2.3	0.4	0.2	4	87	Cambic Arenosols
MP 108	10	6.0	0.6	0.1	4	69	
SA 1	11	9.4	0.7	0.2	3	43	
SA 93	13	9.2	3.0	0.9	53	71	
SA 82	8	5.4	0.4	0.2	29	100	Coarse Eutric Fluvisol
SA 80	13	5.5	1.8	0.2	20	88	Coarse Eutric Regosols
SA 78	15	6.2	1.5	0.5	53	-	
MP 56	11	3.6	1.0	0.2	21	69	Xanthic Ferralsol
SA 12	11	7.6	0.4	0.2	14	31	Orthic Ferralsols
MP 30	15	8.6	0.9	0.1	7	35	
SA 120	17	3.4	1.0	0.1	0.2+	79	
MP 38	19	4.0	1.2	0.2	4	58	
SA 21	21	5.4	0.7	0.3	4	73	
SA 2	24	12.2	1.1	0.3	12	26	
SA 43	25	7.7	0.9	0.3	10	83	
SA 124	26	6.3	2.2	0.2	0.1+	74	
SA 121	27	9.4	1.0	0.5	4+	92	
SA 26	46	4.9	1.8	0.3	3	61	
SA 58	21	5.9	2.0	0.8	4	60	Xanthic Ferralsol
MP 72	43	6.2	2.2	0.1	10	31	Rhodic Ferralsol

+ 0.3 NHCl

TABLE 2. SELECTED ANALYTICAL DATA FROM SOME MODERATELY SUITABLE FERRIC LUVISOLS AND HIGLY SUITABLE CHROMIC CAMBISOLS AND EUTRIC FLUVISOLS

Profile number	Clay %	CEC/ 100g	Org. C%	Kme/ 100g	P ppm	Base sat %	Soil Map of the World Unit
SA 3	17	10.7	1.1	0.3	92	55	Ferric Luvisols
SA 24	24	10.7	1.2	0.4	15	68	
MP 40	58	13.6	1.4	0.6	7	82	
MP 71	31	28.0	1.3	0.4	6	95	Chromic Cambisols
MP 7	32	26	1.1	0.5	12+	100	
MP 80	16	18	2.3	0.5	186	89	Eutric Fluvisols
SA 83	16	15	2.7	0.7	52	93	
MP 12	18	18	1.4	0.7	8	93	

+ Olsen

TABLE 3. RELATIONSHIP BETWEEN ALTITUDE AND PERCENTAGE ORGANIC CARBON AND CLAY TO A DEPTH OF 30CM OF SOME SOILS IN THE REGION

Profile number	Altitude in m	Clay %	Organic C%	Soil Map of the World Unit
SA 82	871	8	0.4	Coarse Eutric Fluvisol
SA 106	1829	5	0.6	Ferralic Arenosol
SA 17	1527	4	0.4	Cambic Arenosols
SA 1	1908	11	0.7	
MP 38	1181	19	1.2	Ferralsols
MP 56	1333	11	1.0	
MP 30	1410	15	0.9	
SA 43	1537	25	0.9	
SA 120	1670	17	1.0	
SA 12	1713	11	0.4	
SA 121	1770	27	1.0	
SA 124	1775	26	2.2	
MP 72	1804	43	2.2	
SA 21	1814	21	0.7	
SA 2	1855	24	1.1	
MP 40	1082	58	1.4	Ferric Luvisols
SA 24	1772	24	1.2	
SA 3	1860	17	1.1	
MP 12	770	18	1.4	Eutric Fluvisols
SA 83	867	16	2.7	
MP 80	913	16	2.5	
MP 23	1017	52	2.6	
MP 7	770	32	1.1	Chromic Cambisol

TABLE 4. SELECTED ANALYTICAL DATA FROM SOME NON-ARABLE SOILS

Profile number	Clay %	CEC/ 100g	Org. C%	Kme/ 100g	P ppm	Base sat'n%	Soil Map of the World Unit
MP 92	13	16	2.2	0.4	11+	88	Sodic Eutric Regosol
MP 95	16	13	1.0	0.4	0.5+	100	Sodic Calcaric Regosol
SA 74	15	11	1.1	0.3	44	95	Sodic Eutric Cambisol
MP 31	17	8.4	0.7	0.2	13	92	Sodic
MP 123	23	9.2	1.8	0.6	-	93	Eutric
SA 69	58	20.3	1.4	0.5	18	78	Gleysol
SA 94	32	26	2.0	2.3	31	73	Gleyic Solonetz
MP 18	67	27	1.7	1.1	18	79	Pellic
MP 47	57	35	1.1	0.3	4	92	Vertisols
MP 11	40	26	1.2	0.5	0.9	90	Sodic Eutric Fluvisol
MP 21	19	22	5.0	1.0	11	90	Eutric Fluvisol
MP 23	52	28	2.6	0.7	43	76	Eutric Fluvisol (imperfectly drained)

+ Olsen

APPENDIX 6: CROP ZONES IN EAST AFRICA

The diagram below shows the altitude requirements of crops and vegetation with some adaptations for the Southern Highlands of Tanzania (Acland, 1971; Agricultural Division, undated; Jakobsen, 1979)

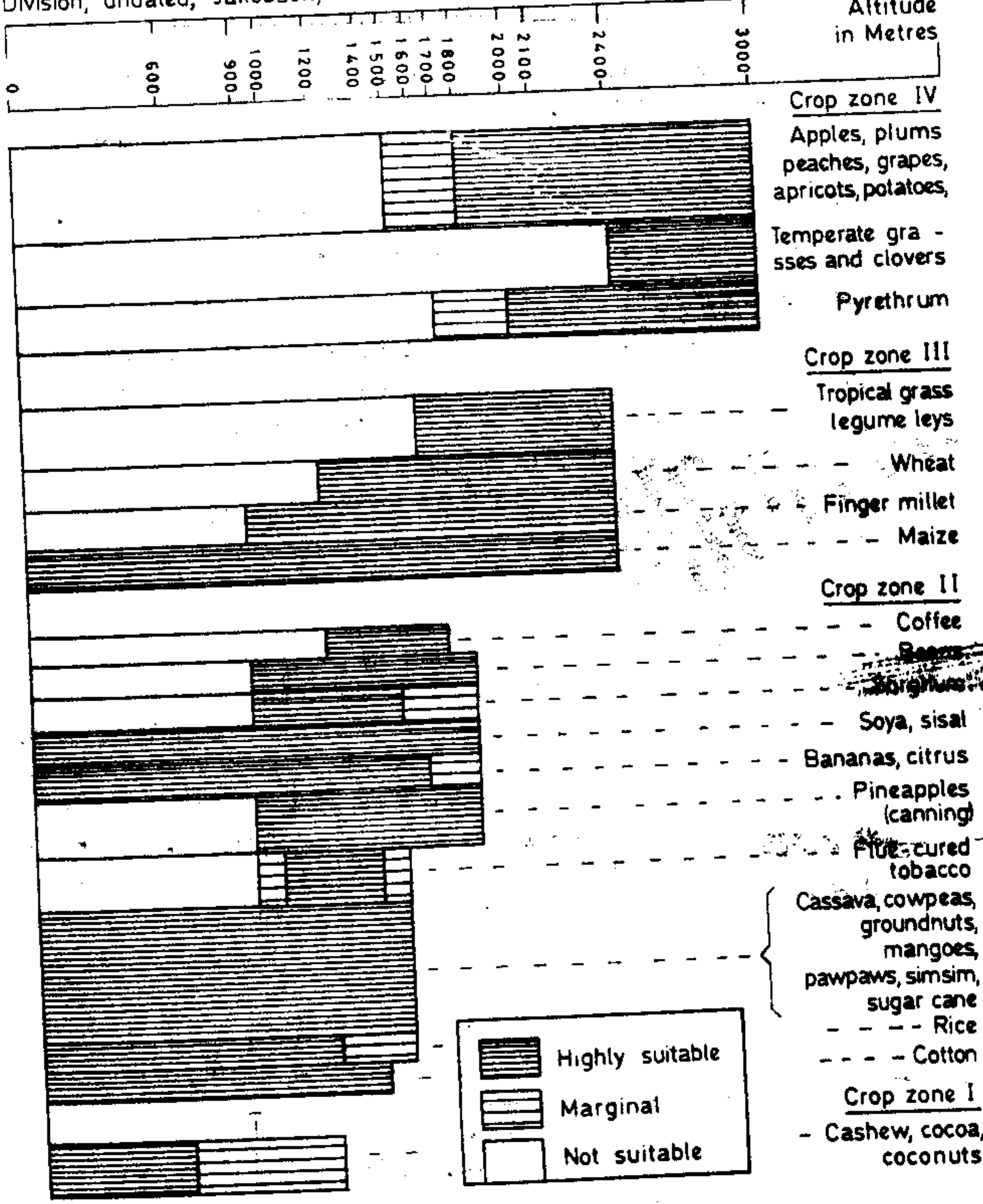


Fig. 7: CROP ZONES IN EAST AFRICA

APPENDIX 7

LAND UNIT DESCRIPTIONS AND DEFINITIONS AND METHODS OF MEASURING LAND SYSTEM PARAMETERS

Parameters are discussed in the same order that they appear in the land system descriptions.

AREA

Areas were measured from a grid overlay superimposed on to Map 1. The minimum square size counted was 0.6 km^2.

GEOGRAPHICAL CO-ORDINATES OF CENTRE

The geographical co-ordinates of land system centres were estimated from the 1:1000 000 Tabora map of the International Map of the World series and the Lake Nyasa map of the Africa series.

MEAN ANNUAL RAINFALL

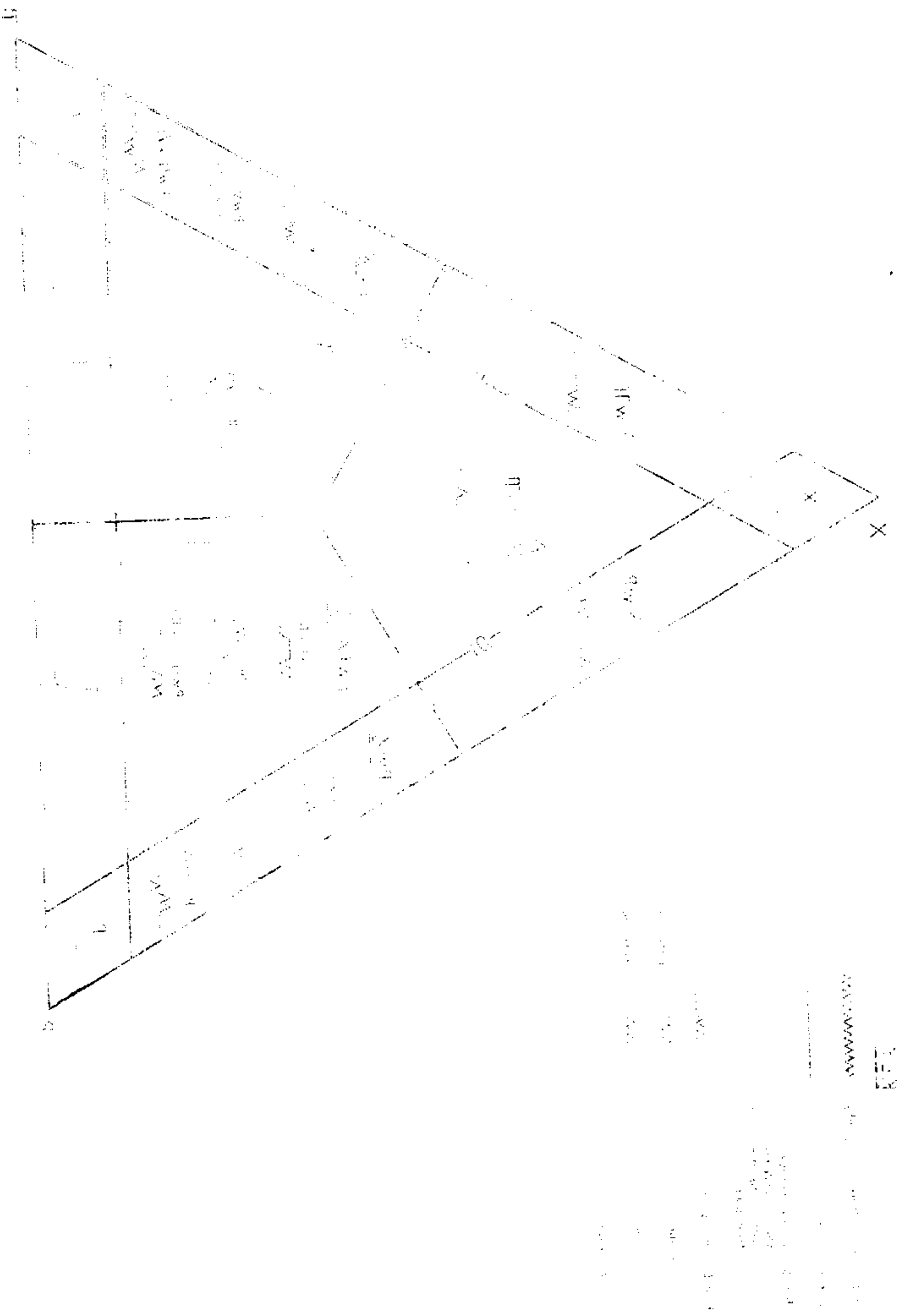
Mean annual rainfall was extrapolated from very limited rainfall data. The figures are very approximate and should only be taken as indicative.

GENERAL MORPHOLOGY

General morphology is a basic simple description of the land system according to texture, modal slopes and five basic land units: plains, plateaux, valleys, hills and escarpments. Texture is a gross measure of drainage density (see 'Topography'). Definitions of terms used are given in Table 1 which should be compared with Figure 4. All values are at a scale of 1:50 000. Modal slope classes were defined according to degree ranges as shown in Table 2. Approximate percent conversions are also given.

TABLE 1 TEXTURE CLASSES - After Rackham (1972).

Fine	> 5.0 km/km^2
Moderate	2.5-5.0 km/km^2
Coarse	> 2.5 km/km^2



KEY

X > 6' = accidented topography

P < 6' = plain

Π < 6' = plateau, but is only used in conjunction with and to differentiate from plain.

E > 6' = escarpment

H = hills (upstanding)

V = valleys (depressed).

w = with

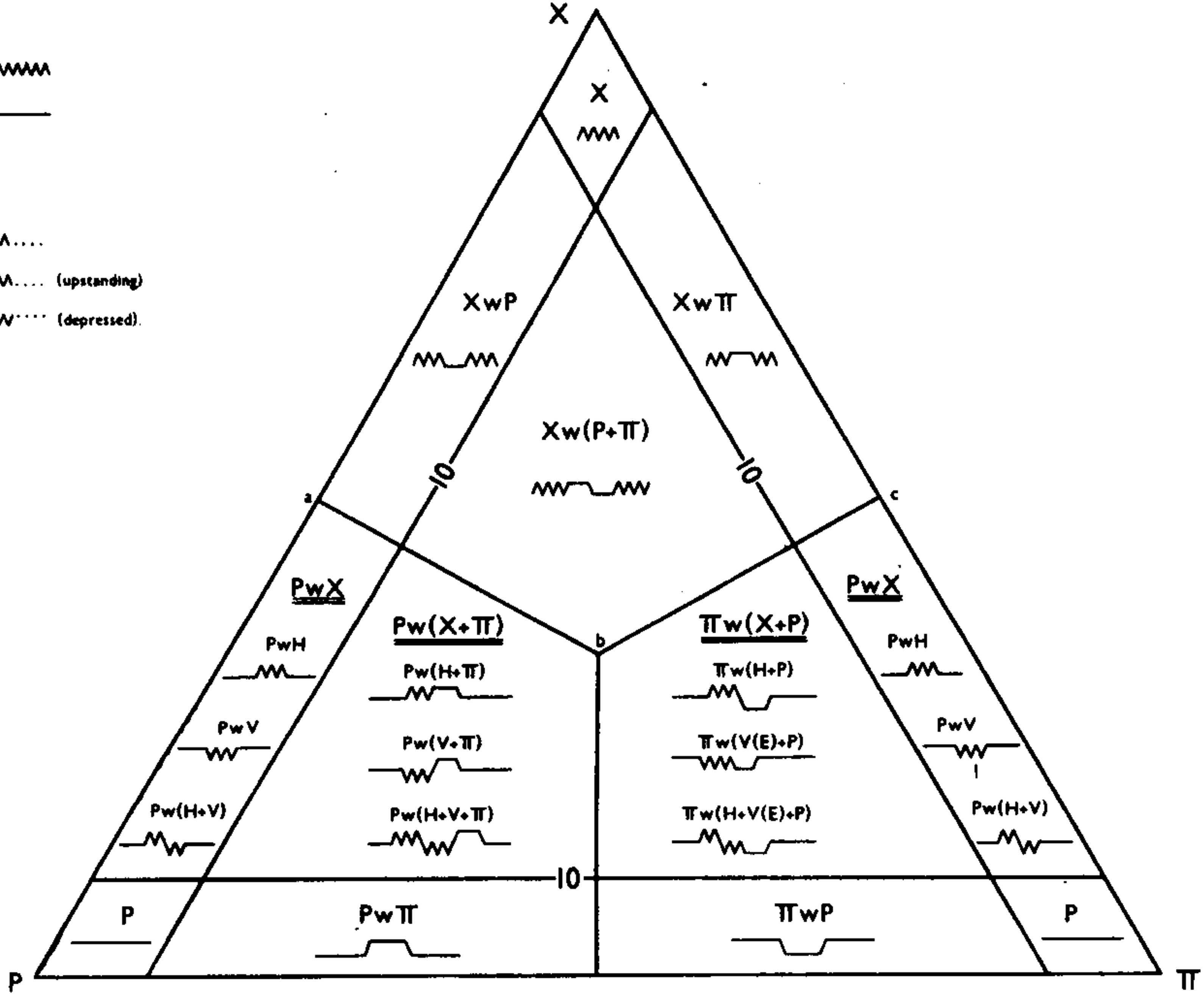


TABLE 2 SLOPE CLASSES

Class	Slope	
	Degrees	%
Flat	< 0.5	< 1
Very gentle	0.5–3	1–5
Gentle	3–6	5–10.5
Low moderate	6–10	10.5–17.5
High moderate	10–15	17.5–27
Moderately steep	15–20	27–36.5
Steep	> 20	> 36.5

Basic land unit descriptions are usually self-evident. However exact difinitions are necessary to decide marginal situations. A method of distinguishing such situations is given in Figures 8 and 9; but basically plains and plateaux encompass all landscapes with slopes less than 6°. Plains are at the same level as or lower than their surrounds, whereas plateaux are upstanding (with respect to > 50% of their boundary). Landscapes with slopes greater than 6° are termed hills, valleys or escarpments depending on whether they are respectively upstanding, depressed, or a combination of the two with respect to their surrounds. Subsidiary units, prefixed with the word "with", are only included in the general morphology description if they occupy more than 10% of the land system (Figure 8). Descriptions of ruggedness, which is explained and defined in the 'Topography' section, and actual values are included under 'General morphology'. Descriptive categories are taken from Map 5.

ROCK

Rock extent and angle of dip classes are given in tables 3 and 4 respectively. Where angles of dip were not indicated on geological maps, they were estimated from stereoscopic examination of aerial photographs. Rock types are grouped into series and listed according to age (intrusive rocks and oldest first). The most extensive series is underlined.

TABLE 3. EXTENT CLASSES - After Rackham (1972)

Very limited	< 25%
Limited	25-50%
Extensive	50-75%
Very extensive	> 75%

TABLE 4. ANGLE OF DIP CLASSES - After Rackham (1972)

Horizontal	0-1°
Very gentle	1-5°
Gentle	5-10°
Moderate	10-20°
Strong	20-45°
Steep	45-90°

LOCAL RELIEF

Local relief istheaverage vertical height difference between the valley bottom and the nearest adjacent interfluve crest. Where available, values were taken from 1:50 000 scale advance information sheets; but most values were estimated from stereoscopic examination of aerial photographs.

ALTITUDE

Altitude values were derived as indicated in the Topography section.

GEOMORPHIC PROCESS

The geomorphic process terms used are broad, representing generalised processes affecting large areas of landscape, as listed in F B. King (1970). More detailed and exact terms are considered inappropiate at this scale. The term peneplanation" can be considered as the "slow flattening of divide slopes' resulting in "multi-convex profiles" (Wooldridge and Morgan, 1957). "Pediplanation' is the parallel retreat of escarpments concomitant with piedmont enlargement (L C King, 1953). Where slopes are mostly governed by fluvial downcutting, the term 'valley incision' is used (R B King, 1979). 'Alluvial deposition" refers to both riverine and lacustrine deposition.

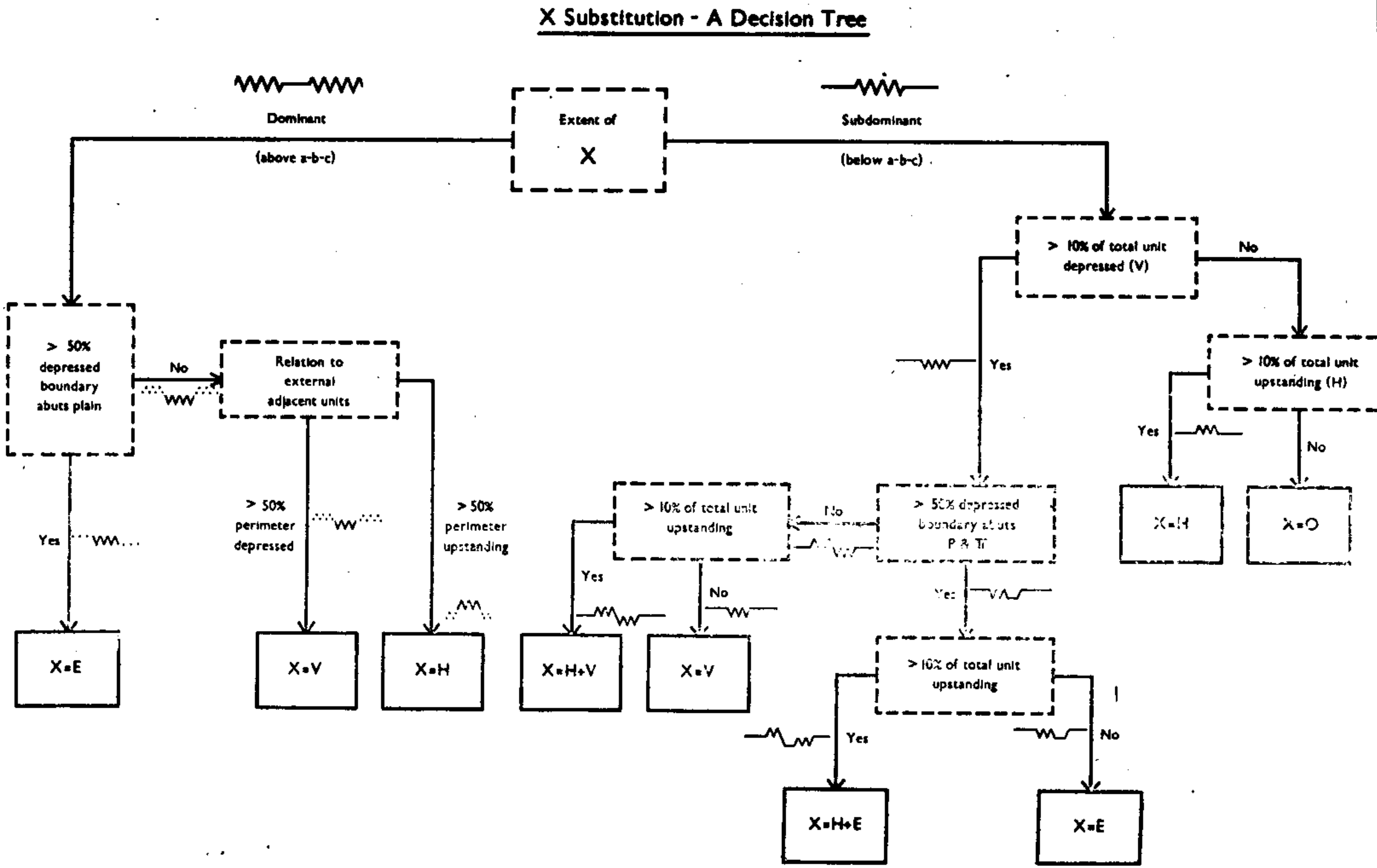


FIGURE [illegible] A decision tree for the substitution of X in Figure 8 (after King, 1974)

DOMINANT LAND FACETS

A land facet "is a part of the landscape, usually with simple form, on a particular rock or surficial deposit, and with soil and water regime that are either uniform over the whole of the facet or if not, very in a simple and consistent way. Each land facet is sufficiently homogeneous over its extent to be managed uniformly for all but the most intensive kinds of land use "(Webster and Beckett, 1970). Land systems consist of a recurring pattern of land facets. A dominant land facet is one "occupying more than 10% of the area of the land system "(R B King, 1970). Definitions of land facet terms used (excepting those which are self-explanatory) are given below in alphabetical order. The names refer to land facets described within Rukwa Region for this particular project. Most of the terms have been taken from a similar survey conducted in the neighbouring Northern and Luapula provinces of Zambia (Mansfield and coworkers, 1976) and are referenced as such. Names should not necessarily be considered as universally adopted geomorphic terminology.

The dominant land facets within each land system are listed in order of decreasing extent within the land system. Modal slope class and slope shape of each land facet are also included. Where no slope class or shape is given, the slopes are flat and planar respectively, except for piedmonts which are always concave. The name of the land facet is underlined. Sometimes the slope class is included in the name to distinguish it from land facets with the same geomorphic form but different slope.

Alluvial fan

'Alluvium deposited by a stream emerging from an escarpment is called an 'alluvial fan'' (Mansfield and coworkers, 1976). It is characterised by a distributa.y drainage pattern and its plan shape resembles that shown for that drainage pattern in Figure 11.

Backland

Backland is "the flat usually swampy land between the levée (or channel if there is no levée) and the floodplain edge (Mansfield and coworkers, 1976).

Bajada

Where alluvial "fans coalesce into an apron of deposition along the length of an escarpment, the term 'bajada' is used" (Mansfield and coworkers, 1976).

Dambo

The searonally waterlogged grassland in the valley bottom, but excluding the floodplain if present, is called a "dambo" (Mansfield and coworkers, 1976). A dambo is a narrow feature, often very gently sloping, usually occupying a width much less than the land facet upslope from it (usually an interfluve). It is normally distinguished from the upslope land facet by the marked ecotone from woodland to grassland produced by the seasonal emergence of the water table. Often there is no landform break between a dambo and the land facet upslope (Mansfield and coworkers, 1976).

Delta

Riverine deposition into a lake characterised by a distributary drainage pattern (Figure 11) is termed a "delta".

Dipslope

Resistant rock strata with a gentle angle of dip can produce an asymmetrical 'cuesta' ridge with the angle of slope of one side of the ridge parallel (or nearly so) with the angle of dip. Such a slope is called a 'dipslope'.

Dissected piedmont

A dissected piedmont is a piedmont (q.v) with a convex profile parallel to the escarpment (Mansfield and coworkers, 1976).

Floodplain

A "floopplain is the valley flat through which the river flows" (R B King, 1964). It might be regularly flooded or only occasionally, but all floodplains (unlike a river terrace-see later) are flooded at least some time. Floodplain soils are deposited by rivers.

Floodplain bench

Where a floodplain has been incised, and another floodplain developed below it, but the higher is still flooded during exceptional floods, both floodplains are termed 'floodplain benches' (Woodyer, 1968) distinguished from each other within any one land system by prefixes 'high', 'low' and sometimes 'middle' or some other distinguishing characteristic. However, a low floodplain bench within one land system is not necessarily at the same relative level as a low floodplain bench in another land system, and their flooding regimes might be totally different. Furthermore they do not necessarily correspond with the group 2 soil-physiographic units described in the 'Soils and Land Suitability' section. The correlation between land facets and soil-physiographic units for each land system is indicated under 'Soils'.

Interfluve

"Interfluve" is the most common land facet and represents a smooth, usually convex (but sometimes with a flat crest) slope extending from the upper edge of the dambo (or semidambo) in one valley to the upper edge of the dambo (or semidambo) in the adjoining valley. If there is no dambo (or semidambo) present, the boundary is taken as the valley bottom. Where the interfluve has been truncated by an escarpment or a valley, it is still called an interfluve, although it does not attain the full extent of a normal interfluve" (Mansfield and coworkers, 1976).

Lacustrine plain

" A plain which was formerly occupied by a lake is called a 'lacustrine plain' "(Mansfield and coworkers, 1976).

Lacustrine terrace

A lacustrine terrace has the some orgin as a lacustrine plain but has been dissected into a number of 'outliers' or one or few distorted fragments.

Levée

A levée is the low ridge along a river produced by "the sudden loss in transporting power when a river overspreads its banks" (Thornbury, 1954).

Mbuga

An Mbuga is a wide flat seasonally waterlogged alluvial plain. It is a distinct landform unit with a distinct break from land facets upslope from it (unlike a dambo). Its width is often greater than that of land facets upslope from it, and at least greater than half the land facet upslope (unlike a dambo, except for the Zambian 'hanging dambos" (Mansfield and coworkers, 1976).

Piedmont

The concave slope below an escarpment is called a "piedmont' (Mansfield and coworkers, 1976) (see Figure 10).

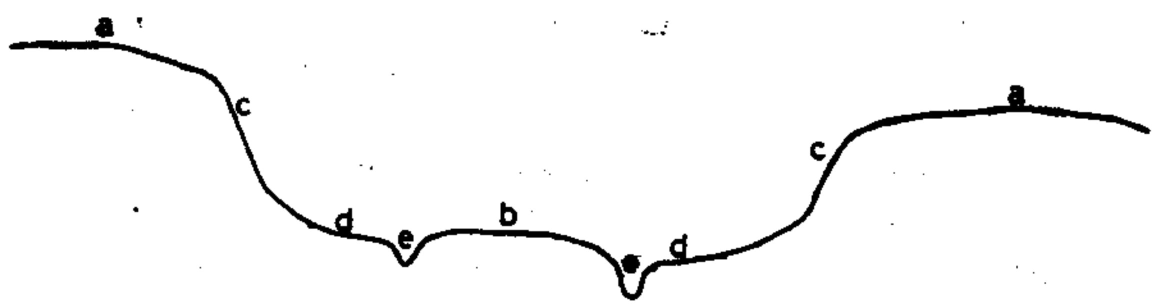


Fig. 10. DIAGRAM SHOWING PLATEAU AND VALLEY INTERFLUVES ("a" AND "b" RESPECTIVELY) (AFTER MANSFIELD AND COWORKERS, 1976). OTHER LAND FACETS SHOWN ARE AS FOLLOWS: c = ESCARPMENT; d = PIEDMONT e = VALLEY.

<u>Plateau interfluve</u>

Interfluve remnants on dissected planation surfaces are called plateau interfluves (Mansfield and coworkers, 1976) (Figure 10).

<u>River terrace</u>

"Where a floodplain or valley floor has been incised such that it is no longer flooded, it is called a 'river Terrace'" (Mansfield and coworkers, 1976).

<u>Semidambo</u>

Where the vegetation on a dambo is bushed or wooded grassland, it is called a 'semidambo' (Mansfield and coworkers, 1976).

<u>Strand plain</u>

"The sandy deposit formed in lakes across a river mounth or similar re-entrant is termed a 'bar'. Where a number of bars have combined into an undulatory foreland, extensive along the coast, the term 'strand plain' is used. The depressions in a strand plain are called 'swales'" (Mansfield and coworkers, 1976). Strand plains in the Rukwa Valley are no longer found along the shore of Lake Rukwa. They were formed when the lake was at a higher level.

<u>Valley</u>

"Where the profile from the valley bottom to the interfluve crest is interrupted by a change of slope, the term 'valley' is used for the area below the change of slope" (Mansfield and coworkers, 1976) (Figure 10).

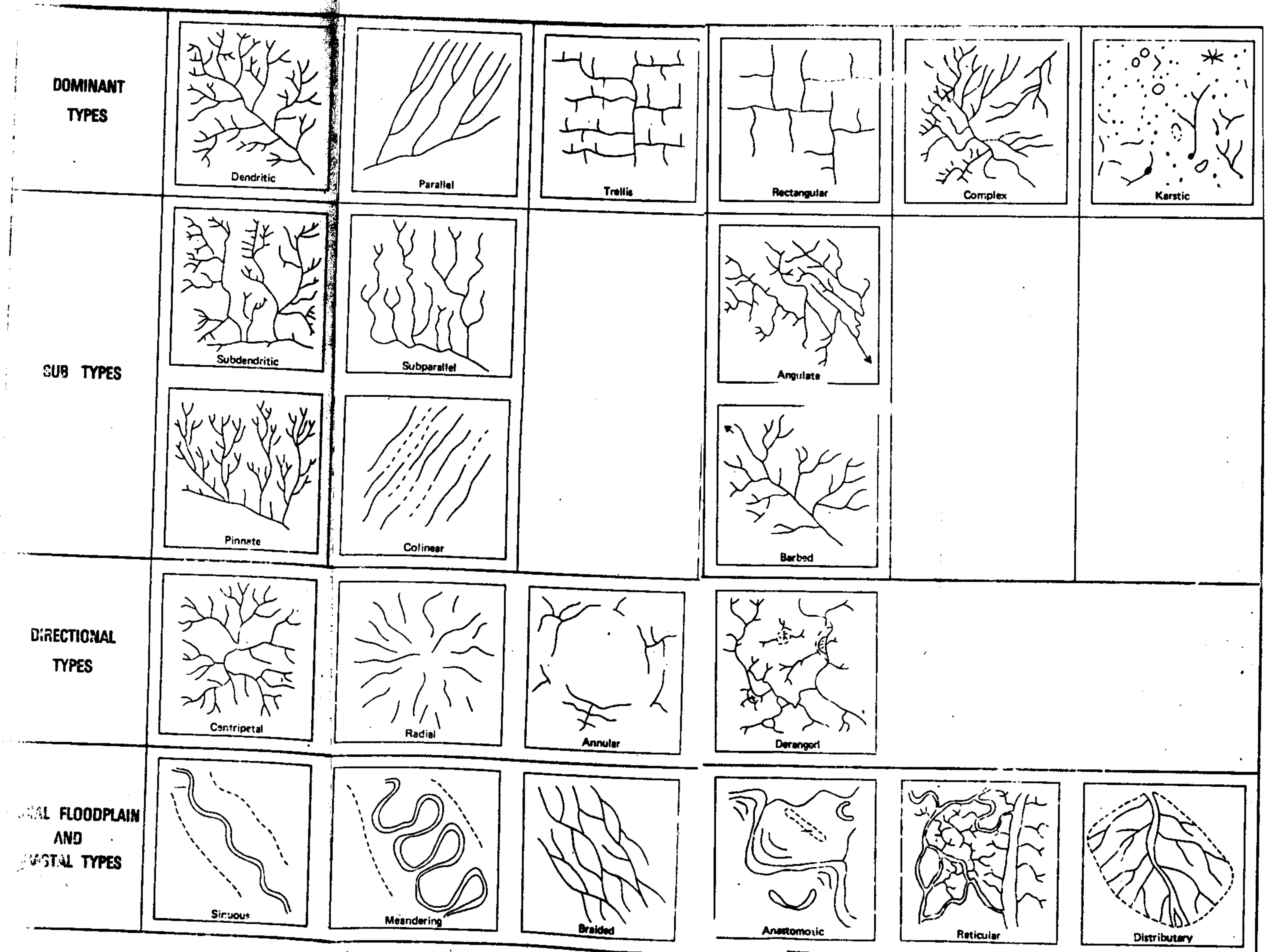


FIGURE 11 Drainage patterns (after L

Valley interfluve

The term 'valley interfluve' is sometimes used in land systems comprising dissected zones of transference (Moss, 1968) between two planation surfaces to distinguish those interfluves on the younger surface below (Mansfield and coworkers, 1976) (Figure 10).

MODAL SLOPE CLASS

Modal slope class values are given in Table 2. They were mostly estimated from stereoscoopic examination of aerial photographs together with ground observation and measurements at soil sampling sites (Map 7) with Abney level or clinometer.

DRAINAGE DENSITY CLASS

Drainage density was defined in the 'Topography' section. Class assignments were estimated by comparing Figure 4 with 1:50 000 scale topographic maps or aerial photographs. An 'exceptionally low' class, less than 0.625 km/km^2, was also added.

DRAINAGE PATTERN

Drainage pattern terminology is taken from Figure 11.

GEOMORPHIC HISTORY

Geomorphic history denotes age and subsequent development of the planation surface on or from which the land system is developed (see under 'Geomorphic History' in "Topography' section for a fuller discussion). "The term 'extension' is used where a planation surface is extending below and in front of a retreating escarpment' (Mansfield and coworkers, 1976). Where the land system covers a dissected zone of transperence between two planation surfaces, geomorphic stage names have been used: "youthful" dissection is similar to 'P w V' in Figure 8 except the V percentage lies between 20 and 50. Where less than 50% of the older planation surface is present, the term "mature" is used.

AGRICULTURE

The land suitability of dominant land facets (and sometimes agriculturally important subdominant ones) for maize, cotton, flue-cured tobacco, rice and irrigation are indicated according to the principles discussed in the 'Soils and Land Suitability' section.

TABLE 2. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR [illegible] SAMPLE SITE

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Brachystegia spiciformis	39.5	0.05	2.0
Ozoroa reticulata	6.3	0.02	1.34
Acacia macrothyrsa	33.8	0.03	1.0
Isoberlina angolensis	20.1	0.04	0.8
Pterocarpus tinctorius	14.8	0.04	0.6
Brachystegia sp.	14.7	0.02	0.29
Albizia antunesiana	2.2	0.01	0.22
Combretum capendiculatum	2.2	0.01	0.22
Piliostigma thorningii	2.2	0.01	0.22
Combretum sp.	10.6	0.02	0.21
Pericopsis angolensis	10.6	0.02	0.21
Brachystegia allenii	6.4	0.03	0.19
Acacia sp.	2.2	0.08	0.18
Brachystegia x longifolia	2.2	0.07	0.15
Uapaca pilosa	2.2	0.05	0.11
Combretum gueinzii	4.4	0.02	0.09
Syzigium guineense	2.2	0.04	0.09
Parinari curatallifolia	2.2	0,04	0.08
Pseudolachnostylis maproneifolia	6.3	0.01	0.06
Dombeya sp.	4.4	0.01	0.04
Strychnos cocculoides	4.4	0.01	0.04
Swartzia madagascariensis	2.2	0.02	0.04
Commiphora africana	4.4	0.006	0.003
Protea sp.	2.2	.002	0.004

TABLE 3. COMPOSITION, DENSITY MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KIBANGO-KIPILI SAMPLE SITE.

Species	Density (trees/ha)	Mean b.sal area (m^2)	Basal density
Brachystegia spiciformis	103.1	0.04	4.1
Albizia antunesiana	18.1	0.05	0.9
Pterocarpus angolensis	27	0.03	0.8
Diplorynchus condylocarpon	50.4	0.01	0.5
Trichlia ametica	4.5	0.11	0.5
Bauhimia sp.	27.1	0.01	0.27
Polysias arbersiana	4.5	0.06	0.27
Pericopsis angolensis	9.1	0.02	0.18
Ochna sp.	9.1	0.01	0.09
Pseudolachnostylis maproneifolia	9.1	0.01	0.09
Acacia sp.	18.1	0.004	0.07
Combretum fragans	18.2	0.004	0.07
Acacia tortilis	4.5	0.01	0.05
Combretum sp.	4.5	0.01	0.05
Isoberlinia angolensis	4.5	0.01	0.05
Combretum psidiodies	4.5	0.002	0.01
Terminalia kaiserana	4.5	0.001	0.01
Combretum sp.	4.5	0.001	0.01
Terminalia cerices	4.5	0.001	0.01

TABLE 4. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR INYONGA - 1 SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Brachystegia spiciformis	64.8	0.05	3.24
Brachystegia boehmii	62.8	0.05	3.14
Pterocarpus angolensis	56	0.05	2.8
Pseudolachnostylis maproneifolia	56.7	0.03	1.7
Pericopsis angolensis	14.2	0.11	1.56
Albizia sp.	28.4	0.11	1.14
Terminalia cericea	35.5	0.03	0.9
Flacourtia indica	20.3	0.03	0.61
Bauhinia sp.	20.3	0.03	0.61
Polyscias arbersiana	7.1	0.06	0.43
Combretum sp.	20.3	0.02	0.41
Oldfieldia dactylophylla	7.1	0.05	0.36
Hymenocardia acida	28.4	0.01	0.28
Faurea sp.	35.5	0.002	0.07
Ochna sp.	7.1	0.01	0.07
Acacia sp.	7.1	0.009	0.06
Strychnos madagascariensis	14.2	0.001	0.01
Diplorynchus condylocarpon	7.1	0.001	0.007
Protea sp.	7.1	0.001	0.007
Parinari curatellifolia	7.2	0.001	0.007

TABLE 5. COMPOSITION DENSITY MEAN BASAL AREA AND MEAN BASAL DENSITY FOR INYONGA - 3 SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Brachystegia spiciformis	79.7	0.04	3.19
Pterocarpus angolensis	100.6	0.02	2
Lonchocarpus capasa	7.2	0.14	1
Hymenocardia acida	35.9	0.02	0.72
Brachystegia microphylla	17.2	0.04	0.69
Pseudolachnostylis maprceifolia	64.7	0.01	0.65
Diplorynchus condylocarpon	50.3	0.01	0.50
Syzigium guineense	23.6	0.02	0.47
Brachystegia boehmii	21.6	0.02	0.43
Albizia vesicolor	17.2	0.02	0.34
Albizia sp.	17.2	0.02	0.3
Combretum sp.	17.2	0.02	0.3
Faurea sp.	17.2	0.02	0.3
Terminalia cericea	64.7	0.004	0.26
Terminalia mollis	7.2	0.01	0.07
Schrebera trichoclada	7.2	0.01	0.07
Acacia tortilis	7.2	0.01	0.07
Bauhinia sp.	7.2	0.01	0.07
Combretum gueinzii	7.2	0.01	0.07
Psorospermum febrifungum	7.2	0.01	0.07

TABLE 6. COMPOSITION, DENSITY MEAN BASAL AREA AND MEAN BASAL DENSITY FOR MP[illegible] SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Brachystegia spiciformis	107	0.06	6.4
Pterocarpus tinctorius	25	0.05	1.3
Albizia sp.	9	0.08	0.72
Pterocarpus angolensis	17	0.03	0.51
Anisophilea pomifera	23	0.02	0.46
Uapaca kirkiana	12	0.03	0.24
Erythroem africanum	6	0.03	0.18
Isoberlinia angolensis	6	0.03	0.18
Faurea sp.	3	0.05	0.15
Hexalobus monopetalous	3	0.05	0.15
Xeromphis obvata	3	0.05	0.15
Ochna afropurpurea	6	0.02	0.12
Ochna sp.	3	0.03	0.09
Polysias abersiana	3	0.03	0.09
Doecia saliciphola	3	0.02	0.06
Diplorynchus condylocarpon	6	0.01	0.06
Mapronea africana	3	0.02	0.06
Monotes africanus	3	0.02	0.06
Crossopteryx febrifuga	3	0.01	0.03
Combretum gueinzii	3	0.01	0.03
Ximeria caffra	3	0.01	0.03
Hymenocardia acida	22	0.001	0.02
Protea sp.	3	0.001	0.003
Psorospermum febrifugum	3	0.002	0.006

TABLE 7. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR MWAZI SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Brachystegia allenii	9.8	0.9	8.8
Uapaca kirkiana	13.2	0.3	3.9
Brachystegia spioiformis	66.1	0.04	2.6
Brachystegia bussei	15.9	0.16	2.5
Polysias abersiana	7.9	0.23	1.82
Brachystegia microphylla	2.6	0.13	0.88
Monotes africanus	18.5	0.03	0.56
Acacia sp.	7.9	0.07	0.55
Erythrina sp.	5.3	0.01	0.53
Combretum sp.	7.9	0.03	0.24
Dombeya sp.	5.3	0.04	0.21
Parinari curatelleifolia	5.3	0.04	0.21
Acacia xanthophlea	5.3	0.03	0.16
Pericopsis angolensis	5.3	0.03	0.16
"Myenzela"	7.9	0.03	0.16
Sterospermum kunthianum	2.6	0.05	0.13
Allophyllus abysinicus	2.6	0.03	0.08
Combretum capendiculatum	2.6	0.02	0.05
Faurea spp.	2.6	0.02	0.05

TABLE 8. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR NAMANYERE SAMPLE SITE

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Isoberlinia angolensis	57	0.06	3.42
Brachystegia manga	43	0.07	3.01
Polyscias abersiana	10	0.1	1
Swartzia madagascariensis	3	0.03	0.9
Brachystegia bussei	7	0.1	0.7
Acacia macrothyrsa	17	0.02	0.34
Combretum sp.	30	0.01	0.3
Maytenus senegalensis	3	0.1	0.3
Albizia sp.	7	0.04	0.28
Brachystegia sp.	7	0.03	0.21
[illegible] sp.	7	[illegible]	[illegible]
[illegible]	7	0.01	0.14
[illegible]	7	0.02	0.14
[illegible]	7	0.02	0.14
[illegible]	7	0.01	0.14
Pseudolachnostylis maproneifolia	7	0.01	0.14
Dombeya sp.	3	0.03	0.9
Faura sp.	3	0.03	0.09
Bauhinia tormentosa	7	0.01	0.07
Ochna sp	3	0.02	0.06
Ozoroa mucronata	3	0.02	0.06
Crebea sp.	3	0.01	0.03
Grewia sp.	3	0.004	0.01
Hexalobus monopetalous	3	0.002	0.006
Steronotaenia araliacea	3	0.002	0.006

TABLE 9. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KABWE SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Isoberlinia angolensis	100	0.09	9
Brachystegia manga	22	0.08	1.8
Diplorynchus condylocarpon	134	0.01	1.3
Pseudolachnostylis maproneifolia	58	0.02	1.2
Brachystegia spiciformis	20	0.06	1.2
Brachystegia sp.	11	0.08	0.88
Pterocarpus angolensis	27	0.03	0.8
Pterocarpus tinctorius	22	0.03	0.7
Polysias aberniana	16	0.02	0.3
Terminalia cericea	23	0.01	0.2
Bauhinia sp.	5	0.02	0.1
Ziziphus mucronata	10	0.01	0.1
Combretum sp.	16	0.004	0.06
Grewia sp.	5	0.01	0.05
Ochna sp.	5	0.01	0.05
Dombeya sp.	10	0.003	0.03
Pericopsis angolensis	16	0.002	0.03
Annona senegalensis	5	0.003	0.02
Crossopteryx febrifuga	5	0.003	0.02
Strychnos cocculoides	5	0.003	0.02

TABLE 10. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR MPANDA SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Pterocarpus angolensis	80.3	0.04	3.2
Dalbegia nitidula	3.7	0.56	2.07
Brachystegia boehmii	68.2	0.03	2.05
Brachystegia spiciformis	45.5	0.04	1.8
Albizia sp.	14.8	0.11	1.6
Crossopteryx febrifuga	7.4	0.11	0.81
Dombeya shupagae	3.7	0.04	0.55
Uapaca kirkiana	3.7	0.1	0.37
Parinari curatellifolia	9.3	0.04	0.37
Pericopsis angolensis	3.7	0.09	0.34
Terminalia mollis	10.8	0.03	0.32
Burkea africanus	3.7	0.08	0.3
Bauhina sp.	7.4	0.04	0.3
Psorospermum febrifugum	3.7	0.03	0.11
Terminalia kaiserana	10.8	0.008	0.09
Combretum gueinzii	3.7	0.007	0.09
Annona senegalensis	7.4	0.01	0.07
Dombeya sp.	3.7	0.02	0.07
Diplorynchus condylocarpon	7.4	0.001	0.07
Anisophyllea pomifera	3.7	0.008	0.03
Pseudolachnostylis maproneifolia	3.7	0.005	0.02
Markhamia obtusifolia	9.3	0.04	0.01
Albizia antunesiana	3.7	0.002	0.07
Faurea sp.	3.7	0.002	0.007
Combretum sp.	3.7	0.001	0.004

TABLE 11. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR MWESE SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Isoberlinia angolensis	95.3	0.08	7.6
Brachystegia spiciformis	63	0.04	2.5
Combretum gueinzii	17.7	0.06	1.1
Brachystegia sp.	10.6	0.07	0.74
Terminalia mollis	49.5	0.01	0.5
Combretum sp.	14.1	0.003	0.42
Pericopsis angolensis	3.5	0.05	0.18
Polysias arbersiana	7.1	0.02	0.14
Erythrina sp.	10.6	0.01	0.11
Annona senegalensis	7.1	0.01	0.07
Bauhinia sp.	7.1	0.01	0.07
Ximeria caffra	3.5	0.02	0.07
Protea sp.	17.7	0.003	0.05
Parinari curatellifolia	3.5	0.01	0.04
Dombeya sp	3.5	0.01	0.04
Maytenus senegalensis	7.1	0.004	0.03
Uapaca kirkiana	14.1	0.002	0.03
Strychnos madagascariensis	3.5	0.003	0.01
Ozoroa reticulata	3.5	0.003	0.01
Acacia kirkii	3.5	0.001	0.004

TABLE 12. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR UGALLA SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Brachystegia spiciformis	190	0.07	13.3
Pterocarpus angolensis	60	0.04	2.4
Pericopsis angolensis	21	0.07	1.47
Combretum sp.	32	0.02	0.64
Combretum collium	15	0.03	0.45
Pseudolachnostylis maproneifolia	20	0.02	0.4
Brachystegia allenii	5	0.07	0.35
Crossopteryx febrifuga	5	0.07	0.35
Uapaca kirkiana	5	0.05	0.25
Monotes africanus	5	0.04	0.2
Markhamia obtusifolia	5	0.03	0.15
Erythrophloem africanum	15	0.01	0.15
Strychnos madagascariensis	15	0.01	0.15
Loscia solicipholia	5	0.02	0.1
Anisophylea pomifera	5	0.01	0.05
Albizia sp.	5	0.01	0.05
Pterocarpus tinctorius	5	0.01	0.05
Hegalobus monopetalous	5	0.01	0.05
Diplorynchus condylocarpon	40	0.001	0.04

TABLE 13. COMPOSITION, DENSITY, BASAL AREA AND MEAN BASAL DENSITY FOR URUWIRA SAMPLE SITE

Species	Density (trees/ha)	Mean basal area (m^2)	Basal density
Pterocarpus angolensis	65	0.06	3.9
Brachystegia microphylla	15	0.21	3.15
Brachystegia x Longifolia	32	0.07	2.24
Brachystegia spiciformis	120	0.01	1.2
Hexalobus monopetalous	23	0.05	1.15
Brachystegia manga	40	0.02	0.8
Diplorynchus condylocarpon	40	0.02	0.8
Polisclas abersiana	15	0.05	0.75
Erythrophloem africanum	30	0.02	0.6
Combretum psidoides	10	0.05	0.5
Cussonia arborea	5	0.08	0.4
Terminalia sericea	20	0.01	0.2
Pseudolachnostylis maproneifolia	10	0.02	0.2
Isoberlinia angolensis	10	0.02	0.2
Dombeya shupagne	15	0.01	0.15
Maproneia africanum	10	0.01	0.1
Swartzia madagascariensis	5	0.02	0.1
Combretum gueinzii	5	0.01	0.05
Albizia antunesiana	5	0.01	0.05

8 TABLE 14. COMPOSITION, DENSITY, BASAL AREA AND MEAN BASAL DENSITY FOR INYONGA - 2 SAMPLE SITE.

	Density (trees/ha)	Mean basal area(m^2)	Basal density
Brachystegia boehmii	103	0.05	5.15
Terminalia cericea	22.9	0.08	1.83
Brachystegia spiciformis	34.4	0.04	1.38
Hymenocardia acida	126.2	0.01	1.26
Parinari curatellifolia	45.9	0.02	0.92
Flacourtia indica	34.4	0.02	0.69
Pseudolachynostylis maproneifolia	57.4	0.02	0.57
Terminalia mollis	22.9	0.02	0.46
Combretum sp.	22.9	0.02	0.46
Cassia abbreviata	22.9	0.01	0.23
Psorospermum febrifugum	22.9	0.01	0.23
Pterocarpus angolensis	22.9	0.01	0.23
Annona senegalensis	22.9	0.01	0.23
Diplorynchus condylocarpon	45.9	0.004	0.18
Ochna sp.	34.4	0.005	0.17
Bauhinia sp.	34.4	0.003	0.10
Xeromphis obvata	22.9	0.002	0.05
Faurea sp.	11.5	0.003	0.03
Combretum gueinzii	22.9	0.001	0.02
Ximeria caffra	22.9	0.001	0.02
Ormacarpum sp.	22.9	0.001	0.02

TABLE 15. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KASANZA SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Acacia polycantha	122.2	0.07	7.55
Bauhimia petersiana	52.8	0.12	6.34
Albizia vesicolor	11.7	0.23	2.69
Markhamia obtusifolia	29	0.01	2.9
Sterculia quinquiloba	11.7	0.22	1.17
Dombeya sp.	35.2	0.03	1.06
Kigelia sp.	11.7	0.08	0.94
Combretum gueinzii	11.7	0.02	0.23
Acacia albida	5.6	0.01	0.06
Acacia tortilis	5.6	0.01	0.06
Acacia kirkii	11.7	0.003	0.04
Pluchea discorides	17.6	0.002	0.04
Antidesma vernosum	15.6	0.002	0.01
Commiphora africana	5.6	0.002	0.01

TABLE 16. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN DENSITY FOR IKU-KATUMA SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Sterculia quinquiloba	30.4	0.2	6.1
Acacia tortilis	12.7	0.15	1.9
Acacia polycantha	23.7	0.05	1.2
Terminalia cericea	21.3	0.05	1.1
Sclerocarya caffra	1.6	0.4	0.6
Combretum sp.	50	0.01	0.5
Lonchocarpus capasa	12.7	0.01	0.13
Dombeya sp.	3.2	0.01	0.03
Combretum gueinzii	6.3	0.004	0.03
Markhamia obtusifolia	6.3	0.003	0.02
Bauhinia sp.	1.6	0.003	0.01
Commiphora afrikana	4.7	0.002	0.01
Phyllanthus engleri	4.7	0.002	0.01

TABLE 17. COMPOSITION, DENSITY MEAN BASAL AREA AND MEAN BASAL DENSITY FOR CHIZI SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Brachystegia sp.	170	0.09	15.3
Brachystegia x Longifolia	120	0.06	7.2
Brachystegia allenii	57	0.03	1.7
Brachystegia bussei	12	0.13	1.56
Acacia sp.	14	0.08	1.22
Pterocarpus tinctorius	53	0.02	1.06
Brachystegia spiciformis	20	0.05	1.0
Acacia polycantha	14	0.04	0.56
Erythrina sp.	7	0.1	0.49
Lonchocarpus capasa	7	0.03	0.21
Diplorynchus condylocarpon	20	0.01	0.2
Comiphora africana	12	0.01	0.12
Dichrostachys cinerea	20	0.006	0.12
Piliostigma sp.	7	0.01	0.07
Vernosum corolata	7	0.01	0.07
Combretum sp.	7	0.004	0.03
Polysias arbersiana	7	0.003	0.002
Pseudolachnostylis maproneifolia	7	0.002	0.001

TABLE 18. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KANKWALE SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Acacia sp.	13.8	0.28	3.9
Brachystegia spiciformis	58.1	0.04	2.32
Combretum gueinzii	11	0.06	0.66
Monotes africanus	4.1	0.15	0.62
"*Msoko*"	1.4	0.26	0.36
Parinari curatellifolia	5.5	0.03	0.17
Albizia antunesiana	5.5	0.005	0.15
Rhus vulgaris	6.9	0.02	0.14
Ximeria caffra	4.1	0.03	0.12
Terminalia sericea	4.1	0.03	0.12
Psorospermum febrifugum	1.4	0.06	0.08
Polysias arbersiana	5.5	0.01	0.06
"*Mtufa*"	5.5	0.01	0.06
Faurea sp.	1.4	0.01	0.02
Piliostigma thorningii	1.4	0.01	0.02
Xeromphis obvata	1.4	0.01	0.02
Dichrostachys cinerea	1.4	0.005	0.007
Cordia obvata	1.4	0.004	0.006
Combretum sp.	1.4	0.002	0.003
Ficus sp.	1.4	0.002	0.003
Steganotaenia araliacea	1.4	0.002	0.003

TABLE 19. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KASANGA SAMPLE SITE.

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Julbernardia globiflora	96	0.07	6.72
Brachystegia bussei	38	0.08	3.04
Pterocarpus angolensis	20.5	0.11	2.26
Brachystegia sp.	20.5	0.1	2.05
Pterocarpus tinctorius	26	0.06	1.56
Diplorynchus condylocarpon	35	0.03	1.05
Oxoroa mucronata	8.8	0.06	0.53
Pseudolachynostylis maproneifolia	6	0.03	0.18
Ehretia sp.	3	0.06	0.18
"Mukoyo"	3	0.06	0.18
Albizia antunesiana	8.2	0.01	0.08
Crossopteryx febrifuga	6	0.01	0.06
Combretum sp.	6	0.01	0.06
Brachystegia spiciformis	3	0.02	0.06
Parinari curatellaefolia	3	0.02	0.06
Combretum gueinzii	3	0.01	0.03
"Mtesha"	6	0.004	0.02
Bauhinia petersiana	3	0.003	0.009

TABLE 20. COMPOSITION, DENSITY, MEAN BASAL AREA AND MEAN BASAL DENSITY FOR KIFINGA SAMPLE SITE

Species	Density (trees/ha)	Mean basal area(m^2)	Basal density
Acacia Polycantha	235.8	0.23	54
Lonchocarpus capasa	117.9	0.11	13
Sterculia quinquiloba	10.7	0.3	3.2
Dombeya sp.	16.1	0.13	2
Combretun fragans	26.8	0.04	1.07
Bauhinia sp.	26.8	0.02	0.54
Combretum gueinzii	32.2	0.01	0.32
Sterospermum cunthianum	26.8	0.01	0.27
Terminalia cericea	16.1	0.01	0.16
Pluchea discorides	26.8	0.002	0.05