MINISTRY OF OVERSEAS DEVELOPMENT

SOME SOILS OF NORTHERN BECHUANALAND

WITH A DESCRIPTION OF THE MAIN VEGETATION ZONES

LAND RESOURCES DIVISION,
DIRECTORATE OF OVERSEAS SURVEYS,
TOLWORTH, SURREY, ENGLAND.

1965

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edited by

M. G. BAWDEN

Land Resources Division
Directorate of Overseas Surveys
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PREFACE

In 1963 the Land Resources Division of the Directorate of Overseas Surveys investigated the land use prospects of Northern Bechuanaland and recommended areas of land which had potential for development. During this reconnaissance investigation much detailed information was collected which, while pertinent to the conclusions presented in the report (Langdale-Brown and Spooner, 1963), was not contained in it. It is the purpose of this supplementary bulletin to present this information, so that it will be available to workers concerned with further investigations which are now being undertaken.

C. L. Bascomb was responsible for the analysis of the soil samples; I. Langdale-Brown and R. J. Spooner were responsible for the interpretation of the aerial photographs, for collecting the soil samples and for the field descriptions.

INTRODUCTION

The reconnaissance investigation of the land use prospects in Northern Bechuanaland covered 65,000 square miles. Vertical, panchromatic aerial photographs at 1:30,000 or 1:40,000 scale were available for all this area and photo mosaics at a scale of 1:125,000 were made from them. The investigation was undertaken in four stages:

(a) The sub-division of Northern Bechuanaland into seemingly uniform tracts of land on the basis of their appearance on the air photo mosaics.

(b) Stereoscopic examination of sample air photographs from each tract to check its uniformity and to determine the nature of the vegetation and the land surface.

(c) Ground sampling (1): a brief description and appraisal of sample sites from each of the tracts delineated on the photo mosaics, and selection of the more promising tracts on the basis of their soils, vegetation, present land use, game, pests, climate, water supplies, and communications.

(d) Ground sampling (2): a more detailed examination of the better tracts of land including the digging and sampling of soil profile pits followed by an assessment of land capability.

It was decided that eight of the areas which were examined in detail during stage (d) warranted further investigation with a view to specific development at an early stage, and that a further seven areas merited longer term consideration. The eight "potential development areas" were shown on a map at a scale of 1:2,000,000 and their characteristics were described in the report (Langdale-Brown and Spooner, 1963) together with an assessment of their possible use and recommendations for further action.

In this bulletin the landscape units recognised on the photo mosaics during stage (a) are presented. The vegetation zones recognised during the reconnaissance are defined on a second map at 1:2,000,000 scale and detailed descriptions of the soils studied during stage (d) are presented.

PHYSICAL ENVIRONMENT

The land surface of Bechuanaland is a slightly basin shaped plain, lying mainly between 3,000 feet and 4,000 feet above sea level. Along the eastern margin, adjacent to the Limpopo Valley and the Rhodesian High Veld the ground lies above 4,000 feet and, after sloping gently westwards to the centre of the Kalahari Basin, it rises again towards the higher ground in South-West Africa. About eighty-five per cent of the country is covered by geologically recent wind-blown or fluviatile sands of the Kalahari system. Older rocks outcrop mainly in the eastern part of the country. In northern Bechuanaland basalt and sandstones of the Karroo system occur along the border with Rhodesia near Panda ma tenga. Quartzites, shales, limestones and lavas of the Sinclair system occur between Ghanzi and Lake Ngami. Rocks of this system also form isloated hills such as the Aha Mountains in the extreme west and the Shinamba Hills in the north east. South and west of Lake Ngami rocks of the Karroo system are associated with these older rocks. The geological succession for Northern Bechuanaland is given in Table I.

Table I

Geological Succession

(after Boocock and Van Straten 1962)

System	Lithology
Kalahari	Pan sediments, calcrete, silcrete, sands, sandstone, grit, conglomerate and marl.
Karroo	Basalt and minor sandstone.
	Sandstone, shales, mudstone and marl.
Waterberg	Sandstone, conglomerate, limestone and shale.
Sinclair	Quartz feldspar porphyry and felsite.
	Quartzite, shale, greywacke, limestone and lava.

The Kalahari is the largest physiographic unit in Bechuanaland and it

extends into Cape Province, into South-West Africa, into Zambia and into Rhodesia. The term Kalahari has been variously used and its extent has varied depending on the criteria used to define it. In this bulletin the boundary of the Kalahari is taken as the geological boundary between deposits of the Kalahari system and the rocks of the older systems which surround them.

Within the Kalahari there are two main drainage systems; the Nossop-Molopo system which occupies much of the south of Bechuanaland, and the interior drainage system of the Okavango-Makarikari which dominates the centre and the north. Apart from the Chobe river in the extreme north, the area covered by this bulletin falls entirely within the Okavango-Makarikari system.

After entering Bechuanaland near Mchembo in the north-west of the area the Okavango river flows south-east for about ninety miles in a well defined channel. It then fans out to form an inland delta which covers about 6,000 square miles. Much of the inflow sinks in or evaporates; the remainder drains eastwards by way of the Botletle river to the Makarikari depression where it finally evaporates. The Chobe river and its tributary called the Selinda Spillway are part of the Zambezi river system, although the gradients here are so slight that the Selinda Spillway has been reported flowing either into the Chobe or into the Okavango depending on which of these two rivers is carrying the earlier flood.

In Northern Bechuanaland the Kalahari can be divided into four regions; the east-west trending sief dune complex in the north-west, the Okavango swamp, the Makarikari depression and the remaining areas of relatively featureless sand veld. One of the most striking features of the area is the abrupt change from the swamps to the sand veld which takes place along a north-east south-west line through Maun. Du Toit (1926) has attributed this change to comparatively recent faulting and his view is supported by the south-east margin of these swamps being a seismically unstable portion of the crust of southern Africa. Jones (1962) has described a presumed fault line which runs for about seventy miles to the south-west of Gomare, and van Straten (1963) draws attention to the fact that scattered outcrops of

pre-Karroo rocks in western Ngamiland are all situated to the west of this presumed fault line and that the sief dune complex is also truncated by this feature. 'This evidence would appear to be strongly in favour of the concept that the Okavango delta area occupies an extensive graben caused by comparatively recent faulting in the original (more extensive) basin. A linearity with a similar trend to the structural line through the base of the Okavango delta cuts the Ntwetwe branch of the Makarikari and this, in conjunction with the disposition of outcrops of rocks of Karroo system age and older, suggests the presence of horst and graben structures in this part of the internal drainage basin. The effects of warping rather than actual faulting have however, to be considered in the elecidation of the structure of this part'.

Northern Bechuanaland has a well developed cover of trees, low scrub and grasses. Over most of the area the regeneration of the larger tree varieties is apparently at a minimum and in certain parts, as a result of repeated burning, the savanna woodland has degenerated to pure grass land. Transport of the sand by wind erosion at the present time only occurs where the vegetation has been destroyed (Boocock and van Straten, 1962).

The climate of Bechuanaland is generally described as semi-arid. Virtually all the rain falls during the summer months which are warm and hot, whereas the winter months are dry and cool. The mean annual rainfall over most of Northern Bechuanaland is about 18" while higher values are recorded in the north around Kasane. There are few places where records have been kept, those which have been published are shown in Table II.

TABLE II

Mean Monthly and Annual Rainfall in Inches

(from published records of South African Weather Bureau 1921-1950).

	JAN.	FEB.	MARCH	APL.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Kasane	6.45	6.10	4.02	1.11	0.27	0.02	0.00	0.00	0.11	0.67	2.70	5.23	26.68
Maun	3.96	3.38	3.30	1.02	0.18	0.02	0.00	0.00	0.03	0.55	1.70	2.89	17.03
Ghanzi	4.13	3.58	3.60	1.55	0.37	0.05	0.01	0.01	0.06	0.91	1.75	2.57	18.59
Serowe	3.92	3.09	3.04	0.96	0.24	0.07	0.06	0.07	0.22	0.95	2.21	3.32	18.15
Francistown	4.18	3.10	2.80	0.71	0.16	0.10	0.01	0.04	0.05	0.87	2.20	3.43	17.65

The records published by the South African weather bureau and the Rhodesian Meteorological Department show that in any one year the total rainfall can be expected to vary considerably from the average. Experience also shows that the rain is sporadic in its occurrence and that there can be considerable variation in any one year between adjacent localities. The variation in the monthly rainfall is much greater than that for the annual total; as a rough guide to the extreme range in these variations, the minimum annual rainfall is about half the average and the maximum nearly double.

Apart from the Okavango swamps and the immediate vicinity of the Botletle and Nata rivers surface water is scarce in northern Bechuanaland and is only available for brief periods following rain. Neither surface water nor ground water supplies are obtainable in many areas and where ground water is found it is often brackish or saline. van Straten (1963) has described the ground water potential of Northern Bechuanaland, but it is worth emphasising here that throughout almost the whole basin highly mineralised and unusable waters occur at depth. Consequently wherever potable supplies have been developed bore holes must not be continued to a depth where saline supplies are encountered.

SOILS AND VEGETATION

Although Northern Bechuanaland is, in general, remarkably flat, within each of the four regions mentioned in the previous section there is much subdued relief in the form of low fixed dunes, sandy hollows, pans and extinct drainage lines. This variety of minor relief together with variations in the physiognomy of the vegetation results in many different types of country which can be recognised on photo mosaics and by stereoscopic examination of the aerial photographs.

During the first stage of the land use reconnaissance thirty-five different landscape patterns were recognised on the 1:125,000 scale photo mosaics. Each pattern was given a name describing the main factor by which it was identified; where similar patterns occurred in widely separated areas these were differentiated by suffix letters. The landscape patterns have been grouped into eight major categories as shown in Table III and mosaics at 1:250,000 scale and 1:500,000 scale showing their distribution have been supplied to the Department of Agriculture.

Table III

Preliminary Air Photo Analysis

Landscape pattern		Landscape Pattern	
A1	Woodland	E1	Swamp
2	Woodland savanna mosaic	2	Seasonal swamp A
3	Woodland savanna pitted mosaic	3	Seasonal swamp B
		4	Seasonal swamp C
		5	Swamp savanna
B1	Dense savanna	F1	Flooded dune
2	Savanna	2	Dune A
3	Open Savanna	3	Dune B
4	Striped savanna	4	Dune C
5	Savanna grassland	5	Dune D
6	Savanna cultivation	6	Dune E
		7	Dune F
C1	Grassland	8	Dune G
2	Grassland A	9	Dune H
3	Grassland B		
4	Grassland/Thicket mosaic	G1	Rock A
5	Scattered tree grassland	2	Rock B
D1	Salt grass	H1	Ngami Basin
2	Salt pan		
3	Salt pan mosaic		
4	Salt lake		

Most of the soils of Northern Bechuanaland have been derived from predominately aeolian sands of the Kalahari system. The main exceptions to this are found in the Okavango delta and in the Makariki depression where more silty soils derived from alluvial material occur, and in the areas between Ghanzi and Lake Ngami and near Panda ma tenga where older rocks lie near or at the surface and dominate soil formation.

Soils developed on the Kalahari sands have only poorly developed profiles and loose top soils. The vegetation on this sandveld ranges from a monotonous scrub 5 feet to 9 feet high dominated by Terminalia sericea, Grewia flavescens, Bauhinia macrantha and Dichrostachys cinerea with a sparse grass cover of Aristida species to an open Aristida grassland with a few low bushes. The extensive longitudinal sief dunes in the north and west consist of parallel ridges some 50 feet high and between one and five miles apart with a more or less east to west orientation. They have loose sandy soil and support open savanna communities dominated by Burkea africana and Pterocarpus angolensis. The soils in the intervening lower lying areas are poorly drained compacted sands and they support areas of low Grewia scrub and grassland with wide spaced Lonchocarpus nelsii.

Extensive woodlands dominated by Baikiaea plurijuga are found in the north east between Kasane and Panda ma tenga, while savanna communities dominated by Burkea africana extend in a broad belt from Kachikau south eastwards towards Odiakwe.

The Okavango delta consists of swamp and grassland communities along drainage lines (e.g. Cyperus papyrus and Phragmites sp. swamps and Cynodon dactylon flood plain grassland) separated by large areas of savanna dominated by Acacia giraffae and Colophospermum mopane. The former is associated with a fairly good cover of Cenchrus ciliaris. Panicum makarikariensis, Digitaria and Schmidtia spp. while the latter has a sparse cover of Aristida and Digitaria spp. Fringing the drainage lines there is a belt of woodland with frequent Ficus sycomorus, Lonchocarpus capassa, Combretum imberbe and Diospyros mespiliformis.

Extensive grasslands dominated by Odyssea paucinervis and Sporobolus spicatus occur on the alkaline soils around the Makarikari salt pans.

The following paragraphs describe some of the better soils of northern

Bechuanaland recognised during the investigation of the land use prospects. They comprise the field descriptions and analytical data for sample profiles from the more promising tracts together with some notes on their present and possible future use. The location of each profile is shown on the map. Most of the profiles lie within the influence of the Okavango or Botletle rivers, the areas of sandveld with poorly developed sandy soils have not been studied in any detail. Table VI shows the soils represented by these profiles grouped in terms of the units used for the soils map of Africa (J. L. d'Hoore, 1964). Analytical determinations have been made on samples from one profile at all but one of the eleven sites A - L shown on the map. The methods used for these analyses are given in the appendix.

An idea of the overall environmental pattern can be obtained from the distribution of the fourteen vegetation zones shown on the map. The composition of each vegetation zone is given in the map legend; a fuller account of the composition of the vegetation of Northern Bechuanaland is given by de Beer (1962).

TABLE IV

CLASSIFICATION OF NORTHERN BECHUANALAND SOILS IN TERMS OF

J. L. D'HOORE'S MAPPING UNITS

(Soil Map of Africa, ECT Publication No. 93, 1964)

Mapping unit	Soil	Profile reference
	WEAKLY DEVELOPED SOILS	
Ba	Lithosols (skeletal Soils) and lithic soils on lava.	D
Bo	Juvenile soils on recent deposits, on riverine and lacustrine alluvium	B,F,G,
	VERTISOLS AND SIMILAR SOILS	
Da	Derived from rocks rich in ferromagnesian minerals	C
	HALOMORPHIC SOILS	
Ma.	Solonetz and solodized solonetz.	I
Mb.	Saline, alkali and saline alkali soils	J,K
Md.	Soils of lunettes	L
	HYDROMORPHIC SOILS	
Na.	Mineral hydromorphic soils	E,H
Nb.	Organic hydromorphic soils	A

PROFILE 'A'

Horizon	Depth in inches	Description
1	0 - 9	10YR2/1 (Moist) black, 10YR4/1 (dry) dark grey silt; structureless; even consistence; abundant roots
2	9 - 24	5YR2/2 (moist) very dark brown, 5YR3/2 (dry) dark reddish brown peat; structureless; spongey consistence; occasional roots.
3	24 - 40	10YR6/2 (moist) light brownish grey and dry sand; structureless; loose consistence; occasional roots.

Horizon		1	2	3
% Coarse sand		n.d.	n.d.	85
% Fine sand		n.d.	n.d.	10
% American silt		n.d.	n.d.	2
% Clay		n.d.	n.d.	2
% loss on ignition		17.4	58.3	0.7
% Organic carbon		5.4	31.8	n.d.
% Total nitrogen		0.41	1.93	n.d.
C/N ratio		13	17	n.d.
Exchangeable cations	Ca^{++}	n.d.	n.d.	0.24
m.e./100 grams	Mg^{++}	n.d.	n.d.	0.11
	K^{+}	n.d.	n.d.	0.02
	Na^{+}	n.d.	n.d.	0.01
	H^{+} equiv.	n.d.	n.d.	1.10
Cation exchange capacity		n.d.	n.d.	1.5
% Base saturation		n.d.	n.d.	27
pH in water		4.5	4.6	5.5
pH in $\frac{M}{100}$ $CaCl_2$		4.3	4.0	4.9

PROFILE 'A'

Peaty Alluvium

This soil was sampled some 10 miles north-east of Nokaneng on the western side of the Okavango Delta, where it occurs as a fringe, 50 to 200 yards wide, on either side of the Taoghe River. The land is very nearly flat, the fall of the river being approximately 1 foot per mile (Bell, 1962). The soil is permanently waterlogged below a depth of 24 inches and is flooded annually.

The natural vegetation is a herbaceous mixture with abundant Pennisetum glaucocladum, Cynodon dactylon and Sesbania sp. and occasional Phragmites and Cyperus sp.

This organic Hydromorphic soil consists of three distinct layers: a topsoil which is a worked mixture of peat and fine grained alluvium, a peat layer and a coarse sand layer. A dominant feature is the high content of organic matter which is well humified in the surface layer but there is a serious deficiency of bases and the acidity is high. The annual flood appears to deposit a sufficient quantity of silt to maintain the productivity of the soil at a high level despite the serious deficiency of bases in the underlying sand.

Areas of this soil are sought out by the Bayei people for Maize production. It is an extremely productive soil and yields of up to 3 tons of Maize an acre have been reported. Provided that the water balance is not upset this and other acid-tolerant crops such as rice and possibly cotton, merit further investigation for future development.

PROFILE 'B'

Horison	Depth in inches	Descriptions
1	0 - 6	5Y2/1 (moist) black, 5YR4/1 (dry) dark grey silty clay loam; blocky structure; firm consistence; abundant roots.
2	6 - 30	5Y2/1 (moist) black, 5Y5/1 (dry) grey clay; blocky structure; firm consistence; frequent roots.
3	30 - 60	7.5YR7/2 (moist) pinkish grey, 7.5YR8/2 (dry) pinkish white sand; structureless; loose consistence; frequent roots.

Horizon		1	2	3
% Coarse sand		n.d.	7	56
% Fine sand		n.d.	9	41
% American silt		n.d.	33	1
% Clay		n.d.	43	0
% loss on ignition		12.4	7.8	0.6
% Organic carbon		3.5	n.d.	n.d.
% Total nitrogen		0.31	n.d.	n.d.
C/N ratio		11	n.d.	n.d.
Exchangeable cations m.e./100 grams	Ca^{++}	23.6	18.1	0.61
	Mg^{++}	4.71	2.81	0.12
	K^{+}	1.53	0.23	0.03
	Na^{+}	0.53	1.58	0.08
	H^{+} equiv.	5.9	3.6	0.3
Cation exchange capacity		36.3	26.3	1.1
% Base saturation		84	.86	73
pH in water		6.5	6.7	5.8
pH in $\frac{M}{100}$ $CaCl_2$		6.0	6.2	5.6

PROFILE B.

Grey Silty Clay Loam

Grey clay loams occur throughout the Nokaneng Flats - a flood plain of about 150 square miles on the western side of the Okavango Delta. The sample profile was located near profile, A, about 10 miles north-east of Nokaneng. The profile showed 2 distinct layers : a silt-clay mixture down to about 30 inches depth underlain by coarse sand, the first being further differentiated chemically and physically above and below 6 inches.

The vegetation is a Cynodon dactylon grassland (see Plate 1) which is persistently grazed with a high density of livestock. This use could continue indefinitely provided small adjustments were made to livestock numbers to attune them to the carrying capacity of the pasture. The area also has possibilities for arable farming under irrigation and recommendations have been made for a detailed soil survey and agronomic trials (Langdale-Brown and Spooner, 1963).

PROFILE 'C'

Horizon	Depth (ins)	
1	0 - 6	7.5YR2/0 (Moist) black, 7.5YR3/0 (dry) very dark grey clay; columnar structure; plastic consistence; $\frac{1}{8}$" $CaCo_3$ fragments.
2	6 - 20	7.5YR2/0 (moist) black, 7.5YR3/0 (dry) very dark grey clay; columnar structure; plastic consistence; $\frac{1}{8}$" $CaCo_3$ fragments.

Horizon		1	2
% Coarse sand		8	3
% Fine sand		0	11
% American silt		21	16
% Clay		66	64
% loss on ignition		6.7	6.6
% Organic carbon		1.1	1.0
% Total nitrogen		0.06	0.06
C/N ratio		18	17
Exchangeable cations	Ca^{++}	37.1	39.5
m.e./100 grams	Mg^{++}	12.1	11.8
	K^{+}	2.02	2.05
	Na^{+}	0.29	0.48
	H^{+} equiv.	4.3	3.4
Cation exchange capacity		55.8	57.2
% Base saturation		92	94
pH in water		7.1	7.7
pH in $\frac{M}{100}$ $CaCl_2$		6.5	7.0

PROFILE 'C'

Black Clay

A wide area of poorly drained black clay soil occupies a major part of the old Commonwealth Development Corporation ranch at Panda ma Tenga. The topography comprises a gentle upland with a number of large depressions separated by low ridges. This profile was sited in one of the depressions. The pit was stopped at 20 inches owing to the hardness of the soil. Auger-ing below this level showed that the black clay was more than 48 inches with calcrete fragments becoming commoner between 24 and 48 inches. deep The organic matter content is moderate but not well humified. The high exchange capacity suggests a montmorillonite-type clay, the drainage of which poses a problem to cultivation.

The vegetation is a secondary grassland dominated by Setaria sphacelata. Other grasses present include Urochloa sp., Panicum coloratum, Dicanthium papillosum, Hyparrhenia and Andropogon spp. There are also remnants of the vegetation which preceded clearing operations: Combretum imberbe, Acacia nilotica subsp. subalata and Colophospermum mopane.

For several years in the recent past this soil was used for the production of crops, it has now, however reverted to mixed types of grazing. There are two major limitations to its further use for cropping. First the intractability of the soil when wet which results in cultivation only being possible for short periods; second a lack of sufficient data on which to base a cropping system which can overcome this disability. Until such time as this second problem is solved, the most suitable use for this soil would be for depasturing stock under a system of controlled management.

PROFILE 'D'

Horison	Depth (in inches)	Description
1	0 - 11	5YR2/2 (Moist) dark reddish brown, 7.5YR4/2 (dry) brown clay loam; vertical fissures; some rounded rock fragments; occasional roots.
2	11 - 48	2.YR3"3 (moist) dusky red, 2.5YR5/2 (dry) weak red rotted rock, layered horizontally; calcrete fragments; rare roots.
3	At 48	Basalt lava.

NO CHEMICAL ANALYSES

PROFILE 'D'

Reddish Brown Clay Loam

This is a lithosolic soil derived from basalt. It was found on a low gravel ridge overlooking the clay depressions described under profile 'C'. The vegetation is a woodland dominated by Colophospermum mopane, Lonchocarpus capassa, Sclerocarya caffra and Baikiaea plurijuga with a sparse cover of Aristida, Heteropogon contortus and Hyparrhenia sp.

At present this vegetation supports a mixed type of grazing and these areas are used for extensive cattle ranching. This is a system appropriate to their potential as far as is at present known. Further knowledge of the soils' behaviour in supporting a limited range of crops might extend its usefulness in the future, though shallowness would seem to preclude this.

PROFILE E.

Horizon	Depth (ins)	
0		Surface litter.
1	0-10 cm 0-4	10YR3/1 (moist) very dark grey, 10YR4/1 (dry) dark grey clay; structureless; loose consistence; abundant roots.
2	10-22,5 4-9	10YR3/2 (moist) very dark greyish brown 10YR4/2 (dry) dark greyish brown clay; structureless; loose consistence; abundant roots.
3	22,5-90 9-36	10YR3/2 (moist) very dark greyish brown 10YR4/2 (dry) dark greyish brown clay, mottled red-brown in layers; columnar structure firm, plastic consistence.

Horizon		1	2	3
% Coarse sand				
% Fine sand				
% American silt				
% Clay				
% loss on ignition		12.8	13.9	13.6
% Organic carbon		3.5	4.4	n.d.
% Total nitrogen		0.35	0.33	n.d.
C/N ratio		10	13	n.d.
Exchangeable cations	Ca^{++}	16.1	13.2	13.9
	Mg^{++}	5.7	5.0	4.2
m.e./100 grams	K^{+}	2.84	1.40	0.58
	Na^{+}	0.59	0.55	0.43
	N^{+} equiv.	12.3	17.5	17.4
Cation exchange capacity		37.5	37.8	36.5
% Base saturation		67	54	52
pH in water		5.1 exch.acid	4.1 exch.acid	4.2 exch.acid
pH in $\frac{M}{100}CaCl_2$		4.4 exch.acid	3.7 exch.acid	3.9 exch.acid.

PROFILE E.

Grey Clay

Soils of this type occur throughout the Lake Ngami flood plain at the southern extremity of the Okavango Delta. The sample profile was located 2 miles south of Sehitwa in an area of Cynodon dactylon grassland with Sesbania sp. sub-shrub (Plate 2).

This soil is strongly acid and the finer particles are strongly agregated with oxides. Mottling below a depth of 9 inches is indicative of the impeded drainage of this area while dead trees on the fringe of the grassland (Plate 3) are the result of a recent high flood.

At present this grassland is used for grazing and supports mixed livestock in very large numbers. Such use has led to denudation of the soil surface. The predominance of Cynodon dactylon could be maintained and its productivity, and the stability of the soil, could be improved by a more rational system of pasture management. Alternatively, setting aside the human problems of a population with strong pastoral traditions these soils could probably be used for crop production under irrigation. Detailed pasture and soil surveys and agronomic trials have been recommended to investigate these possibilities.

PROFILE 'F'

Horison	cm	Depth in inches	Description
1.	0–10	0 - 4	10YR4/2 (moist) dark greyish brown, 10YR5/2 (dry) greyish brown fine sand; structureless; loose to friable consistence; abundant roots.
2	10–85	4 - 34	10YR5/2 (moist) greyish brown, 10YR6/2 (dry) light brownish grey fine sand; structureless; compact; occasional roots.
3	85–120	34 - 48	10YR5/3 (moist) brown, 10YR6/3 (dry pale brown fine sand, slightly mottled; structureless; compact, rare roots.

Horison		1 S	2 S	3 S
% Coarse sand		34	32	36
% Fine sand		58	64	57
% American silt		2	1	1
% Clay		5	2	6
% Loss on ignition		1.9	0.5	0.8
% Organic carbon		0.9	n.d.	n.d.
% Total nitrogen		0.08	n.d.	n.d.
C/N ratio		11	n.d.	n.d.
Exchangeable cations m.e./100 grams	Ca^{++}	1.21	0.95	2.54
	Mg^{++}	0.41	0.28	0.74
	K^{+}	0.26	0.09	0.26
	Na^{+}	0.03	0.06	0.12
	H^{+} equiv.	1.3	0.5	0.4
Cation Exchange Capacity		3.2	1.9	4.1
% Base saturation		59	74	90
pH in water		6.3 Sl. acid	6.2 Sl. acid	6.8 Neutral
pH in $\frac{M}{100}$ $CaCl_2$		5.6 Med. acid	5.7 Med. acid	6.3 Sl. acid.

PROFILE 'F'

Grey Brown Sand.

This profile was sited on the fringe of the Lake Ngami flood plain 2 miles East of Sehitwa. It showed a distinct topsoil about 4 inches deep, darker and moister than the remainder, which graded imperceptibly with depth from grey-brown to brown.

The soil is almost entirely dependent on organic matter supply for moisture and nutrient retention. It supports a savanna community in which Acacia giraffae is associated with grasses of the genera Chloris, Eragrostis, Schmidtia and Urochloa (Plate 4).

The grass cover is of low productivity and has been grazed heavily for a long time. While its main possibilities appear to lie in a system of livestock production it is clear that improvements could result from a careful balancing of stock numbers with the growth of the sward.

PROFILE 'G'

Horison	Depth in inches	Description
1	0 - 12	10YR3/1 (moist) very dark grey. 10YR4/1 (dry) dark grey sand; structureless; loose consistence; abundant roots.
2	12 - 40	10YR4/2 (moist) dark greyish brown, 10YR5/2 (dry) greyish brown sand; structureless, loose consistence; frequent roots.
3	40 - 72	10YR6/3 (moist) pale brown, 10YR7/3 (dry) very pale brown sand; structureless; compact occasional roots.

Horison		1	2	3
% Coarse sand		49	64	63
% Fine sand		41	29	29
% American silt		3	1	2
% Clay		5	6	6
% Loss on ignition		2.3	1.0	0.8
% Organic carbon		1.2	n.d.	n.d.
% Total nitrogen		0.11	n.d.	n.d.
C/N Ratio		11	n.d.	n.d.
Exchangeable cations	Ca^{++}	6.2	2.9	8.7
	Mg^{++}	0.96	0.82	2.44
m.e./100 grams	K^{+}	0.33	0.29	0.54
	Na^{+}	0.03	0.02	0.02
	H^{+} equiv	0.9	0.7	0.4
Cation Exchange Capacity		8.4	4.7	12.1
% Base saturation		89	85	97
pH in water		7.3 Neutral	7.3 Neutral	8.4 Mod. alk.
pH in $\frac{M}{100}$ $CaCl_2$		6.9 neutral	7.1 neutral	8.0 Mod. alk.

PROFILE 'G'

Grey Sand.

This type of soil occurs throughout the Okavango Delta on the higher ground between the drainage lines. The profile was sited on the Moshu Experimental Farm where the vegetation consisted of a mixed savanna with Colophospermum mopane, Terminalia sericea, Acacia nilotica subsp. subalata A. giraffae and Rhus burchelli common among the trees and an open cover of Digitaria sp. Aristida sp., Panicum makarimariensis and Cenchrus ciliaris (see Plate 5).

This soil is almost entirely dependent on organic matter supply for moisture and nutrient retention. It is largely unused at present owing to the incidence of tsetse flies and the dangers of human and bovine trypanosomiasis. Efforts are being made to clear the area of tsetse flies and a series of agronomic trials has been started to determine the possibilities of this soil for arable agriculture.

PROFILE 'H'

Horizon	Depth in inches	Description
1	0 - 6	10YR2/1 (moist black, 10YR4/1 (dry) dark grey fine sand; structureless; loose consistence; abundant roots.
2	6 - 36	10YR2/1 (moist) black, 10YR4/1 (dry) dark grey fine sandy clay loam; columnar structure; firm consistence; frequent roots.
3	36 - 72	10YR3/1 (moist very dark grey, 10YR5/1 (dry) grey fine sandy clay loam; columnar structure; firm consistence; occasional roots.

Horizon		1 (cSl)	2 (scl)	3 (scl)
% Coarse sand		36	30	22
% Fine sand		48	34	40
% American silt		6	3	5
% Clay		8	23	33
% Loss on ignition		2.1	2.4	3.4
% Organic carbon		1.4	n.d.	n.d.
% Total nitrogen		0.07	n.d.	n.d.
C/N Ratio		20	n.d.	n.d.
Exchangeable cations	Ca^{++}	3.3	6.8	8.8
	Mg^{++}	0.59	2.12	3.20
m.e./100 grams	K^{+}	0.13	0.37	0.33
	Na^{+}	0.14	0.18	0.25
	H^{+} equiv.	1.4	0.9	1.6
Cation Exchange Capacity		5.5	10.4	14.2
% Base saturation		75	91	89
pH in water		6.3 Sl. acid	6.8 Neutral	7.1 Neutral
pH in $\frac{M}{100}$ $CaCl_2$		5.5 Sl. acid	6.4 Sl. acid	6.5 Sl. acid

PROFILE 'H'

Grey Sandy Clay Loam

This profile was located on a drainage line within the Okavango Delta close to profile 'G' on the Moshu Experimental Farm (Plate 5). The soil is inundated for 2 to 3 months each year and supports a grassland with abundant Setaria sphacelata, Panicum sp. and Juncus sp. Better drainage would improve humification of organic matter. The main differences between the soil of this profile and that of profile 'G' lie in their texture and drainage. The higher clay fraction in 'H' would make it much harder to cultivate than 'G', and there is the additional hazard of seasonal flooding. Flood control could lead to the use of this soil for irrigation farming and experiments are in progress to determine the possibilities for both rain fed and irrigated crops.

PROFILE I

Horizon	Depth (ins.)	Description
1	0 - 12	10YR4/1 (moist) dark grey 10YR5/1 (dry) grey silt loam; structureless; loose consistence; abundant roots.
2	12- 16	10YR4/1 (moist) dark grey, 10YR5/1 (dry) grey silt loam; structureless; loose consistence; abundant roots.
3	16 - 50	10YR4/1 (moist) dark grey, 10YR5/1 (dry) grey clay loam; blocky structure; firm consistence; frequent roots.
4	50 - 60 125 cm	10YR7/1 (moist) light grey, 10YR8/1 (dry) white clay loam; structureless; firm consistence; rare roots. Calcareous

Horizon		1	2	3	4
% Coarse sand		n.d.	n.d.	6	n.d
% Fine sand		n.d.	n.d.	14	n.d.
% American silt		n.d.	n.d.	40	n.d.
% Clay		n.d.	n.d.	35	n.d.
% Loss on ignition		10.4	9.0	6.7	6.2
% $CaCo_2$ equiv.		1.2	8.0	1.0	7.9
% Organic carbon		2.6	1.4	n.d	n.d.
% Total Nitrogen		0.24	0.14	n.d.	n.d.
C/N ratio		11	10	n.d.	n.d.
Exchangeable cations m.e./100 grams	Ca^{++}	n.d.	n.d.	15.7	n.d.
	Mg^{++}	n.d.	n.d.	28.0	n.d.
	K^{+}	n.d.	n.d.	1.49	n.d.
	Na^{+}	n.d.	n.d.	8.94	n.d.
	H^{+} equiv	n.d.	n.d.	0.4	n.d.
Cation exchange capacity		n.d.	n.d.	54.5	n.d.
% Base saturation		n.d.	n.d.	99	n.d.
pH in water		7.8	9.2	8.7	8.2
pH in $\frac{M}{100}$ $CaCl_2$		7.5	8.5	8.1	7.9

PROFILE I

Grey Silt Loam

This profile was located on a flat area between two drainage lines 3 miles south of Rakops (Plate 6). The soil supports grass-land dominated by Cynocon dactylon, which is heavily grazed by cattle. In some localities this soil is cultivated and small grain cereal crops are grown.

The high exchangeable sodium (20% of the sum of metal cations) and high pH indicate a salinity problem.

PROFILE J

Horizon	Depth (ins.)	
1	0 - 6	10YR3/1 (moist) very dark grey, 10YR4/1 (dry) dark grey loam; structureless; loose consistence; abundant roots.
2	6 - 13	10YR3/1 (moist) very dark grey, 10YR4/1 (dry) dark grey fine sandy clay loam; structureless; loose consistence; abundant roots.
3	13 - 40	10YR4/1 (moist) dark grey, 10YR5/1 (dry) grey fine sandy loam; structureless; firm consistence; compact; frequent roots.
4	40 - 44	10YR3/1 (moist) very dark grey 10YR4/1 (dry) dark grey loamy fine sand; structureless; firm consistence; occasional old roots.
5	44 - 50	10YR5/1 (moist and dry) grey fine sand; structureless; firm consistence.

Horizon		1	2	3	4	5
% Coarse sand		6	9	22	7	11
% Fine sand		22	35	61	65	83
% American silt		44	27	8	12	5
% Clay		22	26	8	16	1
% Loss on ignition		8.6	5.8	1.7	1.9	0.5
% $CaCo_2$ equiv.		2.3	1.0	Tr.	nil	nil
% Organic carbon		2.4	1.6	0.5	0.5	n.d
% Total nitrogen		0.20	0.15	0.05	0.04	n.d
C/N ratio		12	11	10	13	n.d.
Exchangeable cations	Ca^{++}	n.d	n.d.	n.d	6.1	1.4
	Mg^{++}	n.d.	n.d.	n.d.	1.71	0.36
m.e./100 grams	K^{+}	n.d.	n.d.	n.d.	0.42	0.11
	Na^{+}	n.d.	n.d.	n.d.	0.22	0.05
	H^{+} equiv.	n.d.	n.d.	n.d.	1.0	0.7
Cation exchange capacity		n.d.	n.d.	n.d.	9.4	2.6
% Base saturation		n.d.	n.d.	n.d.	89	73
pH in water		8.5	8.8	7.9	8.0	7.2
pH in $\frac{M}{100}$ $CaCl_2$		7.8	8.0	7.4	7.3	6.7

M.a. 30

PROFILE J.

Grey Loam

This profile was dug in cultivated land in an old drainage channel adjacent to soil I, 3 miles south of Rakops in the Makarikari Depression (Plate 7). The profile showed a succession of dark and light horizons below 40 inches which are presumably successive deposits of water-born material.

This soil is used in preference to soil I to grow maize and sorghum; possibly on account of its greater moisture or because it has a different nutrient status. The surface layers are alkaline.

PROFILE 'K'

Horizon	Depth in inches	Description
1	0 - 9	10YR4/1 (moist) dark grey, 10YR 5/1 (dry) grey silty clay; structureless; loose consistence; abundant roots.
2	9 - 13	2.5YR5/2 (moist) weak red, 2.5 YR6/2 (dry) pale red silty clay; structureless; loose consistence; occasional roots.
3	13 - 24	10YR3/1 (moist) very dark grey; 10YR4/1 (dry) dark grey silty clay; structureless; loose consistence; occasional roots.

Horizon		1	2	3
% Coarse sand				
% Fine sand				
% American silt				
% Clay			>35	>40
Loss on ignition		9.5	4.8	7.9
$CaCo_2$ equiv.		7.3	5.3	0.8
% Organic carbon		5.0	n.d.	n.d.
% Total nitrogen		0.38	n.d.	n.d.
C/N Ratio		13	n.d.	n.d.
Exchangeable cations	Ca^{++}	n.d.	n.d.	22.2
	Mg^{++}	n.d.	n.d.	8.12
m.e./100 grams	K^{+}	n.d.	n.d.	3.21
	Na^{+}	n.d.	n.d.	9.96
	H^{+} equiv.	n.d.	n.d.	1.4
Cation Exchange Capacity				44.9
% Base Saturation				97
pH in water		8.8	8.7	7.7
pH in $\frac{M}{100}$ $CaCl_2$		8.2	8.3	7.6

PROFILE 'K'

Grey Silty Clay

This grey silty clay was sampled on a grass plain adjoining Lake Dow in the Makarikari Depression. Three horizons were distinguished - the middle one, from 9 to 13 inches, being diatomaceous in origin.

The finer particles in this profile were strongly aggregated with oxides. The high exchangeable sodium (≈25% of the sum of metal cations) and the high pH throughout the profile indicate a salinity problem.

A mineralogical examination of the middle horizon showed that it was composed largely of opaline silica (isotropic, non crystalline, refractive index approx. 1.43). The most numerous forms in which this occured were:

(a) Valves of Diatoms, such as Pinnularia sp.,

(b) Fragmentary sponge spicules,

(c) Phytoliths - siliceous reinforcements of large plants, possibly grasses.

In addition there were some clay mineral aggregates of unknown composition, which were partly birefringent, and occasional detrital grains of quartz sand.

Opaline material from organic matter occurs fairly commonly in soils (Smithson, 1956, 1959), but rarely to the large extent seen in this sample. The abundance of diatoms and fragments of diatoms supports the idea that this horizon is derived largely from diatomaceous earth.

The commonest grasses in this area are Cynodon dactylon, Sporobolus spicatus and Odyssea paucinervis. They are heavily grazed by cattle and small stock.

PROFILE 'L'

Horison	Depth in inches	Description
1	0 - 7	10YR4/1 (moist) dark grey, 10YR5/2 (dry) greyish brown fine sand; structureless; even consistence; abundant roots.
2	7 - 18	10YR4/1 (moist) dark grey, 10YR5/2 (dry) greyish brown fine sand; structureless; even consistence; abundant roots.
3	18 - 42	10YR5/2 (moist) greyish brown, 10YR6/2 (dry) light brownish grey loamy fine sand; structureless; even consistence; occasional roots.
4	42 - 72	7.5YR6/2 (moist) pinkish grey, 7.5YR7/2 (dry) pinkish grey fine sand; structureless; even consistence; rare roots.

Horizon		1	2	3	4
% Coarse sand		39	38	34	14
% Fine sand		51	49	46	84
% American silt		2	4	6	1
% Clay		7	8	13	1
% Loss on ignition		1.9	2.1	2.3	1.6
$CaCo_2$ equiv.		1.2	3.3	10.5	12.4
% Organic carbon		0.6	0.6	n.d.	n.d.
% Total nitrogen		0.06	0.05	n.d.	n.d.
C/N Ratio		10	12	n.d.	n.d.
Exchangeable cations	Ca^{++}	n.d.	n.d.	n.d.	n.d.
m.e./100 grams	Mg^{++}	n.d.	1.56	n.d.	n.d.
	K^{+}	n.d.	0.44	n.d.	n.d.
	H^{+} equiv.	n.d.	Nil	n.d.	n.d.
Cation exchange capacity		n.d.	n.d.	n.d.	n.d.
% Base Saturation		n.d.	n.d.	n.d.	n.d.
pH in water		8.2	8.3	8.4	8.9
pH in $\frac{M}{100}$ $CaCl_2$		7.7	7.8	7.8	8.1

PROFILE 'L'

Greyish Brown Sand

This soil occurs extensively to the north-west of the Makarikari salt pans. The sample profile was located approximately 10 miles south east of Sihoro in a Digitaria-Odyssea grassland (Plate 8). It is largely dependent on organic matter supply for moisture and nutrient retention.

This grassland area is remote and unpopulated, and is seasonally grazed by game, mainly Wildebeeste. There would be scope for improved range utilization using cattle provided adequate water supplies could be provided.

APPENDIX

Methods of Analysis

Preparation of sample: The soil taken from the field was air dried and, using a Rukuhia soil grinder (Waters and Sweetman, 1955), crushed to pass a 2mm screen. A sub-sample was ground in a Morrice mechanical pestle and mortar (agate) to pass a 0.5 mm sieve. The 2mm sample was used for all determinations except carbon, nitrogen and calcium carbonate equivalent which were made on the 0.5 mm sample.

Mechanical analysis: Sodium hexa-metaphosphate ('Calgon') and sodium hypochlorite were used for dispersion. Calcium carbonate was not dissolved. Sedimentation analysis for fractions $50/^{u}$ was done with the Bouyoucos hydrometer (Bouyoucos, 1951); appropriate sieves were used for the coarser fractions. *

Loss on ignition: This value was determined using a muffle furnace maintained at 850°C and was corrected for decomposition of calcium carbonate, where this was present.

Calcium carbonate equivalent: A calcimeter (Bascomb, 1961) was used to measure the volume of carbon dioxide evolved from the sample on treatment with 1:3 hydrochloric acid. This volume was calculated to the equivalent amount of calcium carbonate irrespective of whether other carbonates contribute to it.

Organic carbon: Tinsley's (1950) procedure of wet oxidation under reflux with a mixture of 0.4N sodium dichromate, 15N sulphuric acid and 3N phosphoric acid, at 140°C for 2 hours, was used to determine the amount of organic carbon present. The excess of dichromate was titrated against ferrous ammonium sulphate using barium diphenylamine sulphonate as indicator.

Total Nitrogen: A Kieldahl digestion was followed by steam distillation of an aliquot using a Hoskins (1944) apparatus. The distillate was absorbed in boric acid and titrated with 0.01N hydrochloric acid.

pH measurements: These measurements were made electrometrically in a 1:2.5 suspension of soil (a) in water and (b) in 0.01M calcium chloride (Schofield and Taylor, 1955).

Exchangeable bases: The soil was leached with neutral normal ammonium acetate. Sodium and potassium in the leachate were determined directly using an Eel flame photometer; calcium was determined in the same apparatus after the addition of magnesium as release agent (Rowe, 1963) Magnesium was determined spectrographically using a porous cup technique (Scott and Ure, 1958).

Exchangeable hydrogen equivalent: A modification of the method developed by Modos (1943) was used. The soil was equilibrated with 0.2N ammonium hydroxide and formaldehyde added. After shaking, the formaldehyde was centrifuged off with 0.1N sodium hydroxide and 2.5N barium chloride added. The supernatant liquid was then titrated.

*Sieve sizes

Coarse sand		200 - 2,000 /u
Fine sand		50 - 200 /u
American silt		2 - 50 /u
Clay	less than	2 /u

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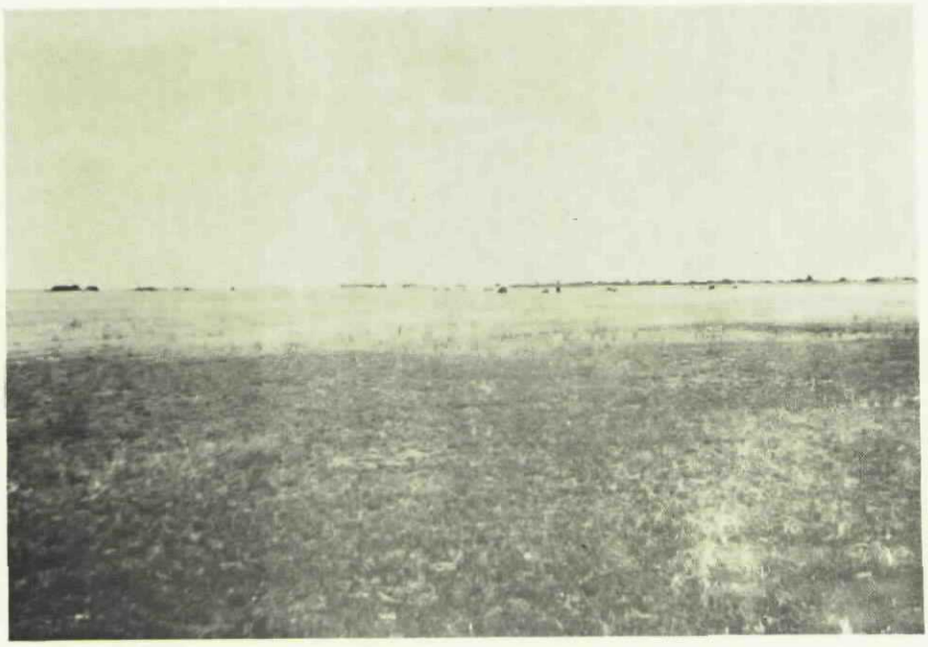


Heavily grazed *Cynodon dactylon* grassland on grey silty clay loam (Profile B) on flood plain within the area of the Okavango Delta (Nokaneng Flats). Plate 1

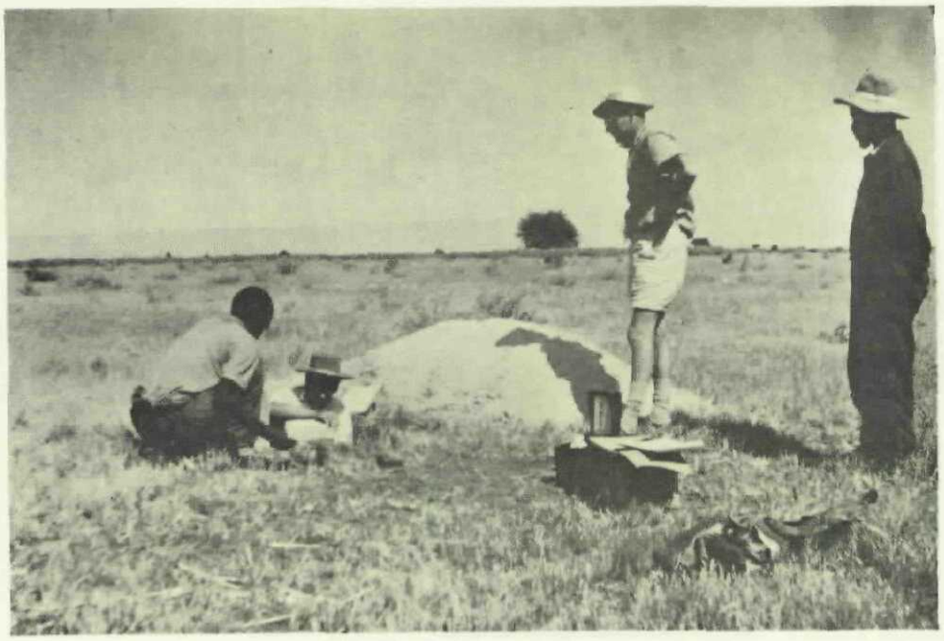
Cynodon dactylon grassland with *Sesbania* sp. on grey clay (Profile E) on Lake Ngami flood plain at the southern extremity of the Okavango Delta. Plate 2

Extensive view of Lake Ngami flood plain showing *Cynodon dactylon* grassland and dead *Acacia giraffae* trees - a result of an exceptionally high flood about 5 years ago (near site of profile E). Plate 3

Acacia giraffae savanna with grasses of the genera *Chloris, Erogrostis, Schmidtia* and *Urochloa* on a sandy soil (Profile F) on higher lying land adjoining the Lake Ngami flood plain. Plate 4

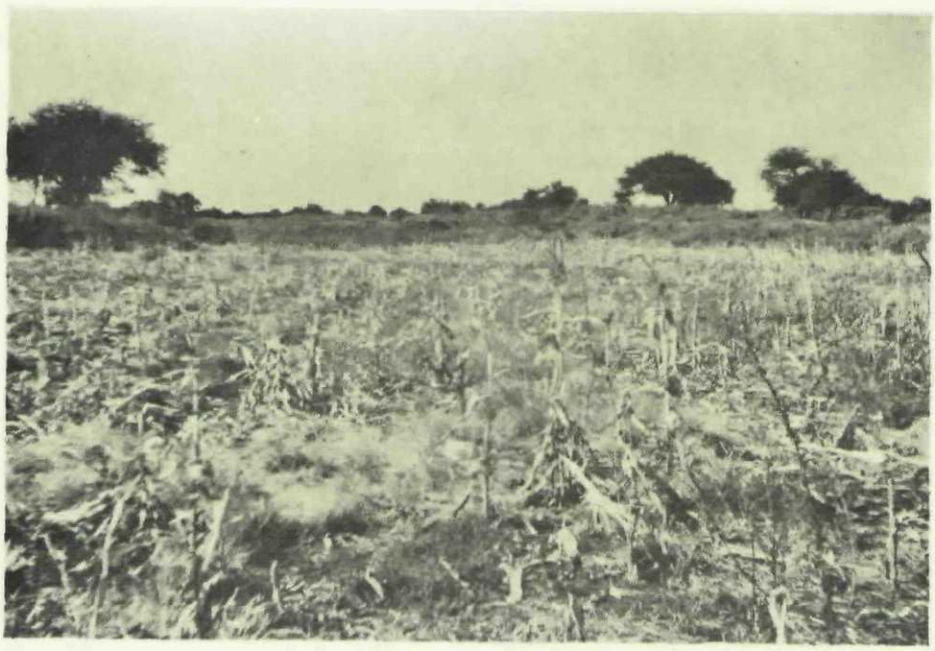
Seasonal swamp grassland on sandy clay loam (Profile H) at Moshu within the Okavango Delta. This photograph also shows Fringing Woodland with *Lonchocarpus capassa* and *Diospyros mespiliformis* (left) and *Acacia - Colophospermum* savanna (right) on rises between drainage lines (Profile G).

Plate 5



Cynodon dactylon - Odyssea paucinervis grassland on grey alkaline silt loam (Profile I) near Rakops in the Makarikari Depression.

Plate 6



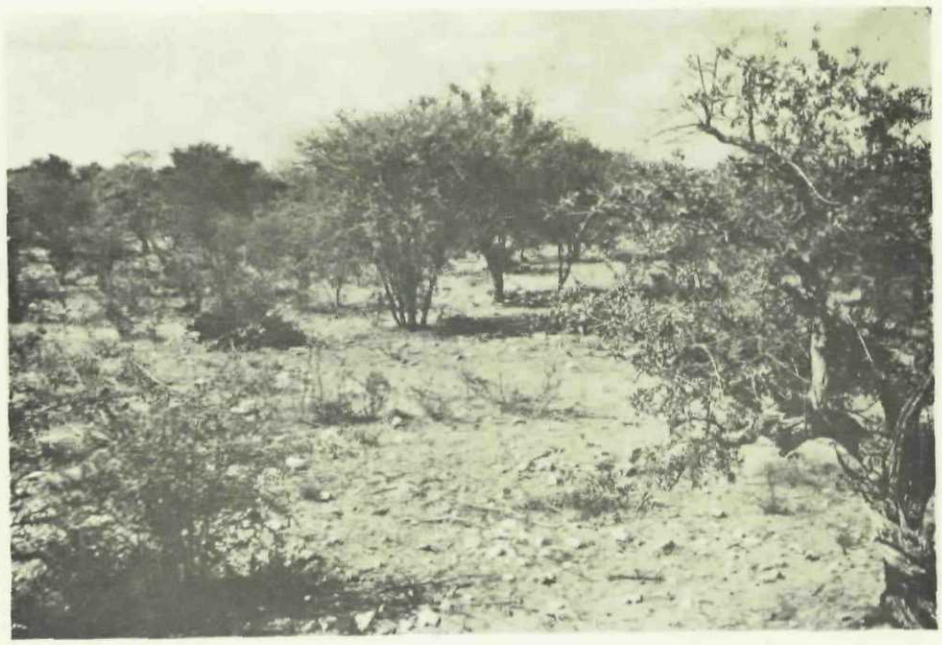
Sorghum and maize on grey alkaline loam (Profile J) in a drainage channel near Rakops.

Plate 7

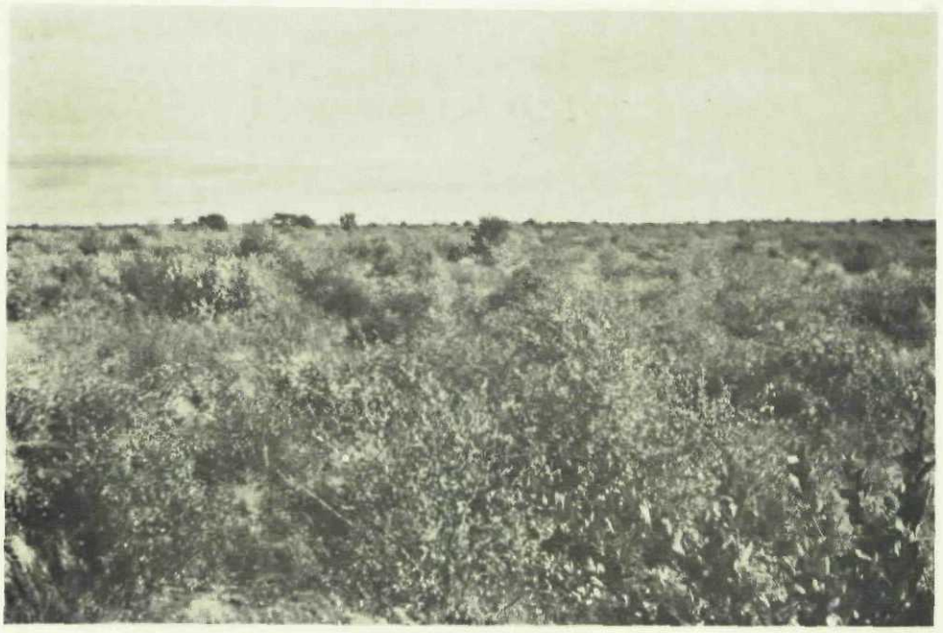
Digitaria sp. - *Odyssea paucinervis* grassland on alkaline fine sand (Profile L) east of Sihoro in the Makarikari Depression.

Plate 8

Colophospermum mopane woodland with undershrub layer of stunted *C. mopane* and a sparse grass layer consisting mainly of *Aristida* sp. on compacted grey sand between drainage lines in the Okavango Delta near Kwaai. Plate 9



Acacia sp. bushland on shallow rocky soils near *Ghanzi*. Plate 10

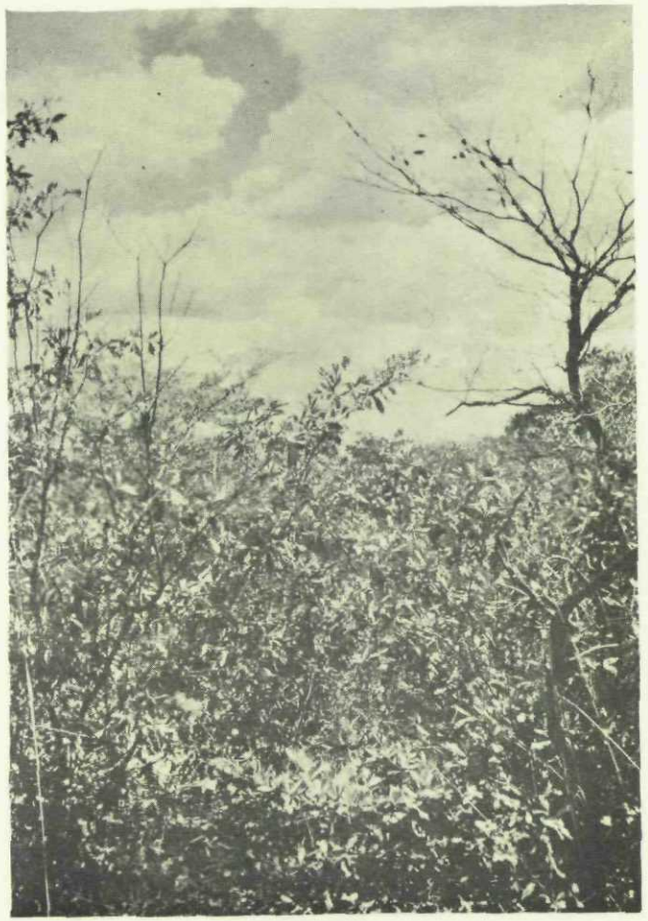


Grewia - Croton - Combretum scrub with *Aristida* sp. grass on loose sandveld soils 20 miles west of Kuki.

Plate 11

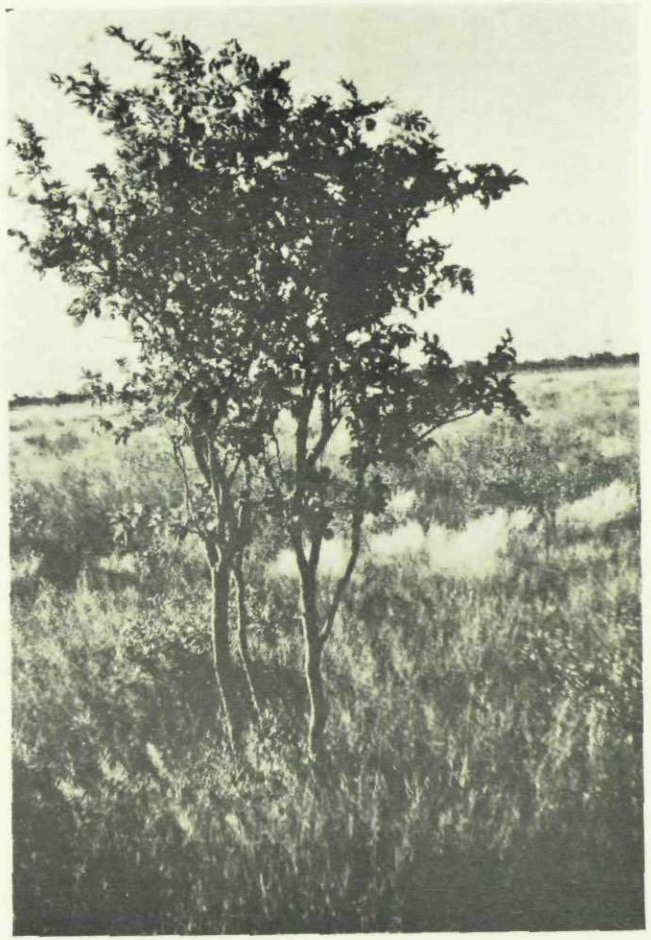
Burkea africana - Pterocarpus angolensis savanna on loose sandy soil on dune ridge 30 miles west of Nokaneng.

Plate 12



Grewia - other species scrub on compacted grey sandy soil at base of dune ridge 30 miles west of Nokaneng.

Plate 13



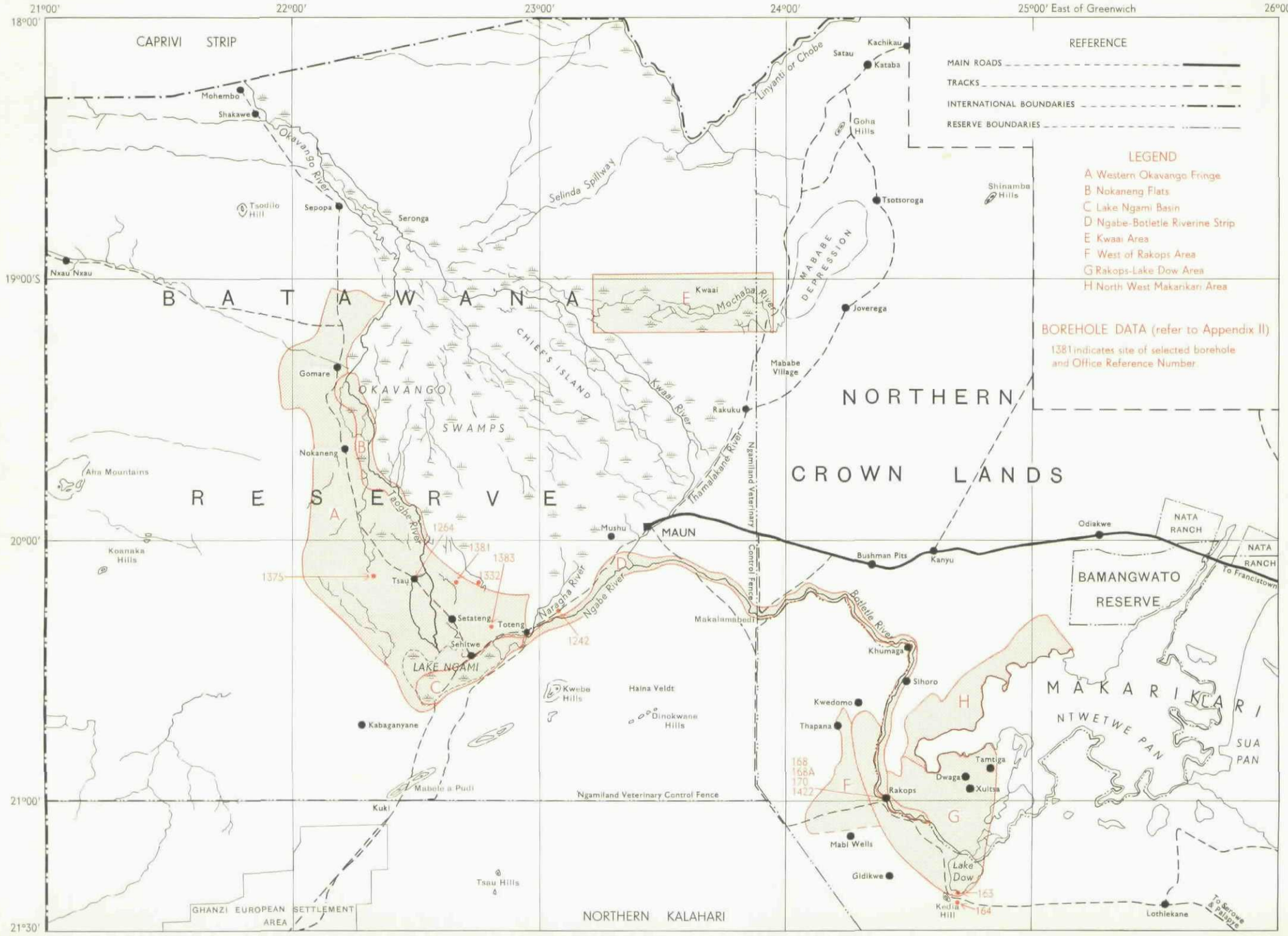
Lonchocarpus nelsii (foreground) in *Digitaria* - *Aristida* grassland on compacted grey sandy soil in valleys between dune ridges 30 miles west of Nokaneng. One of the low ridges can be seen in the background (see also plates 12 and 13).

Plate 14

22963 b

NORTHERN BECHUANALAND

Potential Development Areas



REFERENCE

MAIN ROADS

TRACKS

INTERNATIONAL BOUNDARIES

RESERVE BOUNDARIES

LEGEND

A Western Okavango Fringe
B Nokaneng Flats
C Lake Ngami Basin
D Ngabe-Botletle Riverine Strip
E Kwaai Area
F West of Rakops Area
G Rakops-Lake Dow Area
H North West Makarikari Area

BOREHOLE DATA (refer to Appendix II)

1381 indicates site of selected borehole and Office Reference Number.

D.O.S. (Misc) 368C

SCALE 1:2,000,000 (Approx.)

Miles 10 0 10 20 30 40 50 60 70 80 90 100 Miles

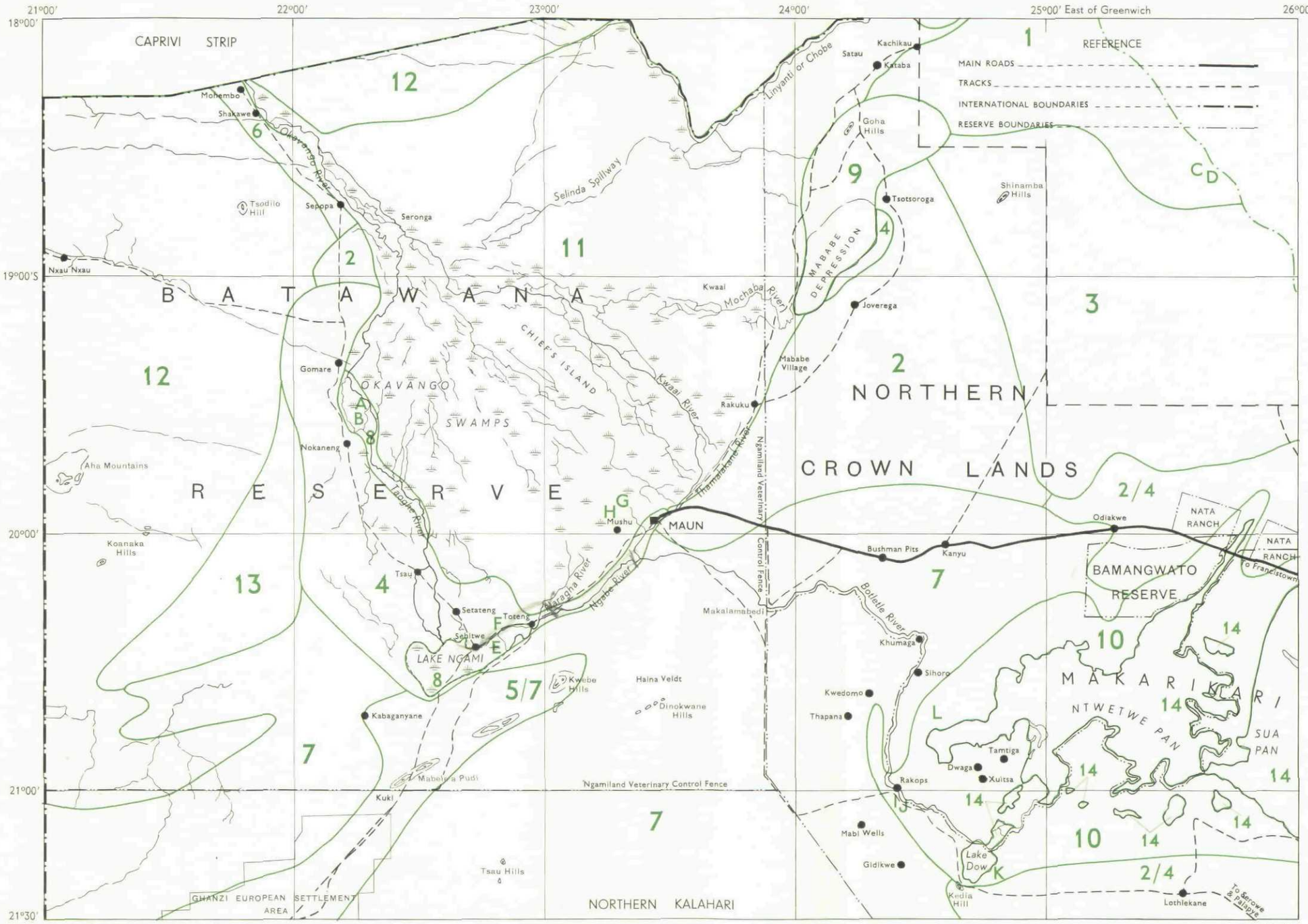
7/68/659/OA

This map is one of four which accompany a report entitled "Land Use Prospects of Northern Bechuanaland" by I. Langdale-Brown and R.J. Spooner, Directorate of Overseas Surveys.

22963a

NORTHERN BECHUANALAND

Vegetation Zones and Soil Profile locations



LEGEND

VEGETATION ZONES

1 *Baikiaea plurijuga* woodland

2 *Colophospermum mopane* woodland

3 *Burkea africana* savanna

4 *Acacia giraffae* savanna

5 *Terminalia prunoides - Acacia spp.- Boscia sp.* savanna

6 *Terminalia sericea - Combretum* savanna

7 *Grewia - Croton - Combretum - Terminalia sericea - Dichrostachys* scrub with areas of *Aristida* grassland

8 *Cynodon dactylon* grassland

9 *Cenchrus - Chloris - Cymbopogon - Sorghum* grassland

10 *Odyssea paucinervis - Sporobolus spicatus* grassland

11 Okavango Mosaic
Uplands: *Colophospermum mopane* woodland and *Acacia giraffae* savanna
Valley sides: fringing woodland with *Ficus sycamorus, Lonchocarpus capassa, Combretum imberbe* and *Diospyros mespiliformis*
Valley bottoms: seasonal swamp grassland, *Phragmites* and *Cyperus papyrus* swamp

12 Dune Mosaic
Ridges: *Burkea - Pterocarpus* savanna
Valley sides: *Grewia* scrub
Valley bottoms: *Lonchocarpus nelsii - Digitaria* open savanna

13 *Acacia* bushland - *Lonchocarpus nelsii - Digitaria sp.* - open savanna mosaic

14 Sparse halophytic vegetation on saline pans

Letters A-L show location of soil profiles described in the accompanying report.

REFERENCE
MAIN ROADS
TRACKS
INTERNATIONAL BOUNDARIES
RESERVE BOUNDARIES

This map accompanies a report on "Some Soils of Northern Bechuanaland" (D.O.S. 1965) which was supplied to the Department of Agriculture, Bechuanaland as a supplement to a report entitled "Land Use Prospects of Northern Bechuanaland" (D.O.S. 1963).
The map was compiled by I. Langdale-Brown from information collected during the investigation of the land use prospects.

D.O.S. (Misc) 368D

SCALE 1:2,000,000 (Approx.)

Miles 10 0 10 20 30 40 50 60 70 80 90 100 Miles

7/68/659/OA

This map is one of four which accompany a report entitled "Land Use Prospects of Northern Bechuanaland" by I. Langdale-Brown and R.J. Spooner, Directorate of Overseas Surveys.