Soils and Land Capability in Swaziland

SOILS AND LAND CAPABILITY IN SWAZILAND

Chapter 3 – LAND CAPABILITY

Chapter 4 – TRENDS IN THE RURAL ECONOMY

APPENDICES

TABLES

TABLES — Continued.

TABLES — Continued.

In Separate Folder or Canister

MAPS in the Text

FIGURES

FIGURES — Continued.

PREFACE

OBJECTIVES:

My chief aims in this memoir are to characterize the soils of Swaziland, both descriptively and cartographically, and to examine their suitability for crops which are grown, or which it has been found will grow, with a view to specifying, as nearly as present-day knowledge and methods allow, the kinds of future agroforestal systems which can be vindicated as profitable for the kingdom to pursue. The best localities for more intensive farming and for expansion of less intensive forms of land use will be suggested.

While I have travelled some distance along these paths, I am aware that there is a great way still to go, and if some of the alleys I have taken are shown to be blind this will be no surprise. Wrong turnings may prove to be mine, but it will not necessarily be true as a corollary that I can claim full credit for all useful signposting along the road. As the acknowledgements below testify, a team has participated in soil survey work here as elsewhere. Constructing the soil and land capability classifications entitles me to sole authorship of this thesis, but my earnest desire is that adapting and interpreting those classifications will be deemed to be their prerogative by the maximum number of my colleagues. Opinions expressed, on development and other topics, do not necessarily reflect Swaziland Government policy.

The Swaziland Soil Survey began work in 1955 when Dr. H. Greene, then British Colonial Office Adviser on Tropical Soils, initiated my soil mapping of the Lower Usutu Basin (South), where irrigability was the main land capability assessment. Already 6,000 acres were being irrigated in the country by 1955. During the subsequent 13 years this total has increased to 75,000 acres, virtually all of which have been provided with detailed or semi-detailed soil maps.

In 1958-1960 I made first attempts to define agricultural potential for several important crops, based on recognition of soil series and of land slope categories. Concurrently agricultural research, undertaken spasmodically since 1925, was invigorated by A.C. Venn, then Soil Fertility Officer, and his colleagues.

Prior to October 1963, when I was accepted as a Ph.D. student, about one million acres or less than quarter of Swaziland had been soil-mapped - 840,000 acres by myself and 80,000 acres by J.P. Andriesse and 60,000 acres by others. The National Soil Reconnaissance was then mounted to speed up the accretion of soil knowledge and of soil-geographical facts with a bearing on agroforestal potentiality.

At reconnaissance and more intensive levels enough of the remainder of the kingdom had by 1967 been surveyed to permit the compilation of the accompanying* 1:125,000 maps — another 2,130,000 acres by me and 220,000 acres by I.C. Baillie. To complete the maps I have delineated soil boundaries for the residual 970,000 acres by air photo interpretation. This stage was finalized in May 1968. On all previous ground surveys I invariably used aerial photographs as aids to soil cartography. Swaziland had complete cover flyings in 1947 and again in 1961.

I started to correlate yields of maize, cotton and sugarcane with soils on which they are commercially grown in 1964. The results, presented here along with similar later studies of pine tree growth, provide checks on theoretical land capability ratings, which are in any case periodically reviewed and revised, and give quantitative values enabling predictions of yields in

*The Soil Map and the Land Capability Map, each of them in two sheets about 4 by 3 feet, have been printed separately and should be consulted in conjunction with this volume.

the near (but not the distant) future to be made.

More attention is devoted to applied than to pure pedology in this memoir and my researches exemplify the role of a practising geographer who synthesizes data on distributions of interrelated spatial phenomena with the express purpose of influencing and assisting administrators, planners and members of the public participating in agroeconomic development. Chapter 4 is intended to provoke reactions from them and to keep meaningful discussions going between all concerned with the country's material advancement.

THE PROFESSIONAL GEOGRAPHER:

This thesis also illustrates one man's solution of the dilemma, whether to specialize or be a "general" geographer. I feel that by specializing (e.g. in soil survey) both the individual and the community are likely to be more rewarded, provided the essentials of the broad sweep that is the "geographical approach" are retained at the same time. Those essentials include always placing one's findings in their spatial setting and never losing the disciplined curiosity that is the hallmark of the geographer, with his basic questions for every situation, as put by Ogilvie (1947) – What is it? Where is it? Why is it there?

The fourth dimension is implicit in this questing. It could be made explicit, to help in recording and evaluating the rapid pace of development in a country such as Swaziland, whose physical and human resources augur well for graduation from "have-not" to "have" in the foreseeable future, by adding two more questions – How is it changing? How should it change? In order to tackle this last, the pooling of experience and judgements by citizens and advisers qualified in many fields is called for. A contribution from a soil geographer will, I trust, usefully swell the flow of factual comment: it has been strengthening remarkably, as is implied by the many bibliographical references of recent years which I am able to quote.

ACKNOWLEDGEMENTS:

My debt to the literature is more than matched, however, by my good fortune in working with stimulating and very helpful colleagues and friends.

Successive heads of the Swaziland Ministry (formerly Department) of Agriculture, J.G.M. King and A.C. Venn and S.J. Sibanyoni, have been at appropriate times patient, persuasive or acclamatory, and always interested and co-operative. Officials, not only in Agriculture but also in nearly every other branch of Government, have assisted me greatly, as have the farmers whose soils I have been inspecting. To be able to return to the sites of profile pits on several dates, years apart, and make observations about the way cultivation and irrigation and other techniques have affected the soil has been a particularly valuable privilege.

I esteem highly the opportunities I have had to discuss soils in the field with I.C. Baillie, J.K. Coulter, J.P. Andriesse and many others, and I am glad to record the sterling service rendered to the soil survey by P. Bembe, my technical assistant since 1955. To T. Ginindza and to previous soil survey staff by thanks are also due.

From my original drawings C. Verlaan has produced final maps for printing with great skill and artistry. It is a pleasure to pay tribute to his endeavours and those of P. Mavuso, tracer. I thank Mrs. J. Clark for typing the manuscript, Mrs. C.I. Wallace for assembling the typescript and B. Hansen for supervision of printing. The financial aid received from the British Government (who are bearing about three-quarters of the total printing costs) and from the Swaziland Government (the remaining quarter) is greatly appreciated.

At Edinburgh University, the valued criticisms and constant encouragement I have had from Dr. D.N. M'Master – and earlier Prof. A. M'Pherson – have been of immeasurable benefit. I am indebted to them for helping to steer these studies towards a timely conclusion and presentation.

Finally, I should like to express my most sincere thanks to my wife both for her conjugal, companionable involvement at all times with every aspect of my progress and for her cartographic achievements during the years, until 1967, when she too was on the staff of the Ministry of Agriculture. The detail and precision of her topocadastral, agroeconomic and physiographic mapping have made my task as soil surveyor the lighter and my findings the easier to integrate with and apply to the rural scene.

G. MURDOCH
Mbabane.
November, 1968.

ADDENDUM TO THE PREFACE

This printed version of "Soils and Land Capability in Swaziland" is in a sense the third edition. The previous two appeared simultaneously and comprised four bound typewritten theses, one of which can be consulted in the Centre of African Studies, Adam Ferguson House, George Square, Edinburgh, and 170 cyclostyled bulletins, or rather trilogies of bulletins, issued by the Swaziland Ministry of Agriculture. Bulletin 23 is subtitled "Background Data and Soil Classification", Bulletin 24 "Soil Properties and Land Capability" and Bulletin 25 "Trends in the Rural Economy". This last also contains the references, index and appendices.

Apart from corrections and very minor revisions, the main difference between the present volume and the bound thesis is that regretfully the 37 coloured photographs of soils and landscapes forming Appendix D in the latter have had to be omitted here as too expensive to reproduce.

The author wishes to add a special word of thanks, because over the past two years much of the burden of transforming the text into print has been borne by C. Verlaan. In addition C. Verlaan has scrupulously carried out the culminating stages of colour-map compilation.

G. MURDOCH
Ibadan, Nigeria.
August, 1970.

ABSTRACT

THE QUINTESSENCE:

Swaziland soils are mapped and defined. Soil-slope combinations are the basis for establishing Land Classes which relate to irrigability and to the capability to produce raingrown crops. The pattern of Land Classes suggests ways of channelling agricultural advances to gain most advantage per unit area of fields, orchards and forests. Concentration of effort in Intensive Farming Blocks is advocated.

SUMMARY BY CHAPTERS:

1 – The location, physiography, geology, climate, landforms, hydrology and vegetation of Swaziland are briefly described. The people of the kingdom, its economy, produce from its soil, and water consumption by irrigators are discussed. Sugarcane is the principal irrigated crop, followed in order of acreage by cotton, rice and citrus. Rainfed agroforestal plantings comprise maize, pine trees, cotton, sorghum, beans etc. Irrigation, afforestation and the more intensive dryland cropping are features of the four Cores, the main zones of economic activity and urbanization. Elsewhere, in the much larger Periphery, subsistence maize farming and cattle-keeping predominate.

2 – The basic soil classification unit is the series. Agriculturally significant combinations of 107 soil series into 34 soil sets for mapping purposes during the National Soil Reconnaissance (NSR) 1963-1967 have proved useful. The sets are portrayed at 1:125,000 scale. Series are also apportioned among broad Service Pédologique Interafricain mapping units, the commonest in terms of area being Raw Mineral Soils 30% then Weekly Developed Soils 26% then Ferralitic Soils 15%. An analytical key to series is succeeded by morphological descriptions of sets and series, with supporting laboratory data from the records pertaining to 3,900 soil samples. Comparison is afforded with series and other narrow soil groupings of 7 countries in Eastern and Southern Africa. There are shorter notes on fertilizer needs, internal series variability and colour aerial photographs as aids in recognizing soil boundaries.

3 – Agroforestal land capability is defined as the longterm profitability of an area, without soil abuse. Soil sets and series are accorded ratings for specified farming systems. The ratings are divided into slope categories to give Land Classes. Ten Classes relevant to an irrigated rotation of crops are mapped at 1:125,000. The potential for irrigation and dryland cropping, for afforestation and for stock-rearing is discussed. The originally theoretical soil ratings have been monitored from yields of irrigated sugarcane and rainfed maize, cotton and pine trees commercially grown since 1957 on nearly 1,800 plots where management was relatively constant, at rather above average standards. Quantitatively, benefits derivable from farming the better soils are striking. Revision of ratings is foreseen as more advanced techniques and new crop varieties are introduced. Yield prediction will thus be further refined.

4 – Trends in the rural economy since the 18th century indicate that convergence of farmers on choice tracts of high potential has been an almost continuous process. The history of land use and lessons learned which have a bearing upon plans for future agroforestal development are reviewed. Present-day debates (e.g. on holding size, land tenure) concerning the next era in farming are summarized. New agroforestal patterns will result from recognizing and vigorously promoting Intensive Farming Blocks (IFB) of good soil on suitable slopes inside existing Cores, round their fringes, and along linking routeways. About 6% of the country

(240,000 acres) might fall within IFB, whereof two-thirds could be irrigated, one third intensively cropped but rainfed. These figures are simply guidelines. Land capability should continue to be a prime consideration on less intensively farmed and forested land.

Chapter 1

BACKGROUND DATA

Review of the Country and of Production from its Soil

LOCATION:

Swaziland occupies about 6,700 square miles between the 25th and 28th parallels of latitude in Southeast Africa (see Map 1). The country measures 120 by 90 miles and is one of the tiniest political units on the African mainland. Gambia (4,000 square miles) and Ifni (800 square miles) are smaller. Some other areas for comparison, all in square miles, are Kuwait 5,900; Yorkshire 6,100; Wales 7,700; Salvador 8,000; Massachusetts 8,200.

Swaziland lies 30 to 140 miles inland from the Indian Ocean littoral on Delagoa Bay and so, though technically landlocked, is open to maritime influences which have particularly affected the climate, the history of settlement and the export economy.

The country falls within the triangle whose apices are the great Southeast African urban agglomerations of the Southern Transvaal, the Natal Coast and Lourenco Marques. The latter is the nearest large city, some 90 air miles northeast of Manzini in central Swaziland. Johannesburg lies 210 miles west from Manzini and Durban 240 miles south. The motif of the "Metropolitan Triangle" reappears in many aspects of Swaziland's economy and is the main non-political external factor influencing her rate of and kind of development.

Neighbouring countries dwarf Swaziland, Mozambique to the northeast being 45 times as large and the Republic of South Africa on all other sides more than 70 times as large. Small size, position between large cities and lack of coastline are, however, attributes shared with Lesotho (11,700 square miles), the third nearest country, which is 200 air miles southwest at its closest. Northwards Rhodesia approaches to within 240 miles.

Localities inside Swaziland will be identified, when first mentioned, by a bracketed letter-number combination, such as Sebulembu (D3), which refers to the grid along the margins of the accompanying 1:125,000 Soil and Land Capability Maps, see also Appendix C.

PHYSIOGRAPHY:

The country's altitude ranges from 6,120 feet at the summit of Sebulembu (D3) in the northwest to only 80 feet above sea level on the banks of the Usutu River at Abercorn (S0). Four regions are clearly distinguished by elevation and relief, as is demonstrated in the topographic cross-section of Figure 1 : see also Map 2.

The Highveld, the westernmost region, is above 2,700 feet except in a few valley bottoms and mostly 4,000 feet or more. Eastwards successive north-south trending belts comprise the Middleveld at 3,500 to 1,100 feet, with mean height around 2,000 feet, the Lowveld at 1,900 to less than 300 feet (only isolated hills rise above 1,200 feet) and the Lubombo Range with summits of 1,800 to 2,700 feet: dipslope ravines east of its crest and the gorges of major rivers are much lower. The word veld has several meanings in Swaziland, as in the Republic of South Africa, but in regional names a wide connotation is implied — terrain or countryside.

The most gentle relief is in the Lowveld, with 3% as the median gradient, but even here the land is undulating rather than flat and the only localities with slopes less than 1% covering more than 2,000 acres each are the Amanzilukahle (D8) basin, the Usutu-Umbeluzi

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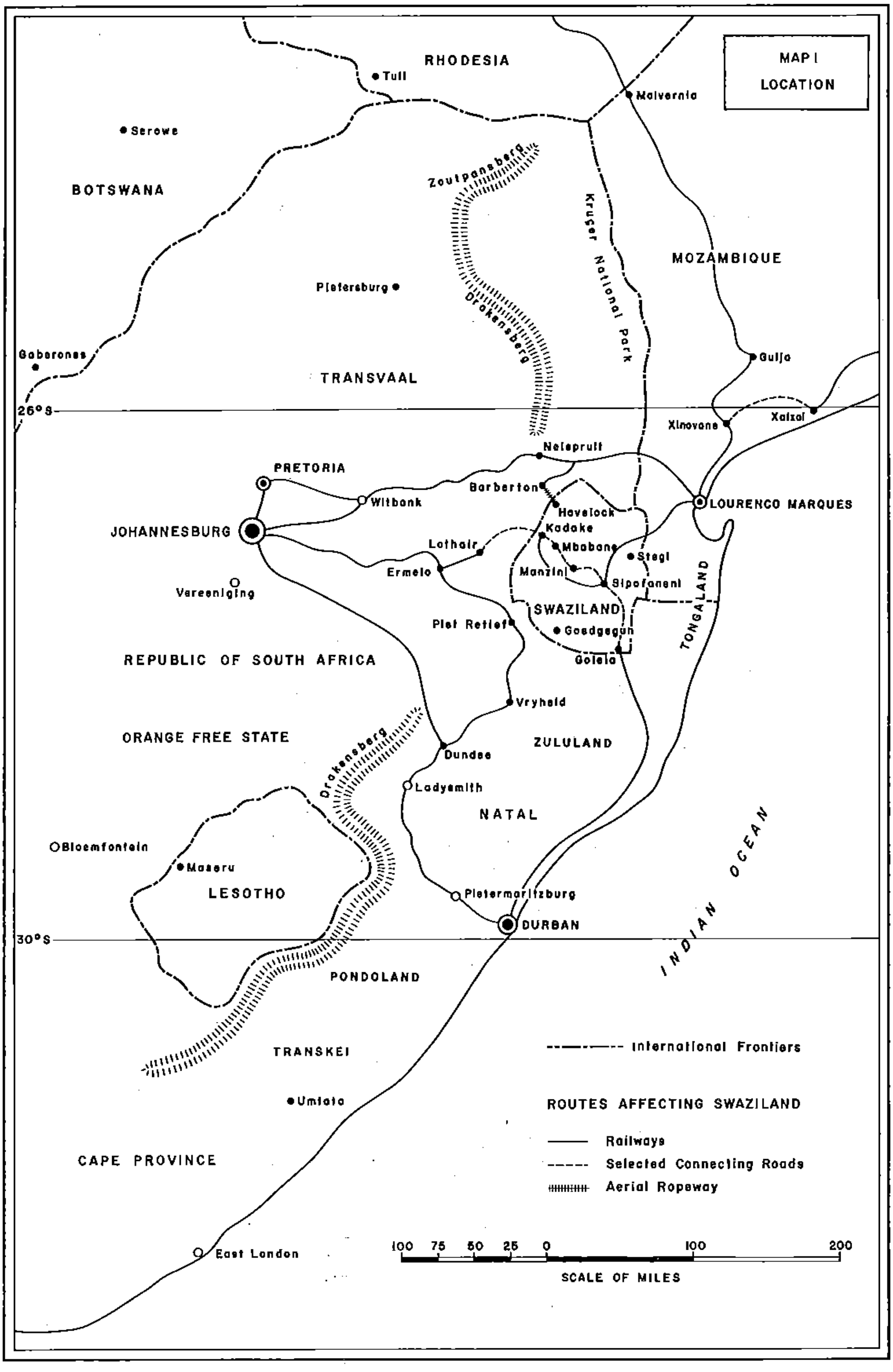
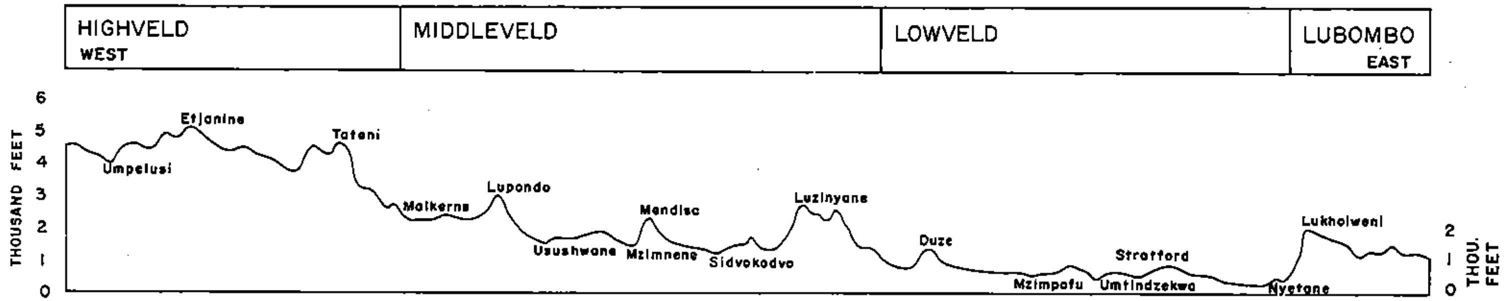

MAP I
LOCATION
RHODESIA
Tuli
Malvernia
Serowe
BOTSWANA
Zoutpansberg
Kruger National Park
MOZAMBIQUE
Pietersburg
Drakensberg
Gaberones
TRANSVAAL
Guija
26° S
Xinavane
Xaixai
Nelspruit
PRETORIA
Barberton
Witbank
Havelock
LOURENCO MARQUES
JOHANNESBURG
Kadake
Lothair
Mbabane
Stegi
Manzini
Ermelo
Sipofaneni
Vereeniging
SWAZILAND
TONGALAND
Piet Retief
Goedgegun
REPUBLIC OF SOUTH AFRICA
Golela
Vryheid
ORANGE FREE STATE
Drakensberg
ZULULAND
Dundee
Ladysmith
NATAL
Bloemfontein
Maseru
LESOTHO
Pietermaritzburg
DURBAN
INDIAN OCEAN
30° S
PONDOLAND
TRANSKEI
International Frontiers
Umtata
ROUTES AFFECTING SWAZILAND
Railways
Selected Connecting Roads
Aerial Ropeway
CAPE PROVINCE
East London
100 75 50 25 0 100 200
SCALE OF MILES

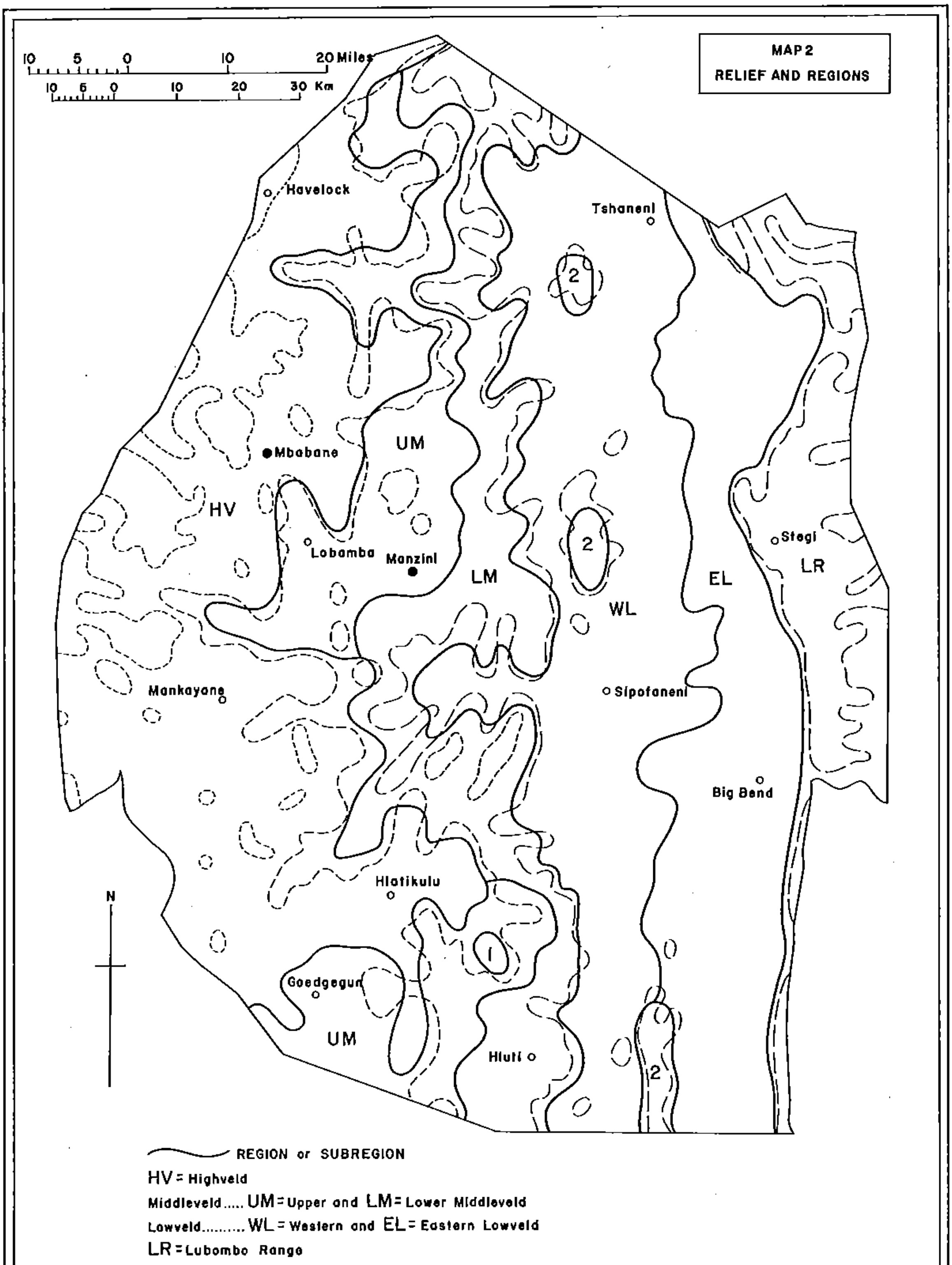
FIGURE I

TOPOGRAPHIC SECTION ACROSS SWAZILAND

I to 8 miles north of the Usutu River, approximately west–east

VERTICAL SCALE 1:75,000 HORIZONTAL SCALE 1:750,000 VE 10




MAP 2
RELIEF AND REGIONS
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
N
Havelock
Tshaneni
2
UM
Mbabane
HV
Lobamba
Manzini
LM
2
WL
EL
Stegi
LR
Mankayane
Sipofaneni
Big Bend
Hlatikulu
1
Goedgegun
UM
Hluti
2
REGION or SUBREGION
HV = Highveld
Middleveld..... UM = Upper and LM = Lower Middleveld
Lowveld......... WL = Western and EL = Eastern Lowveld
LR = Lubombo Range
GENERALIZED CONTOURS
4500 Feet
3000 Feet
1500 Feet
1 Highveld exclave at Qolweni
2 Lower Middleveld exclaves at (north to south)
Nkambeni, Dumezulu and Mbandebande.

water-shed area north and west of Waweni (K8), the Big Bend (S9) area and the Zibe basin, northeast of Golela (Z9).

The Middleveld's median slope is 12% and the only large contiguous areas with grades gentler than 7% are along the Lowveld margin and in the following places:

North — Lomati valley at and around Hhohho (B5), Insolambe (A6) basin and Mayiwane (C6) col:

Centre — Ezulwini (L3) and Umtilane (M4) valleys, Malkerns (N3) low watershed (between the Great and Little Usutus) and Kandinza (P4) hillfoot to riverain strips:

South — Goedgegun (X4) and environs, a minor interfluve, along with Mbukwane (W3) hillfoot strip and the Cibide (Y4) basin: also away from these the Mantambi (X6) and Tonjeni (U5) valleys.

Each of the dozen sectors named above covers more than 3,000 acres. The three zones are evenly spaced north-south and separated by rugged terrain, including waists where the Middleveld narrows in the vicinity of Kopoyi (G6) and Ngudzeni (V6), almost allowing Highveld and Lowveld to meet.

In the very broken Highveld mountainland average gradients exceed 18% and there are many declivities of 50% or steeper. Only a few plateaux and intermontane basins are undulating or rolling. The Forbes Reef (G3) to Kupela (J2) upland, Ulundi (K1) basin, middle Ngwempisi valley and Gege (U2) to Bondela (V3) watershed, between the Ndlozane and Assegai are the parts of the Highveld with least relief. All have 4,000 or more acres sloping at 12% or lower angles.

To give a median gradient for the Lubombo Range would be misleading as the topographic features of four cuesta sites, recurring throughout the region, are so distinct: the scarp rising precipitously for at least 1,000 and sometimes 1,600 feet from the Lowveld, the dipslope descending gently eastwards, whereon 5% grades are common, the areas of deep dissection by Tembi and Nkalishane headstreams along the Mozambique border, and finally the Umbeluzi, Usutu and Ingwavuma gorges.

The general picture is thus of subdued relief in the eastern 40% of the country (except for the Lubombo) and at three localities within the Middleveld hills. The steep topography elsewhere is associated with higher elevations and often a well-defined "step" rising more than 1,000 feet marks the passage from a region to the next above it.

The Lowveld and Middleveld can each usefully be split into two major subregions, as on Map 2, but discussion of these is best held over to the section dealing with soil parent materials — see page 15.

Comparative nomenclature deserves comment. Republic of South Africa usage dispenses with the term Middleveld both north and south of Swaziland. Barberton is considered a Lowveld town even though its altitude is 3,000 feet. In Natal the Tall Grassveld ecological region of Pentz (1945) is virtually equivalent to Middleveld.

Highveld often refers exclusively in the Transvaal to those vast elevated plains which impinge on Swaziland at only a few places along the western frontier, notably Sandlane (N1) to Zwartkop (P2). Highveld Plateaux and Highveld Berg are sometimes differentiated, the latter being the mountainous rim of the former, but the entire continental perimeter scarp from southwest of Lesotho to the Zoutpansberg (see Map 1) is frequently also called Drakensberg, a word seldom heard in Swaziland.

The following are synonyms for the Swazi Lubombo. The Urbantu root is vombo, simply meaning ridge; one finds Lebombo in Pedi and Sotho, as well as most English texts, Libombo in Tonga and Shangane and Portuguese, Ubombo in Zulu and Xosa.

The Highveld is Inkangalo to the Swazi and the Lowveld is Lihlanze. Both terms may be derived in part from Urbantu kyanga, to flourish (of vegetation) or bear fruit, which has become hlanza in the Swazi language. The Middleveld, significantly, has no single vernacular name — see also page 264.

GEOLOGY:

The geological foundation of Swaziland is Basement Complex igneous and metamorphic rock, which Hunter (1968) has found contains some of the oldest outcropping formations in the world, crystallized more than 3,000 million years ago. In a north-south band extending through the western two-thirds of the country (Highveld, Middleveld and the upper edge of the Lowveld) the granite, gneiss and other Archean shield rock types (see Table 1 and Map 3) have been bared of formerly overlying younger formations, or here and there perhaps never covered by them.

In Southeast Africa at the latitude of Swaziland there are no rocks to the west more resistant than the Basement Complex, hence the latter's granite plutons, ribs of quartzite and banded ironstones make the highest hills without, however, producing a straight, striking escarpment, for the undermass is so jointed, faulted and folded that no massive, persistent strata emerge as ridgemakers. The jumbled topography of western Swaziland thus contrasts with both the Natal-Lesotho Drakensberg and the Transvaal Drakensberg, whose single imposing facades of respectively basalt and dolomite, scarcely inclined from the horizontal, give rise to shorter, steeper ascents to Highveld Plateaux.

Successively younger rocks underlie the remaining third of Swaziland, dipping to the east at slopes of 40% and 50% in the central Lowveld, eventually reaching 80% in the Lubombo. The gap in time is enormous — over 2,000 million years — between the last emplacement of A5 granite and the Carboniferous glaciation, whose deposits are preserved as Dwyka tillite, but the only extant geological phenomena with sizeable areas of surface exposure dating from this long interval are two mylonitic shear zones trending north-south through the Middleveld from Mliba (H7) to Puhlapi (Y4).

Beneath the Lowveld there are approximately equal areas of Ecca sandstone and shale in the west, and Stormberg basalt in the east. Both series are interlaced with hundreds of dolerite dykes and, between the Ecca beds, sills. After the basalt lavas the rhyolite, andesite and tuff of the Lubombo were extruded until the end of the Jurassic period. These acid to intermediate volcanics are the youngest banded coherent rocks in the country. Most dolerite intrusions, however, and the east Swaziland granophyre bodies, postdate the entire Karroo system. They could not therefore have been feeders of Stormberg age lavas. Indeed Urie and Hunter (1963) believe that the Lubombo ignimbrite never spread far west of its present location, and that even the basalt was possibly not continuous with Lesotho flows, though certainly coeval.

Mineral workings are numerous and important. In the Archean formations there are major deposits of chrysotile asbestos, mined at Havelock (D3) since 1938, and high grade iron ore, formed by enrichment of banded ironstone and mined at Kadake (H2) since 1964. Before the asbestos was worked mineral production consisted of gold, panned since 1879 at many places in what is now Hhohho District, and tin, sluiced since about 1895; both are now almost exhausted. Extraction of kaolin and associated aluminous materials from the Mahlangatshe Hills (principal mine at R4) began in 1956. Coal is the only commercially valuable mineral found in the Paleozoic and younger rocks. Seams of Ecca age include both bitumen types — produced at

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TABLE 1

Stratigraphy

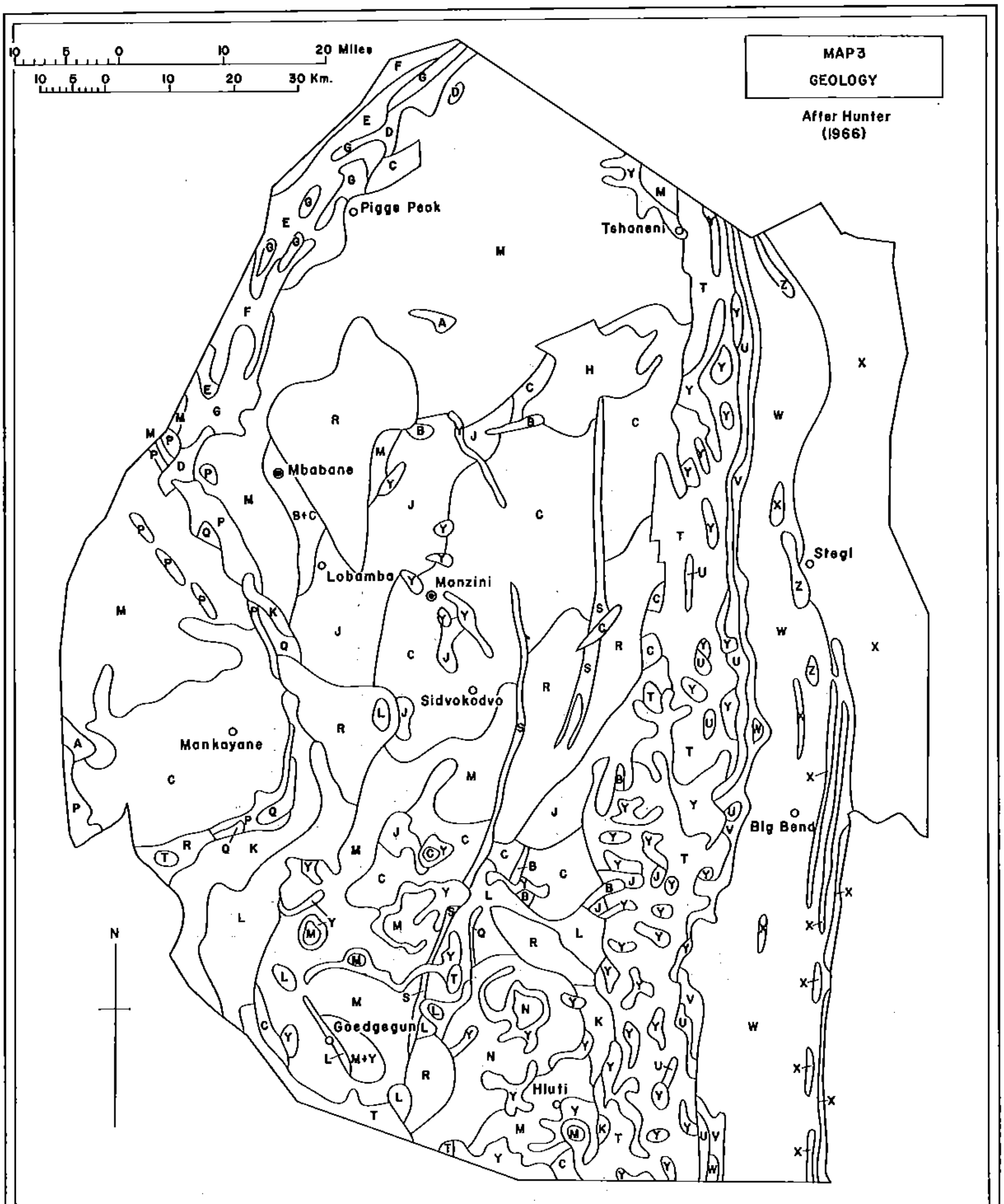
Explanatory Notes on Columns:

(1) Legend for Map 3
(2) Approximate time scale in millions of years before the present
(3) Code for granite and gneiss, after Hunter (1966)
(4) Stratigraphic succession, after Hunter (1961) and (1968): thicknesses are maxima
(5) Names of sedimentary systems
(6) Soil parent materials: A mainly acid, I mainly intermediate, B mainly basic

(1)	(2)	(3)	(4)		(5)	(6)
Z			Postkarroo and Karroo granophyre			A
Y	70–		Postkarroo and Karroo dolerite			B
X			Stormberg series	Lubombo ignimbrite: about 8,000 feet	KARROO	AI
W	150–			Drakensberg basalt: about 14,000 feet		B
V				Cave sandstone: 500 feet		A
U				Redbeds mudstone: 200 feet		A
U				Bolteno quartzite: 200 feet		A
U			Beaufort series shale: 200 feet			A
T			Ecca series sandstone, shale, grit and coal: 3,000 feet			A
T	300–		Dwyka series tillite, varved mudstone: 200 feet			A
S			Shear zone mylonite			A
R	2,800–	A5	Porphyritic granite			A
Q			Usushwane granophyre			A

TABLE 1 — Continued

(1)	(2)	(3)		(5)	(6)
P			Usushwane gabbro		B
N		A4	Porphyritic granite		A
M		A3	Medium to coarse granite: about 2,500 feet		AI
L	3,100–		Mozane series quartzite, conglomeratie, shale: 13,000 feet		A
K			Nsuzi series andesite, felsite, phyllite: 9,000 feet	PONGOLA	I
J		A2	Granodiorite		I
H		A2	Coarse granite		A
G			Jamestown complex amphibolite, talc schist		B
F			Moodie series quartzite, conglomerate	SWAZILAND	A
E			Figtree series phyllite, chert, ironstone, grit		A
D			Onverwacht series basalt, felsite		B
C		A1	Ancient gneiss and metaquartzite		A
B			Ancient amphibolite		B
A	possibly 4,000–		Ancient serpentinite		B



MAIN LITHOLOGICAL TYPES

Amphibolite GB	Granite RNH	Phyllite KE
Andesite XK	Granite (less acid) M	Quartzite ULF
Basalt WD	Granodiorite J	Rhyolite X
Coal T	Granophyre ZQ	Sandstone VT
Chert E	Grit TE	Serpentinite A
Conglomerate LF	Ignimbrite X	Shale UT
Dolerite Y	Ironstone E	Talc schist G
Felsite KD	Metaquartzite C	Tillite T
Gabbro P	Mudstone UT	Tuff X
Gneiss C	Mylonite S	Varved mudstone T

CHRONOLOGY (see also Table I)

A Serpentinite (OLDEST)	N Granite (A4)
B Amphibolite	P Gabbro
C Gneiss, Metaquartzite (A1)	Q Granophyre
D Basalt, Felsite	R Granite (A5)
E Phyllite, Chert, Ironstone ect.	S Mylonite
F Quartzite, Conglomerate	T Sandstone, Shale, Tillite
G Amphibolite, Talc Schist	U Quartzite, Mudstone
H Granite (A2)	V Sandstone
J Granodiorite	W Basalt
K Andesite, Felsite, Phyllite	X Rhyolite, Andesite, Tuff
L Quartzite, Conglomerate, Shale	Y Dolerite
M Less Acid Granite (A3)	Z Granophyre (YOUNGEST)

Mpaka (L8) since 1963, and sporadically before that back to 1882 – and anthracite from Maloma (V7) colliery, opened 1958.

In their role as pedogenetic raw materials, the rocks of Swaziland fall into three broad groups — acid, basic and intermediate (or mixed acid and basic).

Coarse granite, porphyritic granite and granophyre bosses, Mozane quartzite, Lower Ecca grit, Molteno quartzite and Lubombo rhyolite are the chief examples of acid geological formations, with inert quartz the predominant mineral. Soils on them are usually shallow, not infrequently absent. Where a solum has developed it is nearly always sandy.

By contrast basic and ultrabasic rocks, such as Usushwane gabbro, Drakensberg basalt and the dolerites and other mafic intrusions of various ages, on weathering give soils high in clay and often – especially when derived from basalt – deeper than those with acid parent material at topographically and climatically analogous sites.

Over the remainder of the country, rocks are either truly "intermediate" (for example most granediorite and andesite, some gneiss, occasional slightly calcareous Upper Ecca sandstone) or more frequently have veins and lenses set within a matrix of different mineral composition so intricately and inextricably that when geomorphic and soil-forming processes are initiated, the whole mass behaves as a single, though polygenetic, parent material. The commonest admixture is of basic intrusives within a siliceous body — Jamestown amphibolite streaking acid gneiss, epidiorite occupying joint planes in A3 granite, dolerite sills that have penetrated Karroo sediments. Weathering of these composite rocks is hastened by their internal heterogeneity and the deepest soils in Swaziland, including both alluvium and colluvium, have been fashioned from intermediate parent material. These soils are mainly of medium texture, with a range from sandy loam to sandy clay.

Table 2 summarizes the spatial distribution of the three kinds of parent material. The acreages have been calculated from the accompanying 1:125,000 Soil Map or, in the case of the rocky and stony ground which occupies 30% of the country, estimated from Hunter (1966). The assignment of soils to parent material groups is again referred to in Table 27 on pages 158 and 159.

Comparing the three groups, rock outcrops are commonest in places where parent material is mainly acid (43% of the total area, as against 17% and 16% for intermediate and basic parent material zones respectively). Residual and colluvial soil is relatively most extensive where the source is basic rock (80% of the total area). Alluvium, particularly along major rivers, usually originates from fragments of disparate rocks and soil wash, blended as a very mixed parent material. The regional picture in Table 2 of soil parent materials is not supplemented by corresponding details for rocky areas as the margin of error in their computation would be great. Moreover differences stand out plainly enough simply by setting down the percentages of each region and subregion with soils derived from each parent material group.

The Middleveld and Lowveld subregions, shown on Map 2, are more distinct geologically than physiographically. The Lowveld is readily divisible into an Eastern subregion, where the parent material is overwhelmingly basic, and a rather larger Western subregion with more varied rocks and soils, slightly more than half the latter being associated with acid rock. The Middleveld is split less decisively into a discontinuous Upper subregion with much intermediate parent material, mapped in two segments, and a Lower subregion which abuts on Highveld mountains in the Assegai-Ngwempisi basins and above Kubuta (T6). The Lower Middleveld has a higher proportion of acid rocks than any other part of the country.

Some soils can of course be related to more closely defined lithological units than the three broad groups, and where warranted such correlations are made on pages 105-126 in the descriptions of individual soils.

TABLE 2

Rocks as Soil Parent Materials

(A) By the Nature of the Land Surface

Acres	Residual and Colluvial Soil	Alluvial Soil	Soil Thin or Absent	Swaziland
MAINLY ACID P.M.	1,190,000	50,000	930,000	2,170,000
MAINLY INTERMEDIATE P.M.	840,000	180,000	210,000	1,230,000
MAINLY BASIC P.M.	720,000	40,000	140,000	900,000
TOTAL	2,750,000	270,000	1,280,000	4,300,000

(B) By Region and Subregion*

	Units	HV	MV	UM	LM	LV	WL	EL	LR	SD
SOIL WITH MAINLY (ACID P.M.	%	43	51	37	65	34	52	5	37	41
SOIL WITH MAINLY (INTERMEDIATE P.M.	%	49	38	56	20	23	30	12	34	34
SOIL WITH MAINLY (BASIC P.M.	%	8	11	7	15	43	18	83	29	25
TOTAL SOIL X	000 ac.	740	800	400	400	1,340	830	510	140	3,020
ROCKY AREAS where soil thin or absent .... Y	000 ac.	540	340	130	210	190	90	100	210	1,280
PROPORTION ROCKY ...100Y/X+Y	%	42	30	25	34	12	10	16	60	30

*Abbreviations – HV Highveld, MV Middleveld, UM Upper Middleveld, LM Lower Middleveld, LV Lowveld, WL Western Lowveld, EL Eastern Lowveld, LR Lubombo Range, and SD Swaziland.

CLIMATE:

Swaziland has a good network of longterm weather recording stations, including Manzini and Stegi from the 19th century. About 60 raingauges have been in operation for more than 20 years and at 25 places maximum and minimum temperatures have been measured for 10 years or more. Less complete, but on the whole adequate, data are available for other elements of climate.

The climate is subtropical, with summer rains. Between 75% and 83% of precipitation (summed mean monthly amounts) comes in the October-March half-year. The range of mean annual rainfall is from 20 inches at Big Bend (S9) to 90 inches at Nottingham (D3). Orographic influences on precipitation are strong and over most of the country, except parts of the Highveld bordering the Transvaal and the southern Upper Middleveld, the increase in rainfall per annum is steady at one inch every 100 feet altitude, and mean annual inches = 16 plus one hundredth of the height in feet. The rain which is not orographic (the basal 16 inches and a fraction of the remainder) falls in convectional storms, frontal showers or much less frequently deluges associated with Indian Ocean hurricanes — the two this century have been in 1925 and 1966.

In the climate histograms of Figure 2 drought hazard is indicated as well as mean monthly rainfall and temperature. The 4:1 confidence limits, as used by Manning (1956), reveal that for a given month one year in ten there are seriously deficient rains, even on the Highveld. Map 4 shows the chance of failing to receive in the summer six months 25 inches of rain, the amount needed to grow, without irrigation, reasonable crops of maize and beans. Where there is more than 60% risk of summer drought, as mapped, either very poor dryland harvests are taken or else recourse is made to irrigation. The Highveld, Upper Middleveld and tops of the Lubombo Range are seen to be the less hazardous half of the country for raingrown maize farming.

Isopleths on Map 4 run parallel to the isohyets of Murdoch and Murdoch (1958), featured on maps in all Swaziland Colonial Annual Reports since then. The line of 60% summer drought expectation is virtually coincident with the 30 inches isohyet, the 80% line with 25 inches and the 20% line with 40 inches.

The progressive improvement of conditions for raingrown crops above 30 inches mean annual rainfall is attributable both to the increased total moisture and to longer duration of the wet season, the onset of which, as measured by the mean date of "planting rains" (more than 2 inches falling on one day or in consecutive days), is 4 weeks earlier at places along the 50 inches isohyet than on the 30 inches: see Figure 3.

The monthly rainfall means in Figure 2 are repeated at Table 3, interspersed among other longterm stations. From all rainfall returns it is estimated that the national mean annual total is 35 inches, twice that of the Republic of South Africa. To emphasise further the great variability from year to year and month to month the following facts are adduced:-

(a) This century the seasonal rainfall over the whole country has fluctuated about the longterm average (28 inches in summer and 7 in winter) from 55 inches in the summer of 1917-18 to 17 inches in 1930-31 and from 2 inches in the 1904 winter to 22 inches in that of 1943.

(b) The range of annual rainfall experienced, as a function of the observation period, rises for stations in the Middleveld from about 75% of the longterm mean over 10 years to 90% over 20 years and 110% over 50 years.

(c) The highest calendar year's rainfall ever registered has been 130 inches in 1955 at Nottingham; the lowest so far is 8 inches at Golela in 1935.

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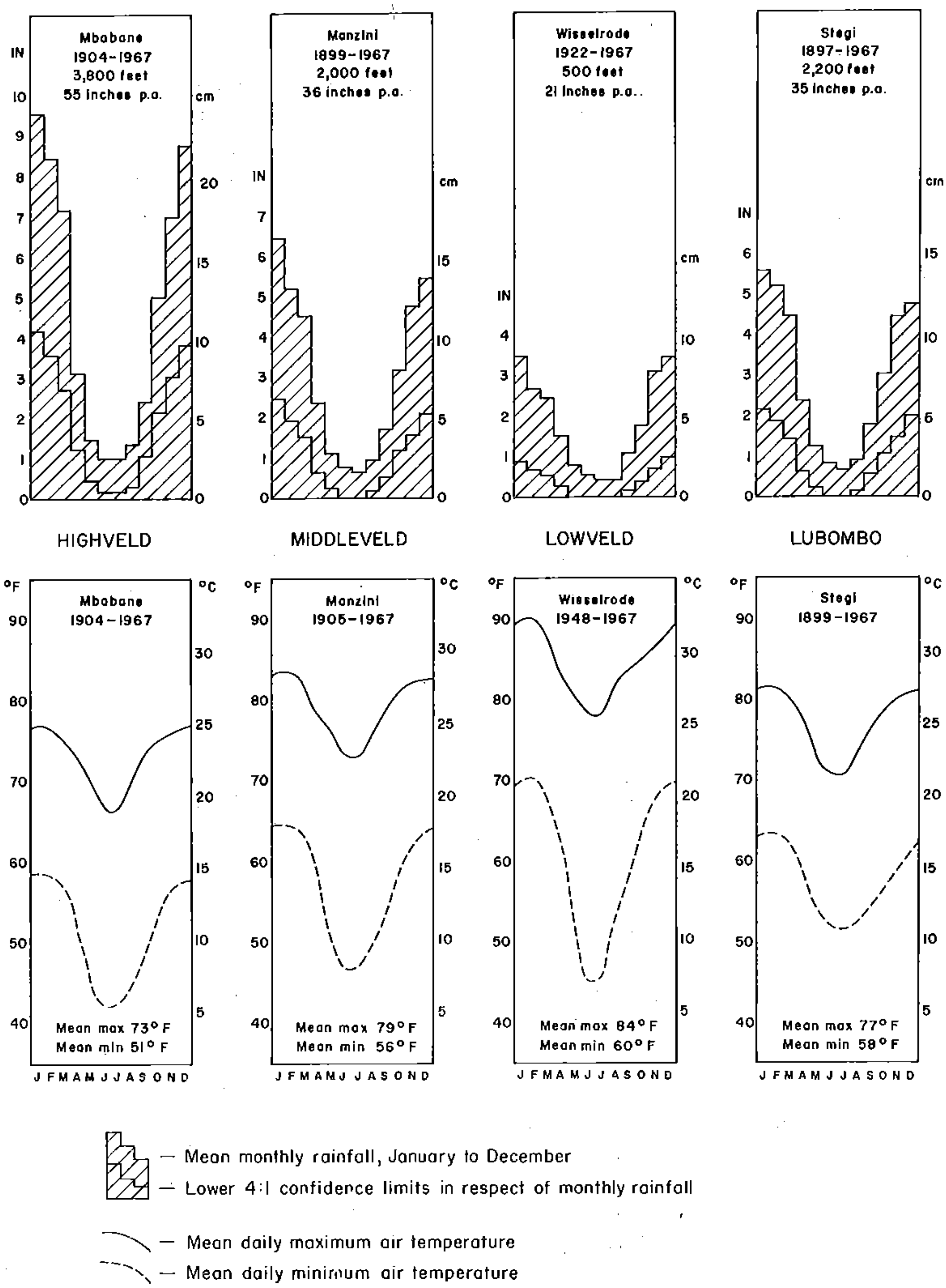
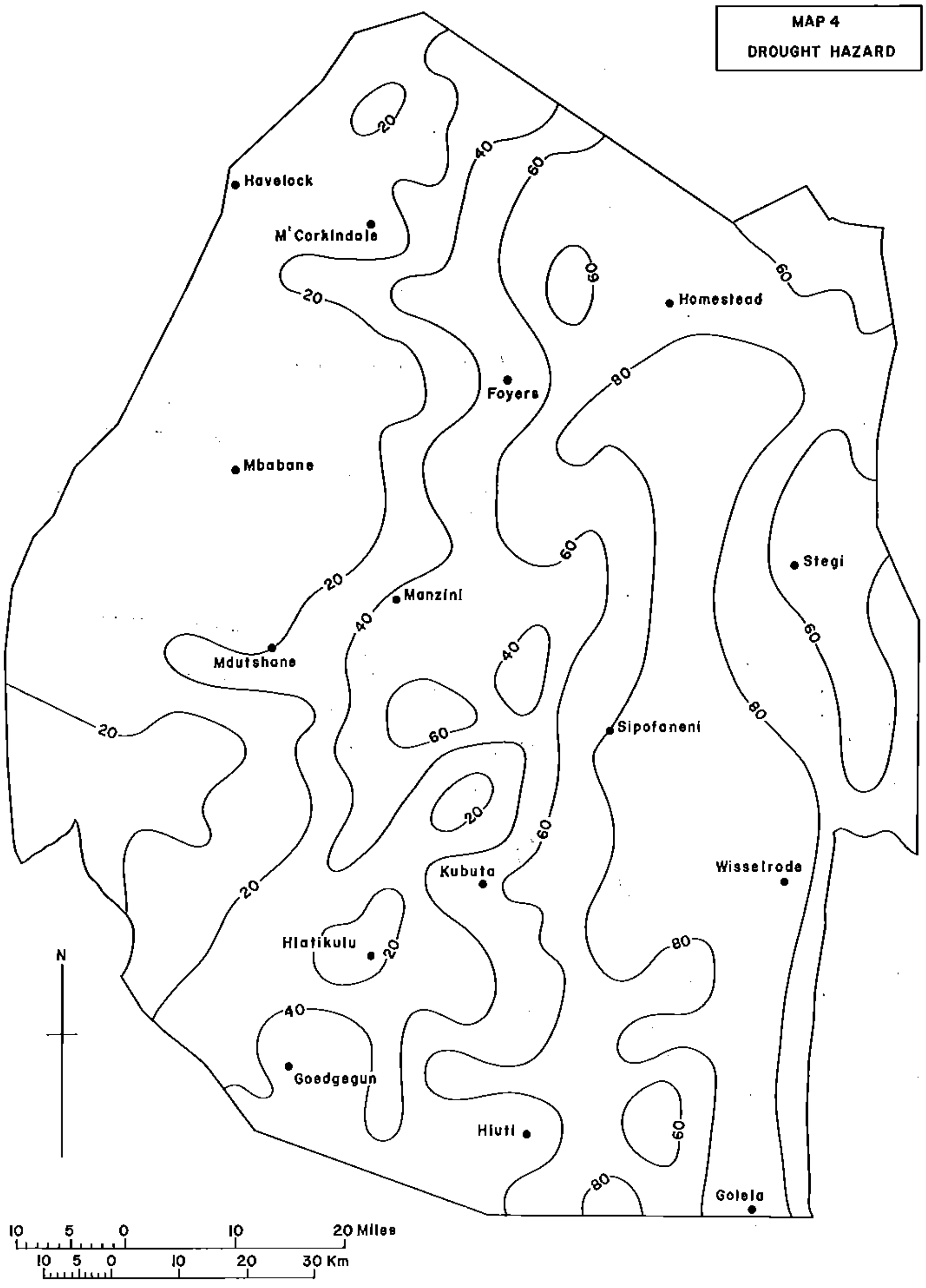
FIGURE 2

Climate Histograms





20
40
60
80

Percentage of summers (October to March) receiving less than 25 inches rainfall

20% drought risk coincides approximately with 40 inches mean annual rainfall: 40% with 35 inches: 60% with 30 inches: and 80% with 25 inches rain

FIGURE 3

Advent of Spring Rains

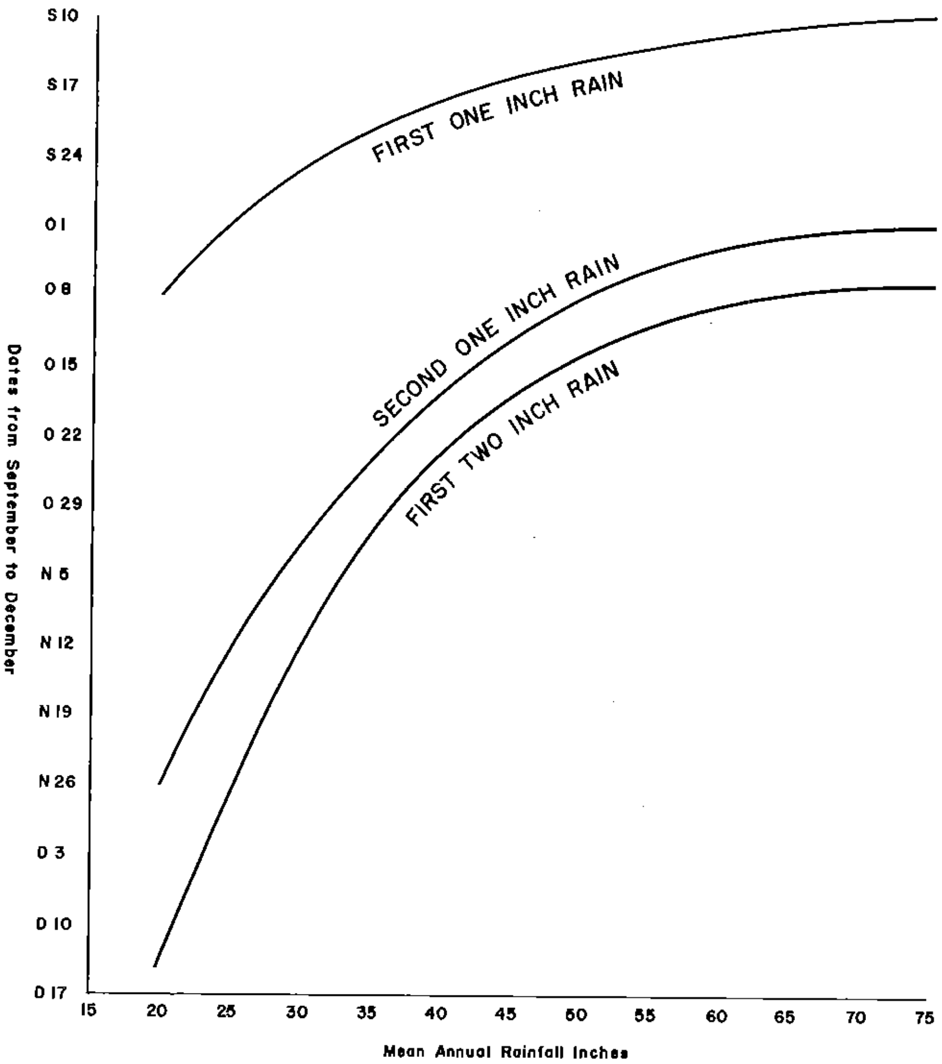


TABLE 3

Mean Monthly Rainfall

Region and Range in M.A.R. Inches	Stations -- Plotted on Map 4	Years of Record	Mean Monthly Rainfall to Nearest 0.1 Inch												Mean Annual Inches
			J	F	M	A	M	J	J	A	S	O	N	D	
	Havelock	37	12.6	10.2	8.0	4.0	1.9	1.1	1.0	1.5	3.2	6.4	9.0	10.4	69.3
HIGHVELD	Mbabane	65	9.5	8.4	7.1	3.0	1.4	0.9	0.9	1.2	2.3	5.0	6.9	8.7	55.4
40 – 90	M'Corkindale	21	7.4	7.3	5.9	3.8	1.6	0.7	0.9	1.0	2.2	3.8	6.7	8.0	49.3
	Hlatikulu	64	7.3	6.1	5.0	2.8	1.3	0.8	0.7	1.0	2.3	4.7	6.5	7.1	45.6
	Mdutshane	35	5.8	5.6	4.9	2.5	0.9	0.4	0.7	0.7	1.8	4.4	5.2	5.7	38.6
	Manzini	66	6.4	5.1	4.5	2.3	1.0	0.7	0.6	0.8	1.7	3.1	4.7	5.3	36.2
MIDDLEVELD	Hluti	55	5.3	4.8	4.4	2.3	0.9	0.6	0.6	0.8	1.9	3.3	4.7	5.4	35.0
30 – 45	Goedgegun	34	4.9	4.8	3.7	2.4	1.0	0.7	0.6	0.8	1.9	3.4	5.2	5.4	34.8
	Foyers	32	5.1	4.9	3.2	2.6	0.8	0.4	0.4	0.7	1.4	3.0	4.2	5.3	32.0
	Kubutu	51	4.7	4.5	3.9	2.1	0.8	0.7	0.6	0.7	1.5	2.7	4.4	4.9	31.5
	Homestead	52	4.8	4.4	3.2	1.6	0.7	0.4	0.5	0.5	1.2	2.0	3.7	3.9	26.9
LOWVELD	Sipofaneni	31	3.8	4.0	3.1	2.2	0.9	0.7	0.6	0.8	1.3	2.2	3.0	3.7	26.3
20 – 35	Golela	38	3.4	3.2	2.1	1.6	0.9	0.6	0.4	0.6	1.3	2.2	3.3	3.5	23.1
	Wisselrode	46	3.4	2.6	2.4	1.4	0.8	0.5	0.4	0.4	1.0	1.7	3.0	3.4	21.0
LUBOMBO 25 – 40	Stegi	68	5.5	5.1	4.4	2.3	1.1	0.8	0.7	0.8	1.7	3.0	4.4	4.7	34.5

(d) Average annual deviations of rainfall increase from 17% of the mean annual total at Havelock and Hlatikulu to 28% at Golela. Average summer season deviations are close to the annual figures, but winter rains are much more unreliable – from 33% average deviation in Mbabane to 57% at Homestead.

Despite the vagaries of rains, longterm observations do reveal an interesting pattern throughout the year at two stations for which precipitation has been plotted by pentads (Mbabane and Wisselrode, see Figure 4). Both places can be said to have a wet start to the summer in mid-September, followed by several weeks of drier weather until the rains proper begin about mid-October. Both have "unseasonable" January droughts, that of Wisselrode being split in two by a short wetter spell. And both have midwinter rains lasting a few days early in July. All these findings are in relative terms. The absolute differences between Highveld and Lowveld are of course marked, Mbabane having 6% to 80% of recorded pentads with more than half an inch of rain, whereas at Wisselrode 0% to 45% is the range. If all pentads with rain are taken, Mbabane's extremes are 17% and 98% while Wisselrode's are 11% and 90%.

The frequency of heavy downpours is more uniform, across Swaziland, than total rainfall. For instance in 20 years the number of days that can be expected to have 3 inches of rain or more is 16 at Mbabane, 12 at Manzini, 14 at Homestead, 7 at Wisselrode and 11 at Stegi.

Temperature has been studied less exhaustively than rainfall as it does not in general affect land use so vitally. Nonetheless, the climatic limits of several crops are dictated by heat or cold rather than by moisture (which could be supplied from irrigation where feasible). Sugarcane and rice do not grow in the Highveld, nor will citrus trees and cotton thrive there, and pineapples do best – Dodson and Murdoch (1967) – between 1,800 and 3,200 feet elevation, largely because of thermal controls.

Mean air temperature decreases from 72°F in the Eastern Lowveld to 61°F on the Highveld at heights around 4,000 feet, giving a lapse rate close to 3°F per thousand feet. Absolute maxima, over several decades, reach 120°F in eastern Swaziland but only 96°F at Havelock. The absolute minimum ever recorded has been 20°F at Mbabane. Mean daily ranges in temperature vary between 17°F and 30°F, the most equable thermal regimes, by this criterion, being on the Lubombo Range (maritime influence) and in the Highveld (cloudier than other regions). The daily range in July is generally half as much again as that of January.

As there are linear relationships over most of Swaziland between altitude and both rainfall and temperature, it follows that isohyets and isotherms are inversely proportionate. The equation linking them has $T = 78 - 0.3R$ where T is mean temperature °F and R is mean annual rainfall in inches.

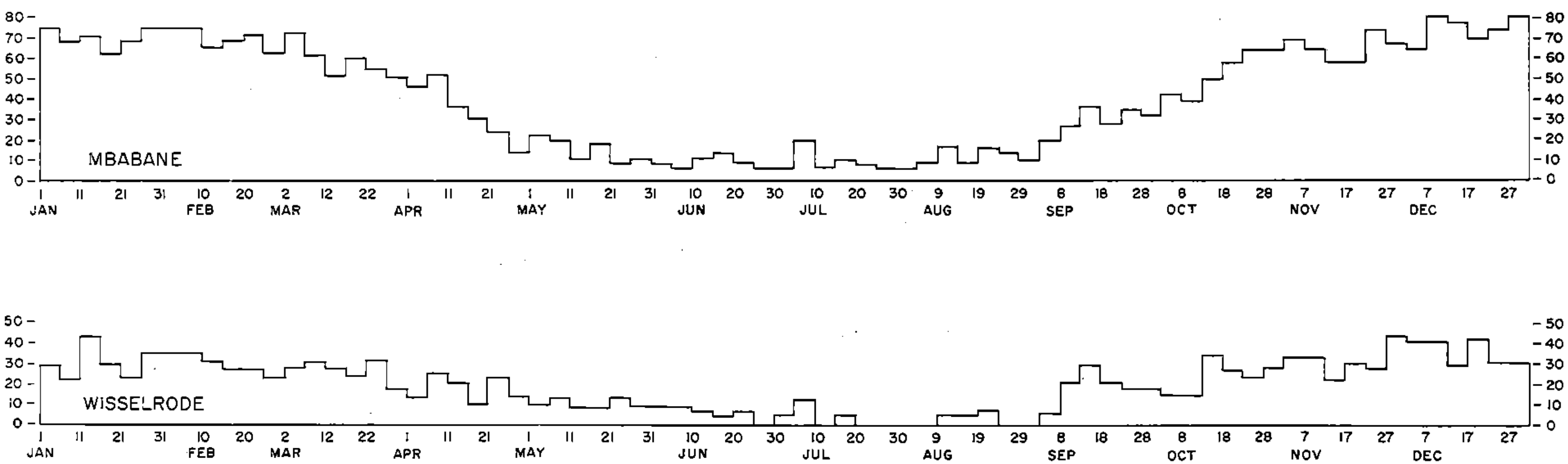
A further consequence of this parallelism is that a good approximation to the PE index, with which Thornthwaite (1948) measures the efficiency of rainfall, can be stated as a function of either R or T. It is, for example, equivalent to $2(R-10)$. This means in turn that the divisions between Thornthwaite's moisture provinces occur at or near the following isohyets: 74 inches superhumid to humid, 42 inches humid to subhumid, 26 inches subhumid to semiarid. The transition to arid would be at 18 inches using the same equation.

Baillie (1968) has calculated the Regenfaktor of Lang (1920) and finds that 40, the boundary between humid and arid, coincides with about 31 inches mean annual rainfall.

Mutual effects of temperature and rainfall variations month by month at 15 longterm stations have been computed. The main conclusions are (a) that 0.5 inch increase of rainfall above the monthly mean is accompanied by 0.8°F decrease in that month's mean maximum temperature and 0.3°F decrease in its mean minimum, (b) that 0.5 inch less rainfall than normal in a month corresponds to a rise of 0.9°F maximum and 0.2°F minimum, and (c) that there is

FIGURE 4

RAINFALL AT MBABANE AND WISSELRODE BY PENTADS



Horizontal scale – pentads (periods of five days) starting on the dates indicated
Vertical scale – percentage of pentads with 0·5 inch or more rainfall
Years of records – Mbabane 1904 to 1967 and Wisselrode 1922 to 1967

a well-defined seasonal rhythm in these influences, temperature being most affected in mid-winter and least in early summer by rainfall excesses or deficiencies.

Potential evapotranspiration has been assessed in conjunction with evaporation, both theoretical and actual, from a free water surface, and by direct measurements of crop water use on the Lowveld Experiment Station (T9). Penman (1964) calculated that the water need for a closed canopy perennial green crop at Wisselrode would be 50 inches per annum. Lea and Murdoch (1964) arrived at a much higher figure, in excess of 70 inches, using the results of field trials to determine water consumption by sugarcane. They found that f = 1.2 whereas Penman had put f = 0.8, f being – see Penman (1954) – the ratio of potential evapotranspiration to open water evaporation from, in this instance, a Symons tank. Even perennial crops are not at complete cover and turgid all the time; Lea and Murdoch (1964) reduce the sugarcane water need at Wisselrode to 66 inches by allowing for young plantings and for drying-off prior to harvest. During Lowveld summers maximum daily evaporation is 0.4 inch.

The nett water and irrigation needs at Kubuta and Piggs Peak, representative of the Lower Middleveld and of the Highveld as Wisselrode is of the Eastern Lowveld, are given in Figure 5, where f is considered to be 1.2 every month. Before being applied to examples of irrigated farmland the duties of water which are quoted, from 130 to 240 acres per cusec, require adjustment in proportion to (a) length of time when the canopy is less than 100% and (b) water losses between the river outtake and the growing crop, commonly 40% in the case of gravity canals, which would reduce the Lowveld water duty to less than 80 acres per cusec, and 20% for sprinkler systems. Actual duties of water in Swaziland are referred to at Table 14 on page 58. The Piggs Peak diagram of Figure 5 underlines the need for supplementary irrigation, even where rainfall is 40 to 60 inches yearly, if profitable crop farming is to be carried out; only 17% of Swaziland receives more than 45 inches mean annual rain, and less than 3% gets 60 inches or over.

Of the other atmospheric elements, hail is common in the western half of the country, especially during November. Its occurrence has been investigated by Murdoch, Black and Venn (1963). Snow occasionally falls in midwinter above 3,500 feet altitude. White frost appears on several mornings each winter in bottomlands throughout Swaziland and also upon Highveld summits. Sunshine hours decrease with altitude. Fog is unknown. Winds are variable in force and direction, quite often strong enough (more than 6 miles per hour) seriously to distort sprinkler irrigation perimeters. Relative humidity is about 75% (mean of all 0800 readings), with 20% range commonly between the highest month, March and the lowest, September. The surveys of climate in the Republic of South Africa by Schumann (1954) and Schulze (1965) embrace Swaziland as well, and may be consulted for further details.

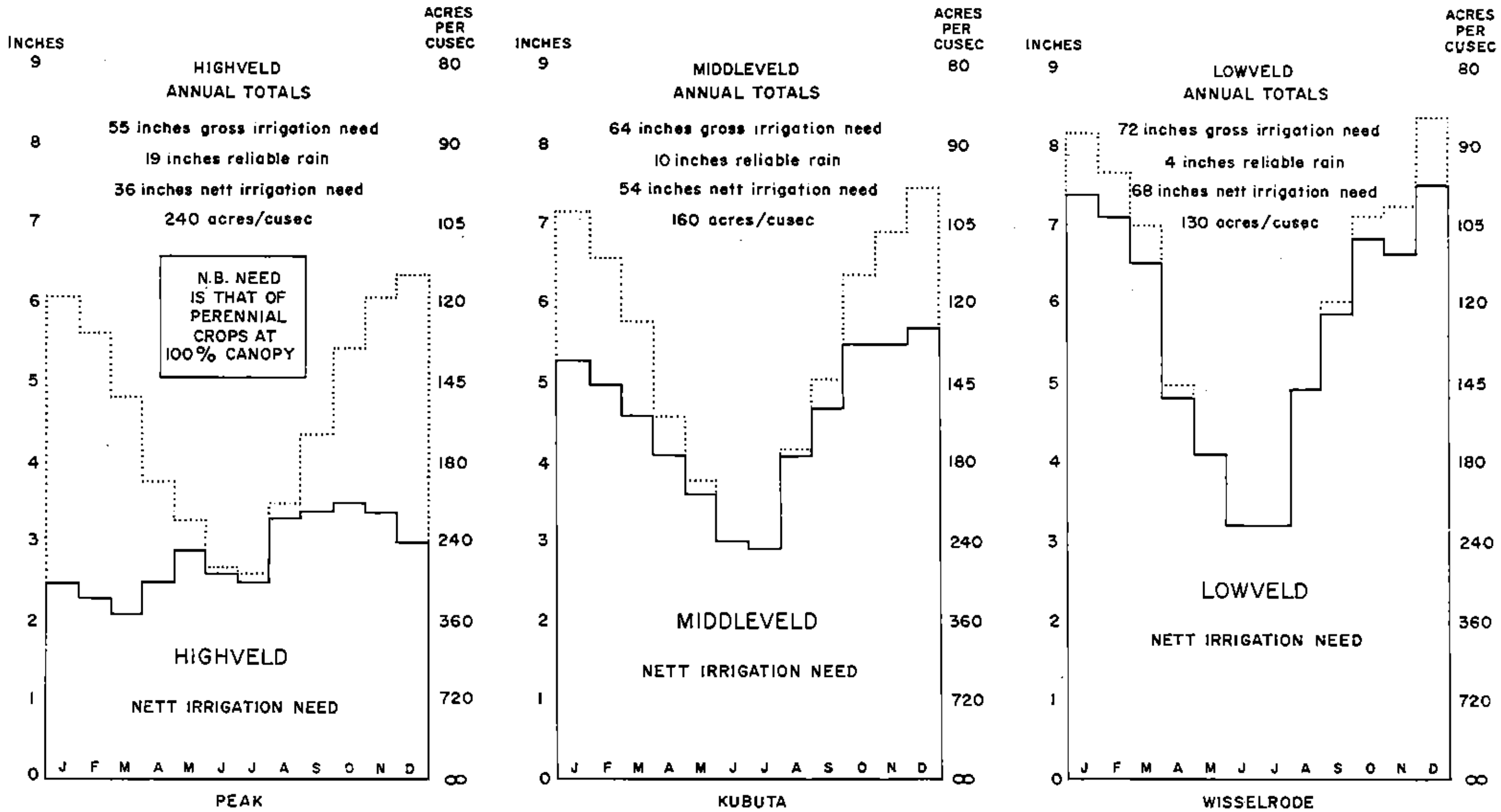
The six regions and subregions make adequately distinctive climatic zones. Indeed the Upper and Lower Middleveld are sometimes called Moist and Dry Middleveld respectively. A seventh subdivision can be discerned: from Map 2 it is evident that an appreciable area of the southern Upper Middleveld lies above 3,000 feet. This Goedgegun-Cibide section has a mean annual temperature of only 64°F – compare Manzini 68°F – and deserves the description Cool Middleveld sometimes bestowed on it.

In the notation of Köppen (1918) the Eastern Lowveld – and the western rim, where rainfall is less than about 26 inches – falls into the Bsh climate belt. The Highveld and Upper Middleveld are of Cwb type and the rest of the country Cwa. Swaziland's climatic range is thus from superhumid and nearly temperate to semiarid and nearly tropical.

Soil temperature, not strictly climatological but convenient to introduce at this juncture, has been measured in Mbabane for 9 years and in Manzini for 7 years. One foot to four

FIGURE 5

CROP WATER NEEDS



= Portion of gross irrigation need that is met by rainfall (4:1 confidence limits) feet underground the mean is 65°F at Mbabane and 74°F at Manzini, these values being respectively 3°F and 6°F above Stevenson screen means – a larger discrepancy than the 2°F found by Smith et al (1960) to be the average in the United States, admittedly at greater depths – ideally, they say, 30 feet. Kellogg (1967) designates as hyperthermic soil bodies whose temperature 20 inches below the surface is 72°F or more, with a difference between the three warmest and three coolest months' means exceeding 9°F. The difference is 14°F at both Mbabane and Manzini. Soil temperature as a pedological criterion is discussed on page 150.

LANDFORMS:

From fieldwork done partly in Natal, King (1942) developed the theory that landscape evolves by parallel scarp retreat, but as Baillie (1968) points out Swaziland's geomorphology is less straightforward than that of neighbouring areas to the south, both because the prominent Lubombo Range precludes the correlation of interior erosion surfaces with aggradational coast deposits, and because there is much more apparently random geological control of basins, nick-points and pedisediment accumulation in the rugged Basement Complex country of west Swaziland than on the high-altitude horizontally stratified rocks of the Natal Drakensberg and its foothills.

Nonetheless, despite the plethora of polycyclic hillslopes and the irregular relief of almost every acre, several erosion surfaces to which ages have been ascribed are recognized in Swaziland by De Blij (1959). They postdate the monoclinal flexure of Karroo System beds which Dixey (1955) states had ended by Early Cretaceous times, some 90 million years ago.

The three principal surfaces of De Blij correspond to lofty plateaux in the Highveld, chiefly above 5,000 feet (Early Tertiary planation): accordant summits in the Highveld, Middle-veld and Lubombo, gently sloping eastward from 4,000 to 1,700 feet at about 0.5% gradient on average (Late Tertiary): and less well defined benches, often at 1,200 feet or so in the Lowveld, marking the last general stillstand period (Early Quaternary). These levels of the Early Quaternary era, perhaps one million years old, extend up major rivers e.g. to the Ezulwini-Malkerns-Kandinza colluvial basin and even into the upper Ngwempisi valley, according to De Blij. At present an erosion subcycle is vigorously proceeding and at least two previous incomplete cycles have taken place during the Late Quaternary.

Turner (1967) agrees with the dating of the highest mountaintops, but restricts Quaternary levels in the Middleveld more than De Blij and argues that the Lubombo caps must be outliers of an Early Tertiary not a Late Tertiary surface, otherwise too much downwarping of the Jurassic Gondwanaland platform – now at 10,000 feet along the Lesotho-Natal border – has to be hypothecated to allow it to plunge beneath Tongaland Cretaceous sediments.

The successive changes of base level, due to tectonic uplifts then to glacio-eustatic incursions and regressions of the sea, in Southeast Africa since the Early Tertiary have had effects on soils and on soil parent material. In Swaziland preweathering, the term coined by Ollier (1959) to describe decomposition in the regolith inherited from a prior erosion cycle, has occurred in residual saprolite beneath Tertiary surfaces except where resistant rocks prevent it – notably A5 granite, Mozane quartzite and Lubombo rhyolite. The depth of preweathered material, as exposed by subsequent dissection, is often several hundred feet. Gold mine shafts at and near Devils Reef (D3) descend more than 400 feet through rotten Swaziland System rock with quartz stringers the only hard formation.

Soil merging into the zone of preweathering is typically very acid and highly leached, with a fine fraction rich in the end-product clay minerals kaolinite and, especially on the Early Tertiary heights, gibbsite.

An underground stream channel in preweathered rock is exposed along a railway cutting near Maloyo (J2). On the slope above there is miniature pseudokarst topography. Micro-relief of this type has been observed elsewhere throughout west Swaziland. Indeed most large gullies which are not manmade probably owe their existence to the collapse of roofs over subterranean caverns. Such phenomena seem to be high-rainfall equivalents of the piping effects described by Parker (1963).

Pedological evidence supports Turner's contentions regarding some Middleveld valleys, where thick colluvium – e.g. at Ezulwini-Umtilane-Malkerns-Kandinza, along the upper Ingwavuma, and from Zibondeni (X5) to Mzinsangu (Z5) – has eroded deeply, is drastically leached, and seems unlikely to be a Quaternary deposit. J.R. Masson (1968, private communication) reports the recovery of no artefacts from the Central Middleveld deep colluvium, another factor supporting Tertiary origin.

Turner's predication about the Lubombo Range is pedogenetically less satisfactory. Soil sufficiently ancient to correlate with that on Highveld Plateaux has not been found there, even on the softer tuffs. It is tempting to treat the cuesta's geomorphological history – of almost uninterrupted dissection – as quite independent of the planation, uplift and erosion sequences westwards. But such a facile disposal of the problem evades explaining the conspicuous bevel on the Lubombo's crest.

Also unsolved as yet is the riddle of how the Lowveld trough formed. Way (1957) postulated faulting of rift valley type, though earlier than the large-scale East African rifting. The Lowveld certainly has the appearance of a graben, and if the Lubombo was planed during the Late Tertiary – at most 13 million years ago – the mechanism of foundering must be invoked, as river erosion alone could not remove in the time available through the few narrow Lubombo gorges the great volume of material which would have been superposed on the present Lowveld. However, geological studies of the past decade – Urie (1967) – have not elucidated the relationships, temporal and spatial, of the dislocations with downthrow to the east along the Lowveld-Middleveld margin, and the extent of faulting in the basalt continues to be difficult to judge.

The compromise answer that both block faulting and normal erosion and wasting have combined to produce the Lowveld cannot be ruled out: nor can the simple solution regarding the Lubombo scarp face, viz. that it is essentially a retreating slope upon which differential erosion has acted.

In contrast to the imponderables associated with many geomorphic phenomena up to and including Early Quaternary events, the more recent record of denudation and aggradation is clearer in its main outlines. The two principal river terraces are an older at 50 to 100 feet above present stream beds, with orange to red sandy loam and loam alluvium, and a younger at 20 to 70 feet, with pale brown to yellow sand and sandy loam alluvium, whose toe slopes and occasional subsidiary low flats or levee-protected hollows are still inundated by peak floods.

Baillie (1968) compares alluvial material throughout Southeast Africa and concludes that Swaziland's pair of terraces can be correlated with estuarine banks (also raised beaches) which are at most 30 and 20 feet above sea level now, as described by Barradas (1962) and Maud (1968). The many juvenile streams in west Swaziland will have ensured a greater supply of alluvium, during the Late Quaternary, down Middleveld and Lowveld rivers per unit area of terrace than was brought by more senile rivers to their coastal reaches, hence the thicker deposits and higher terrace levels inland compared with littoral and marine platforms.

The only natural lacustrine flats of any size in the country lie behind a levee of the older terrace at Balekazulu (D8) and represent little more than a Komati River backswamp of

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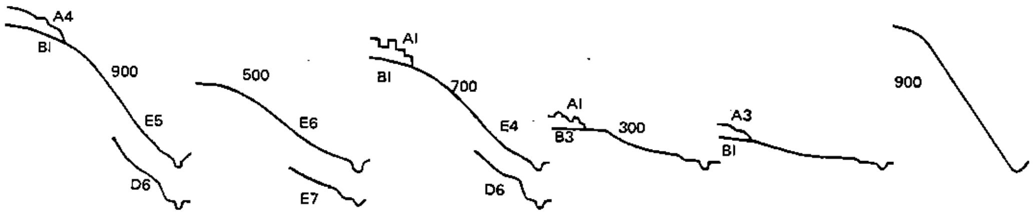
TABLE 4

Inventory of Landforms

Region or Subregion	HIGHVELD	UPPER MIDDLEVELD	LOWER MIDDLEVELD	WESTERN LOWVELD	EASTERN LOWVELD	LUBOMBO RANGE

Usual tributary valley cross-section with available relief in feet. Horizontal scale – 1 mile is 0.8 to 1.3 inch. Alternative profiles labelled as in list below.



Region or Subregion	HIGHVELD	UPPER MIDDLEVELD	LOWER MIDDLEVELD	WESTERN LOWVELD	EASTERN LOWVELD	LUBOMBO RANGE
HILL AND MOUNTAIN SUMMITS, ROCKY						
A1 – Castlekopjes, tors	+++	++	+++	++(a)		
A2 – Knife edges	+++	+				+(b)
A3 – Hogbacks	++(c)				+++(d)	
A4 – Whalebacks, dwalas	+++	+	++	+		+
A5 – Cuesta crests					+	+++
A6 – Tabletops, mesas	+++(a)	++(c)	+++(e)	+(f)		
A7 – Plateaux	+++(g)					
HILL SUMMITS WITH SOIL MANTLE						
B1 – Rounded knolls	++	+++	++	+(h)	+(j)	
B2 – Cuesta crests					+	+++
B3 – Tabletops, mesas	++	+	+++	++		
B4 – Plateaux	+++(g)					
ELEVATED BASINS WITH POOR EXTERNAL DRAINAGE						
C1 – Intermontane values	+++	+	+			
C2 – Pondages, pans				+	+	+++
SLOPES FROM SUMMITS TO VALLEY FLOORS, ROCKY						
D1 – Free faces	+++	++	+++	+	+	+++(k)
D2 – Scree, talus	+				+(l)	+++(k)
D3 – Boulders and blocks	+++	++	+++	++(a)		+
D4 – Sharkstooth outcrops	+++	+				
D5 – Whalebacks, dwalas	+++	+	++	+		+
D6 – Basal rejuvernation	++	+	+++	++	+	(m)

TABLE 4 — Continued.

Region or Subregion	HIGHVELD	UPPER MIDDLEVELD	LOWER MIDDLEVELD	WESTERN LOWVELD	EASTERN LOWVELD	LUBOMBO RANGE
SLOPES WITH SOIL MANTLE						
E1 — Upper Solum on hard rock	++(n)	++(n)	++(n)	+++(p)	+++(p)	+(q)
E2 — Upper Preweathered rock	+++(n)	++(p)	+(n)			
E3 — Upper Deep colluvium	++(n)	+++(p)	+(o)	+(p)		+(n)
E4 — Lower Solum on hard rock	++(n)	+(n)	++(p)	+++(p)	+++(p)	
E5 — Lower Preweathered rock	+++(n)	++(n)				
E6 — Lower Deep colluvium	++(o)	+++(p)	+(n)	+(r)		
E7 — Basal rejuvenation	(m)	++	+	+++	++	(m)
VALLEY FLOORS INCLUDING RIVER TERRACES						
F1 — Older terraces		+	+	+++	+++	
F2 — Younger terraces	+	++	++	+++	+++	++
F3 — Marshy bottomlands	++	+++	+	+	+	
F4 — Active river gravels	+	+	++	+++	++	
NATURE OF TRUNK STREAMS (all perennial)	Many rapids and waterfalls	Some rapids	Many rapids and some waterfalls	Some rapids	Few rapids: most meanders	Rapids in gorges
NATURE OF SMALL TRIBUTARIES	Juvenile and deeply incised: perennial	Juvenile and incised: perennial or intermittent	Juvenile and incised: intermittent	Mostly juvenile and incised: ephemeral:	Juvenile to mature: ephemeral	Juvenile and deeply incised: intermittent
DRAINAGE PATTERNS	Dendritic and trellis	Dendritic	Dendritic	Dendritic	Dendritic N-S grain	Mostly trellis

KEY TO SYMBOLS: + rare, ++ fairly common, +++ very common, reading across.

TABLE 4 — Continued.

NOTES:

(a) Restricted to granite.
(b) Above dipslope ravines.
(c) Mostly Swaziland and Pongola systems.
(d) Of ignimbrite at Lubombo scarpfoot, but mainly dolerite elsewhere.
(e) Granite plutons, dolerite sills.
(f) Dolerite sills: may have Ecca caps.
(g) Bordering Transvaal.
(h) Subdued relief.
(j) Often almost imperceptible.
(k) On scarp, in dislope ravines.
(l) Beneath hogbacks.
(m) Hillsides too steep to retain rejuvenation shoulders.
(n) Usually less than 500 yards.
(o) Variable length.
(p) Usually more than 1,000 yards.
(q) Digitate dipslope remnants.
(r) Scattered patches.

that epoch. The maximum area of the lake was probably less than 1,400 acres.

According to Maud (1968) the main phases of fluviatile deposition ended more than 70,000 years ago in the case of the older terrace, during the Riss-Wurm interglacial, or Kanjeran-Gamblian interpluvial period, and about 10,000 B.P. in the case of the younger terrace, during the Gamblian-Makalian interpluvial. Stream channel loads of today in Swaziland build shifting heaps and bars of gravel and sand up to 10 feet high, the oldest portions of which may date from the Makalian-Nakuran interpluvial, perhaps 5,000 B.P.

Revision of the estimates made on page 7.1 of Murdoch and Andriesse (1964) is permitted by these new datings of the alluvium, although their tentative nature must be stressed. The Australian controversy over whether subtropical pluvials jibed in the Quaternary with glaciations – as assumed by, among others, Ward and Jessup (1965) and Zeuner (1958) – or could not have happened simultaneously, as Galloway (1965) propounds, is also relevant to Southeast Africa.

The distribution of deep red loam to clay loam on sites immediately behind river terraces at various places in the Lower Middleveld and Lowveld, where preweathering is absent, suggests alluvial parentage. Along the Komati in particular these accretions are well preserved from Avondrust (F6) to Tunzini (D7), at heights usually 90 to 180 feet above the present riverbed. Possibly they are the last vestiges of medium-textured fluvial deposits laid down before Kanjeran times, but pedologically they have assumed the fersialitic character of nearby soil known to have been derived from intermediate parent material in situ, for example at Mabiya (F7).

Recent accumulations of true colluvium, away from rivers, are uncommon. Much more frequently during the Late Quaternary there has been erosion of previously formed soil, either wholly or (by truncation) in part. Even the gully wash so produced has largely been swept away, some of it doubtless to reinforce river sandbanks and mudflats, the rest to travel on to the Indian Ocean. Landform features which testify to these denudation processes include:

(a) The paucity and discontinuity of alluvial strips, currently seldom more than 2,000 yards wide. Remnants of the older terrace now cover only 24,000 acres, the younger terrace occupies 50,000 acres and all other bottomland aggradations do not exceed 196,000 acres in extent: a total of 270,000 acres or barely 6% of Swaziland.

(b) Shoulders of rejuvenation above valley floors, often with rock exposed or a thinner, soil mantle than at places higher upslope. Several protrusions of this kind may be etched in a single hillside of a polycyclic basin.

(c) Hardened ferricrete or sesquioxide sheet layers, sometimes outcropping at (b) sites, sometimes flooring an intermontane vale and temporarily hindering rejuvenation. Murdoch (1959) described Lowveld occurences, but the range in altitude of ferricrete is great. Between Forbes Reef and Kupela, at elevations as high as 4,800 feet, there are extensive iron pans, corroded at their edges, which shows that a stage of attrition is in progress, not augmentation. Local structural controls explain the general lack of a pattern in the altitudinal distribution of ferricrete, although a convergence of iron pan levels at various points in the central Upper Middleveld is noted by Baillie (1968).

(d) Profound dissection by Highveld, Middleveld and Lubombo headstreams, with torrent tracts deeply incised in V valleys. This happens even where the rocks are extremely resistant.

Of course not all thin unconsolidated mantles have lost soil. In the Lowveld hard rocks provide almost no detritus, and the less competent ones only a little more, to permit pedogenesis under the prevailing semiarid climate with minimal water percolation.

The general effect of preweathering at high altitudes together with lack of colluviation — or even soil formation — at low elevations, giving much shallower soil in the Lowveld (where the median solum depth is only two feet) than in the Upper Middleveld and Highveld, has important agronomic implications. They have gained recognition only since soil surveys were started, the chief misconception previously being that the Lowveld, as if a rich alluvial plain, simply needed irrigation water to become an agricutural cornucopia.

The atlas of Land Systems in Swaziland by Webster, Murdoch and Lawrance (1968) will, when published, constitute a detailed inventory of landform elements and facets present in the landscape. The 21 Land Systems to be described were identified, in accordance with the policy enunciated by Beckett and Webster (1965), from selected air photographs while the National Soil Reconnaissance was under way, but the two exercises were considered as quite separate. Comparison between the 1:125,000 Soil Map and the deliberately more cursory and broad Land System sketch-mapping, at a much smaller scale, will not therefore be warranted — see also Brink and Partridge (1966).

However, a general analysis of the shapes and sizes of some of the main landforms present in each region and subregion can conveniently be made here (see Table 4) as a summary of this section. Only mezzo-relief features or larger are represented in the table.

The Highveld, with greater relief than any other region, is seen also to have the most complicated slopes and the highest number of recurring geomorphological units: 25 are catalogued in Table 4. The Middleveld too has a good share of many landforms. Those cut from outcropping rock are commoner in the Lower than in the Upper Middleveld. The Lowveld is best endowed, relatively, with alluvium and with long slopes having shallow soils. Typical facets of dissected cuesta topography are exhibited by the Lubombo.

As was noted in regard to soils and lithology, on pages 105-126 soils are specified which have very distinctive landforms or interesting paleoclimatological relics in their fabric — iron and lime segregations and pans, etc.

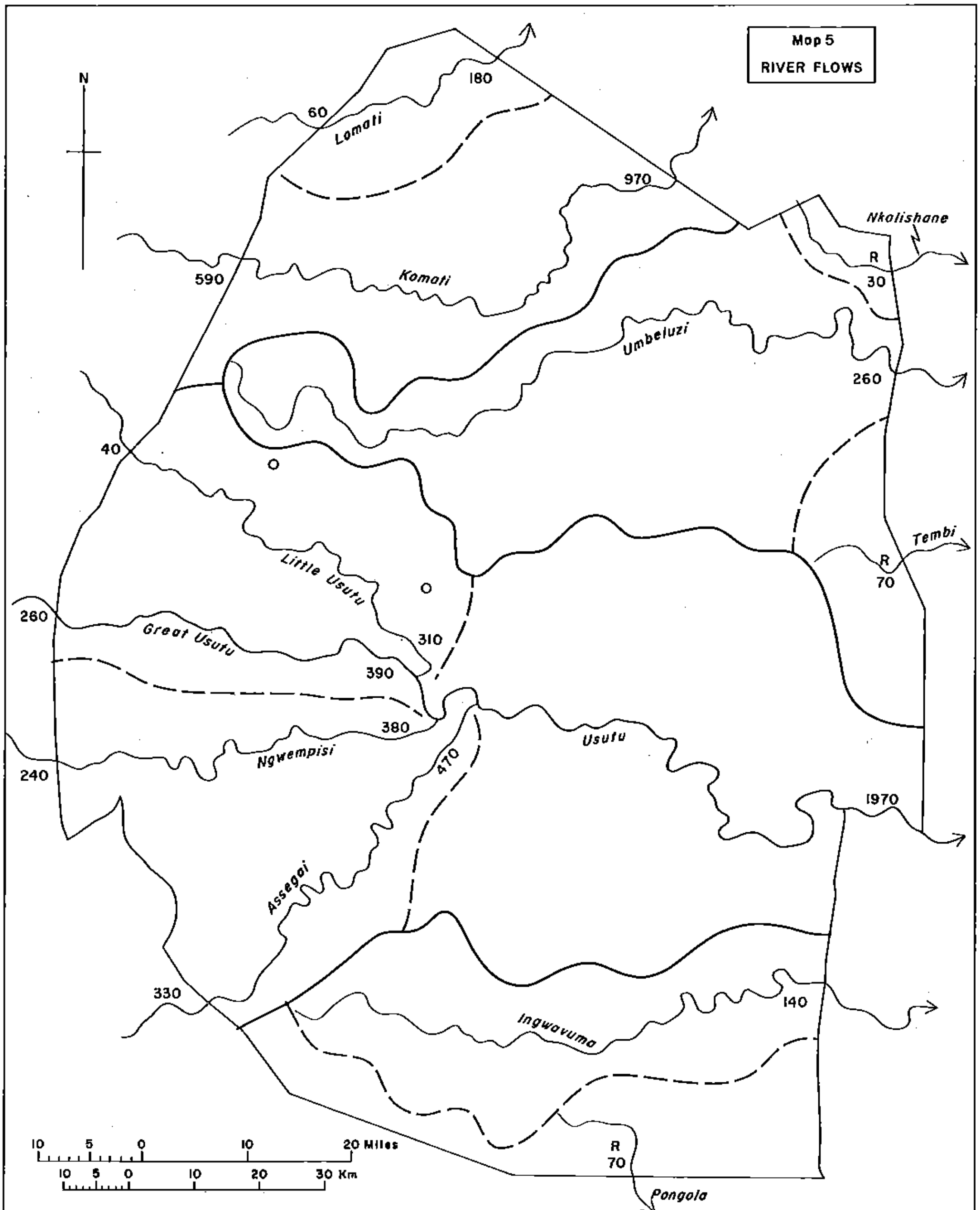
HYDROLOGY:

Highveld streams are perennial and that region's drainage network is dense and largely dendritic, except where jointed granite imposes a rough reticulation. The same conditions apply in parts of the Upper Middleveld above about 2,500 feet, equivalent to about 41 inches mean annual rainfall. Peak floods may come at any time during the summer, but low water is relatively certain each year to be in September or October — occasionally November if a late start to the summer rains delays replenishment of catchments.

Stream flow is intermittent below about 2,500 feet altitude except for trunk rivers and their largest tributaries, all descending from west to east, namely the Lomati, Komati, Umbeluzi (that is, Black Umbeluzi, whose shorter main affluent, the White Umbeluzi, is almost perennial, becoming a dry "sandriver" along some of its Lowveld tract in late winter every second or third year), Usutu (formed by the junction of Little Usutu, Great Usutu, Ngwempisi and Assegai or Mkondvo) and Ingwavuma (which in places ceases to run at long intervals, perhaps once every 10 years).

A more open dendritic drainage pattern is the rule in most of the eastern two-thirds of the country, with trellis tendencies, controlled by the north-south lithological grain, as in the the Eastern Lowveld, or by rock fractures, as on the Lubombo dipslope.

Several river gauges, particularly on the Komati, Umbeluzi and Great Usutu, are long-established, and Thompson (1964) has constructed mass flow diagrams relating essentially to



Major Interfluves

Other Interfluves

Rivers

Figures are undisturbed mean discharge in thousand acre-feet per annum

R = Runoff from whole catchment, not just river marked

TABLE 5

Water Analyses

	A Black Umbeluzi	B Little Usutu	C Black Umbeluzi	D Great Usutu	E Big Bend Canal
pH	6.6	7.1	7.1	7.0	7.0
Dissolved Solids ppm.	25	25	60	135	40
Total Hardness $CaCO_3$ ppm.	9	8	24	32	20
Calcium ppm.	2	2	5	7	4
Magnesium ppm.	2	1	3	4	2
Sodium ppm.	3	4	10	13	9
Chloride ppm.	3	3	7	10	4

A and B are Highveld, C to E Lowveld. A at Hawane (H3) and B at Mantenga (L3) and C at Takeni (G0) were supplied by the Swaziland Railway (1963). D at Sipofaneni (Q7) represents the mean of two analyses by O. Lazar (1957) and E at Ubombo (R9) is by P.T. Viljoen (1960).

the period before about 1960 when consumptive water use could safely be neglected. His findings, then and later, permit an estimate that the undisturbed mean discharge of all Swaziland rivers, measured at the eastern frontier, was about 3,700,000 acre-feet per annum or 5,120 cusecs (cubic feet per second): see Map 5.

Out of the total volume almost 2,200.000 acre-feet per annum accrued, in the era of undisturbed flow, within the boundaries of Swaziland, the rest entering from the Transvaal. In each case these amounts -- gained in the country and extraterritorial – represent 6 inches of water per annum. The Swaziland share is 17% of all rain that falls. This compares with the 8% of all rain which reaches Republic of South Africa rivers – Green and Fair (1962). The discharge from Highveld catchments is more than ten times as great per unit area of basin as that from Lowveld. For instance the Komati above Vergelegen (F5) receives 13 inches of runoff annually on average, the Umbeluzi in its Lowveld stretch one inch, at most 4% of rainfall there.

Rather than by mean amounts, water resources are better characterized for many practical purposes by summation curves and recorded low flows. Thompson (1964) singles out that rate of discharge below which rivers fall for 4% of the time, i.e. for a fortnight in an average year, as "mean low flow". Thus defined, the mean low is about 24% of longterm undisturbed runoff in northern Swaziland but only 15% in the south. The north's advantage is that it gets more rain in Highveld catchments – Lomati, Komati, Umbeluzi and Little Usutu.

The utilization of water in Swaziland (see pages 55 to 61) is clearly going to involve more and more stormwater storage works. Those constructed to date are Sandriverdam Lake (E7), holding 30,000 acre-feet of Komati water, and many very small reservoirs, totalling at most 20,000 acre-feet, some behind weirs across major streams – as at Mkinkomo (M4), the second largest storage site complex, capacity 4,000 acre-feet, regulating the intake to national grid hydroelectric power stations -- but most behind dams with tiny catchments, used for livestock watering, small-scale irrigation and domestic purposes.

Water analysis confirms that Swaziland rivers and canals are among the purest in Africa, as most headstreams flow through collecting grounds floored by acid igneous rock or deep, highly leached soil. A selection of water quality test results is given in Table 5.

The regional watertable is usually deep-seated in Swaziland, because of the present phase of vigorous downcutting by rivers, coupled with aridity in the east and the amplitude of relative relief in the west. At Malkerns, for example, successful wells strike groundwater at 100 to 200 feet depth normally. Due to rock fissures or compartmentation by dykes and veins, nowhere are underground supplies large enough for more than domestic use or stock watering, good borehole yields being 3,000 or 4,000 gallons per day: the latter over a year is only 6 acre-feet.

Perched watertables are another story, and occur frequently in and under soils at depths of a few inches to 7 or 8 feet. They are recharged from percolation after every prolonged rain, with fluctuations also governed by the water holding capacity of each soil horizon concerned. Except in the few perennial swamps and beneath marshland which is only occasionally without standing water, the perched nappes usually disappear in late winter. They receive mention again on, among others, pages 110, 117 and 125.

VEGETATION:

Taking Acocks (1953) as an initial guide, I'Ons (1967) has described and mapped at 1:500,000 eleven "veld types" in Swaziland, grouped thus according to the region which they entirely or predominantly occupy:

TABLE 6

Some Common Grasses of Unimproved Pasture

After l'Ons (1967)	MS	HS	UT	MT	TG	DT	UB	LB	AS	DS	LM
Aristida congesta						++	+	+	+		
Axonopus compressus	+										
Brachiaria brizantha					+	+	+				
Cymbopogon excavatus					+						+
Cynodon dactylon			+	+	+	+					
Digitaria swazilandensis										+	+++
Eragrostis racemosa	+	+	+	+	++	+					
Eragrostis superba								+	+		
Heteropogon contortus					+	+	+				
Hyparrhenia filipendula			++	+++	+++	+++	+++	+			+
Loudetia simplex	+	+		+							
Monocymbium ceresiforme	+	++									
Panicum maximum							+	+++	++	++	
Paspalum commersonii	+			+							
Perotis patens						+	+				
Pogonarthria squarrosa						+	++	+			
Rendlia altera	++	+	+	++							
Setaria nigrerostris			+								
Setaria sphacelata									+	+	
Sporobolus capensis	+	+		+	+						
Themeda triandra	+++	+++						++	+++	+++	++
Trachypogon spicatus			+								
Tristachya hispida		+	+++								+
Urochloa mozambiquensis									+	+	

TABLE 6 – Continued.

MS	=	Mountain Sourveld
HS	=	Highland Sourveld
UT	=	Upland Tall Grassveld
MT	=	Moist Tall Grassveld
TG	=	Tall Grassveld
DT	=	Dry Tall Grassveld
UB	=	Upper Broadleaved Tree Savanna
LB	=	Lower Broadleaved Tree Savanna
AS	=	Acacia Savanna
DS	=	Dry Acacia Savanna
LM	=	Lubombo Mixed Bush

+++	Most frequent, often dominant
++	Second most frequent, sometimes codominant
+	Also prominent

Highveld — Mountain Sourveld, mainly north of the Little Usutu, and Highland Sourveld southwards.

Middleveld — Upland Tall Grassveld (in the Cool Middleveld around Goedgegun: also infiltrates Highveld valley floors, especially in the Ngwempisi basin), Moist Tall Grassveld (Upper Middleveld), Tall Grassveld (wide Upper-Lower transition zone), Dry Tall Grassveld (Lower Middleveld) and Upper Broadleaved Tree Savanna with Hillside Bush (on steep slopes overlooking the Lowveld: also frequently adjoins Moist Tall Grassveld north of the Black Umbeluzi, where intervening types are pinched out).

Lowveld — Lower Broadleaved Tree Savanna (Western Lowveld), Acacia Savanna (both Western and Eastern) and Dry Acacia Savanna, in the Eastern Lowveld south of Tshelani (Q9).

Lubombo — Mixed Bush and Savanna.

Compton (1966) also finds it useful for the purposes of systematic botany to refer to the distribution of plants by the four regions. He notes that there is no conclusive evidence to prove that the entire Highveld's climax flora was once montane forest. At present sheltered hollows and ravines, and some rocky slopes, support at most 90,000 acres of natural woodland, or 7% of the Highveld, some characteristic species being Podocarpus latifolius, Cussonia umbellifera, Rawsonia lucida and Xymalos monospora. The slightly more extensive groves of tall indigenous evergreen trees which are known to have existed in the historical past may define the full spread of the original high forest. Exotic plantations are itemized in Table 10.

For the rest, Highveld grazing grounds comprise short grassland which is "sour" or unpalatable to cattle during winter, Mountain Sourveld losing its nutritive value by March, Highland Sourveld a month or two later. Pasturage of sheep is however possible in winter, either on old grass or on green shoots after burning. Examples of common Swaziland grasses are given at Table 6.

I'Ons (1967) states that the Middleveld vegetal types are now generally ill-defined, having been disturbed or destroyed by man to a greater degree than elsewhere in the country. Consequences of over-grazing have been sparse interceptive canopy, or even bare ground, and much soil erosion. Tall Grassveld is the largest in area of the five Middleveld types, moderately sour with scattered low trees. Even the Lower Middleveld to Lowveld margins have grasses classed as "fairly sour".

Indigenous trees and shrubs in the Moist Tall Grassveld include Syzygium cordatum, Acacia karroo, Maesa lanceolata and Vernonia ampla. A completely different arboreal range is found in the Dry Tall Grassveld, notably Dichrostachys cinerea, Sclerocarya birrea, Acacia nilotica, Maytenus senegalensis and Ficus capensis.

The Lubombo's plant associations have some affinities with the Middleveld, but probably more with the Zululand coastal belt — Acocks (1953). Distinctive bush clumps of the upper dipslope include many trees that are rare in other regions (Diospyros dichrophylla, Scolopia mundia, Nuxia oppositifolia) and among the cliffs of the scarp are centuries-old cycads, Encephalartos lebomboensis.

Another name for the Lowveld is Bushveld: its physiognomy and species composition are varied, often scenic and charming, and moreover of greater significance in the establishment of vegetal indicators for particular soils than the flora of higher elevations. In the Lowveld xerophytes are common and it is more noticeable than elsewhere than "the different components of the plant community compete for moisture, nutrients and light: consequently any weakening or destruction of the grasses upsets the natural balance between them and the trees" — l'Ons (1967).

The result of overgrazing in the Lowveld (in contrast to Upper Middleveld, see page 38) is encroachment by thorny scrub that is difficult to get rid of. The chief invaders are Dichrostachys cinerea, Acacia nilotica and A. tortilis: the two first-named can play the same role in the Lower Middleveld. Eradication, whether mechanical or chemical, costs a great deal and prevention is clearly better than cure (see further on page 255).

Murdoch and Andriesse (1964) describe the rich assemblage of Lowveld plants and their edaphic relationships. Most of the grasses are "sweet" — palatable and nutritious all year. From Table 6 it will be seen that Themeda triandra, the main sour species, is also dominant over most of the Lowveld. Not botany (below family level) but principally climate determines sourness or sweetness.

Trees usually found on certain kinds of soil include Acacia xanthophlea in calcareous bottomland clays of the Dry Savanna (where the smaller A. gillettiae forms dense thickets), Acacia nigrescens on shallow soils derived from basic rocks, Spirostachys africanus and less reliably Zizyphus mucronata over an iron pan or clay pan, Terminalia sericea on deep coarse sands, Pterocarpus angolensis and Strychnos innocua on a rather broader range of light-textured soils. Possibly the commonest broadleaved trees in the Western Lowveld are Combretum zeyheri, or another member of that genus, whereas the Eastern parkland and indeed the whole Lowveld contains many Sclerocarya birrea. Their wide distribution makes neither a good soil indicator.

Plant-soil correlations in the Middleveld and Highveld, though fewer, are as genuine as those cited for the Lowveld. For instance Syzygium cordatum nearly always grows in soil with a seasonal perched watertable: Imperata cylindrica, Typha capensis, and several other hydrophytes are confined to noncalcareous marshes: the tree fern Cyathea dregei is strung along Highveld bottomlands rich in organic matter.

The restriction of Vellozia clavata to thin humic soils on Highveld mountainsides, Phragmites mauritianus to the most recent fluviatile deposits, Adenium swazicum to the younger river terrace sands and all the other proven combinations ease the task of soil survey in the field — although it is always wise to dig and make certain that the expected relationship holds good.

On the Swaziland aerial photographs (see page 73) an appraisal of tone, texture, configuration of tree crowns and, with stereoscopic examination, approximate height of bushes and trees has permitted reasonably accurate interpretation by the writer and colleagues, after practice and provided adequate ground control is maintained, of the kind of vegetation and often also therefore of the kind of soil.

HISTORY:

Turning from the physical geography of Swaziland to man's imprint on the landscape, one continues to build up a picture that has multum in parvo, with diverse human activities carried out in spatial patterns that are readily identifiable — the more so because they span the economic scene from very poor communities in hostile environments to some of the most affluent sectors of Southern African society, including enterprises based on highly enlightened use of soil resources. Different strands of the physical and socio-economic variables are interwoven in differing proportions, giving rise to the historicogeographical intricacy of the country.

Matsebula (1952) quotes royal Swazi genealogies which trace the ancestry of King

Sobhuza II to AD 800 — legendary — and about 1420 — factual. Homelands of the tribe were in southern Mozambique from 1460 to 1700, then after half a century of wanderings through northern Natal the Swazi moved to the Middleveld of what is now Shiselweni District, where royal villages were maintained for the next 70 years until unrest in Zululand caused the northward migration of tribal leaders to central Swaziland.

The first recorded contact with Europeans* came about 1826, when Portuguese traders journeyed to the Hlatikulu (U5) area. By 1830 King Sobhuza I and his Swazi army, modelled on Zulu age-group regiments, had extended their boundaries — see Map 6 — to the present national territory plus land southward (lost as the Pongola Panhandle to Lydenburg Republic Boers in 1855), westward and northward (lost to the Transvaal by frontier demarcations of 1866 and 1880) and a narrow strip in the east, now shared by Natal and Mozambique.

New Scotland colony was sandwiched between the Swazi and Boers in the vicinity of Amsterdam from 1864 to 1872. Thereafter, on the death of their leader A. M'Corkindale, his countrymen drifted west to older farming areas or the new diamond and gold fields. A railway route across Swaziland to link Pretoria and Lourenco Marques was surveyed by M'Corkindale and had he lived to press adoption of his plan the country would have been spared its comparative isolation of the next 90 years. However, when financial and political considerations were eventually favourable for an "Eastern Line" to be constructed (1887-1895) the more northerly, slightly easier way entirely through Boer and Portuguese territory was taken.

King Mbandzeni, who reigned 1874-1889, granted so many concessions to Europeans and became so involved in Boer-British politics that "protectorate" status was inevitable. It was forced on Queen Labotsibeni in 1893. Formal British administration lasted from 1902 to 1968, when the Kingdom of Swaziland regained full independence. Internal self-government had been achieved in 1964.

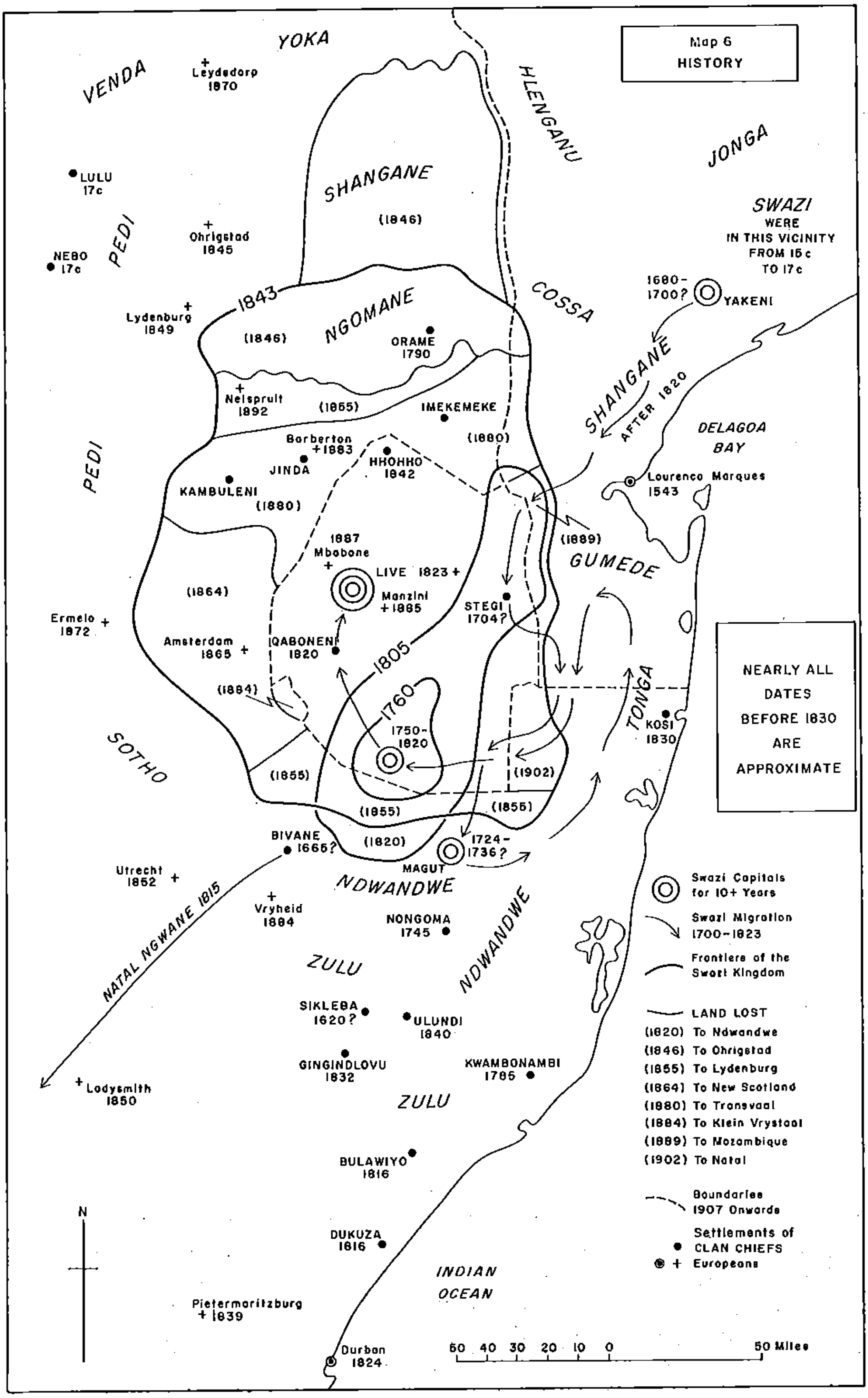
To put the country's stage of development into perspective, some social and economic milestones are now briefly reviewed: for historical data the Colonial Annual Reports of the Swaziland Government (1907-1966) have been freely drawn upon, in addition to Matsebula (1952), Kuper (1953), Walker (1957), Scutt (1966) and the writer's researches.

The last major Zulu invasion of Swaziland took place in 1854 and the last known Swazi raid north against the Pedi and Venda in 1870. Iron ploughs were recorded as being used by Swazi before 1860, the year C. Vermaak arrived at Hluti, the first European settler — in the sense of resident farmer. Wesleyan missionaries had come in 1843. Primary schools opened in 1882, secondary education began 1906, three hospitals had been built by 1928 and in the same year the first African extension staff were appointed to the recently created Department of Agriculture. There had, however, been Government veterinary services since 1910 to combat East Coast Fever and other cattle diseases.

Economic stagnation gave way, from 1938 onwards, to an expanding economy heralded by the mining of asbestos at Havelock. There has been particularly spectacular industrial and commercial development in the past decade. The value of exports, which had first reached R 200,000 per annum+ around 1905 (virtually all gold and tin then), rose from R 250,000 for the year 1938 to R 14,700,000 in 1962, when sugar manufactured on Lowveld

*Local parlance, which does not differ significantly from that in the Republic of South Africa, is adopted. "Europeans" embrace all whites, even those born in Africa, whilst "Africans" in Swaziland include all black people (Transatlantic Negroes who visit or on occasion settle would be among them) and "Coloureds" are of mixed, usually African-European, parentage or descent.

+R 1 (one rand) was equivalent to £0.50 until November 1967, whereafter the exchange rate became £0.58.



Map 6
HISTORY
YOKA
VENDA
Leydsdorp 1870
HLENGANU
JONGA
LULU 17c
PEDI
NEBO 17c
Ohrigstad 1845
SHANGANE
(1846)
SWAZI WERE IN THIS VICINITY FROM 15c TO 17c
1680-1700?
YAKENI
COSSA
Lydenburg 1849
1843
NGOMANE
(1846)
ORAME 1790
SHANGANE AFTER 1820
Nelspruit 1892
(1855)
IMEKEMEKE
DELAGOA BAY
Barberton +1883
(1880)
JINDA
HHOHHO 1842
Lourenco Marques 1543
KAMBULENI
(1880)
(1889)
1887 Mbabane
GUMEDE
LIVE 1823
(1864)
Manzini +1885
STEGI 1704?
Ermelo 1872
Amsterdam 1865
QABONENI 1820
1805
TONGA
(1884)
1760
KOSI 1830
SOTHO
1750-1820
(1902)
(1855)
(1855)
(1855)
BIVANE 1666?
(1820)
1724-1736?
MAGUT
NEARLY ALL DATES BEFORE 1830 ARE APPROXIMATE
Utrecht 1852
NDWANDWE
Vryheid 1884
NATAL NGWANE 1815
NONGOMA 1745
NDWANDWE
ZULU
SIKLEBA 1620?
ULUNDI 1840
GINGINDLOVU 1832
KWAMBONAMBI 1785
ZULU
Ladysmith 1850
BULAWIYO 1816
N
DUKUZA 1816
INDIAN OCEAN
Pietermaritzburg 1839
Durban 1824
60 40 30 20 10 0 50 Miles
Swazi Capitals for 10+ Years
Swazi Migration 1700-1823
Frontiers of the Swazi Kingdom
LAND LOST
(1820) To Ndwandwe
(1846) To Ohrigstad
(1855) To Lydenburg
(1864) To New Scotland
(1880) To Transvaal
(1884) To Klein Vrystaat
(1889) To Mozambique
(1902) To Natal
Boundaries 1907 Onwards
Settlements of CLAN CHIEFS
Europeans

irrigation projects displaced asbestos as the principal item, and R 42,000,000 in 1967, when iron ore, sugar, asbestos and woodpulp each brought in more than R 5,000,000 while the trade in beef, citrus, cotton, pineapples (canned) and rice together was worth almost R 8,000,000.

In the public sector deficit budgeting has allowed enough attention to be devoted to the infrastructure, particularly communications, to accord big private investors adequate essential services. Even in 1938, when total Government spending was just under R 400,000, Britain contributed R 150,000. The 1968 estimates are for expenditure of R 15,300,000 and local revenue of R 10,800,000. The shortfall of R 4,500,000 will be made up by grants and loans, with Britain still the main provider.

Thus Swaziland has been no exception among colonial territories. Exploitation of mining and agriculture, both geared to markets abroad, by Europeans, some of them British but most born in the Union of South Africa, has led to the familiar dual economy.

The dilemmas common to developing countries are here exacerbated by particularly difficult and delicate land tenure issues. Land apportionment was the burning question when Britain took over in 1902, and the colonial power's answer — the 1907 partition, see Figure 6 — has never been recognized by the Swazi authorities as binding on them. Only 38% of the country was entrusted to the tribe at partition, and even though they have since gradually increased the share of communally or nationally owned land to 55% — distributed as shown on Map 7 — the alienation rankles and is currently the subject of intergovernmental negotiations. The mainly European "concessionaires" and their successors have not, moreover, developed evenly and equally their individual tenure properties — mostly freehold, some on long leases. Steep topography or poor soil are often to blame for this, but in several localities crowded Swazi Area adjoins much less densely populated, in fact underused, private farmland.

The study of land capability goes some way towards indicating possible technical solutions to the agrarian problem, and these are put forward on pages 276 to 285.

COMMUNICATIONS:

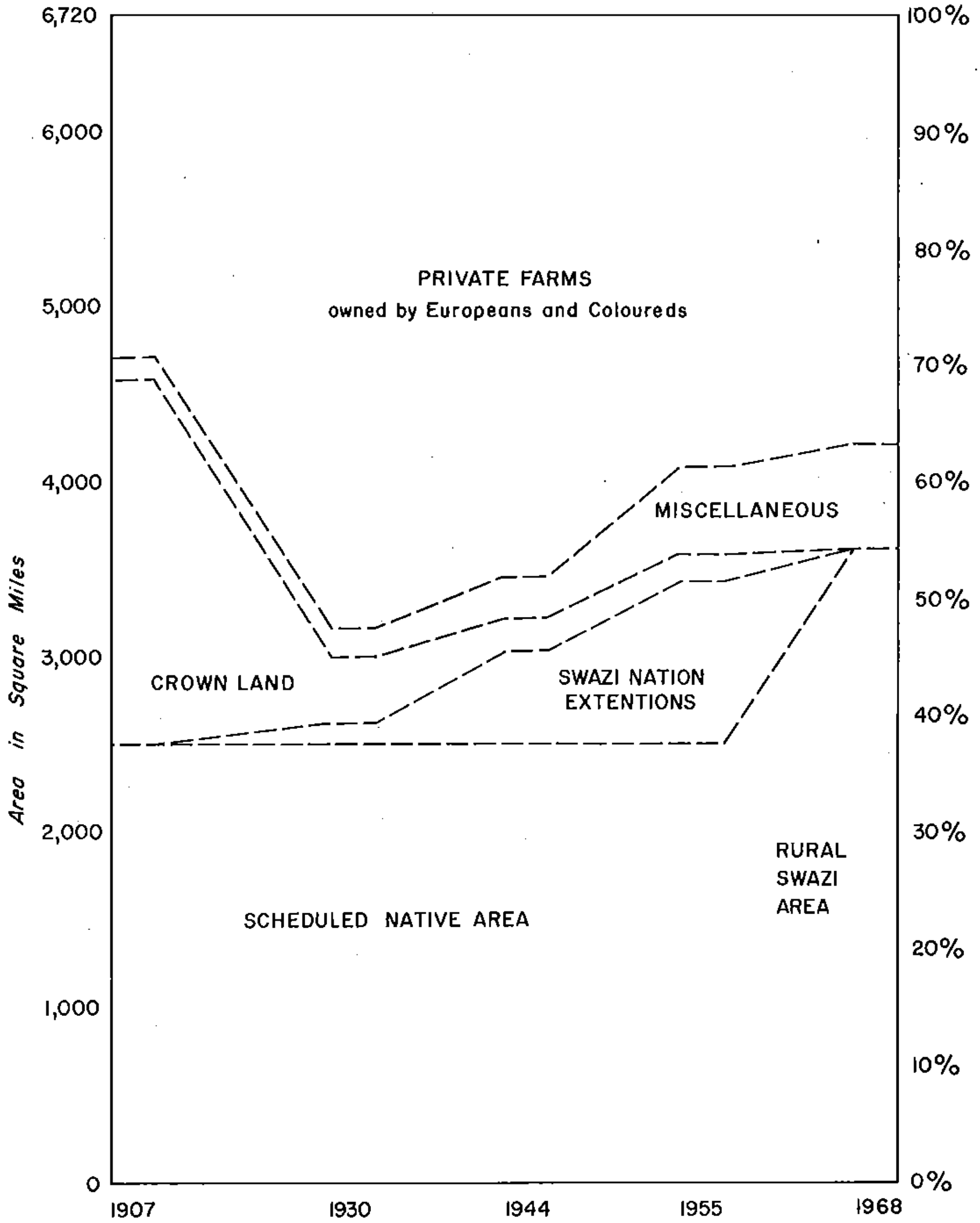
The infrastructure — surface routes, airfields, telecommunications, electricity supply — has been allocated only 20% of all development funds since 1965, but accounted for 78% of Government loans and grants 1950-1964, the tempo of expenditure increasing towards the end of that period.

Of about 1,700 miles of rural motorable roads 100 miles have been tarred, mostly between 1962 and 1964. The rugged areas worst served by roads are Makotangeni (U3) and vicinity, the Lower Ngwempisi valley, the Komati basin from Ohlangotini (E3) to Avondrust (F6) and much of the Lubombo Range. Lacunae in the Lowveld include the Dumezulu (M7) and Hlalugane (W8) localities. But few areas are really remote, most points being within five miles of a track for four-wheel-drive vehicles. Road transport is well organized: over 60 contractors and bus companies are licensed to carry goods.

In 1964 the railway was completed from Kadake, terminal for the iron ore mine, to Goba and thence to Lourenco Marques port, a total distance of 180 miles. A rail link is mooted between Kadake, or a nearby station, and Lothair, which is only 40 miles to the west (see Map 1), to connect Swaziland to what is potentially in economic terms her largest local market, the Southern Transvaal conurbation. Nxumalo (1968) points out that about 75% of Swaziland's imports already come from the Republic of South Africa but, although there is a customs union and exchange control virtually does not exist between the two countries, only 20% of Swaziland's exports in 1967 were to the Republic, both Britain and Japan being bigger customers.

FIGURE 6

Land Ownership
from Partition to Independence



RURAL SWAZI AREA in 1968 should strictly be termed Rural Communal and National land as it includes about 140 square miles of cattle holding grounds, agricultural research stations and game reserves.

SWAZI NATION EXTENSIONS by 1955 comprised 580 square miles of Native Land Settlement and 340 square miles purchased with the Lifa Fund (a cattle levy: Lifa means Heritage).

MISCELLANEOUS (with 1968 areas) = Commonwealth Development Corporation 380 square miles, urban and periurban land 110, private farms owned by Africans 70 and religious mission land 40 square miles.


Map 7
LAND TENURE
N
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
Urban and Periurban Areas with 1968 population over 2,000
Rural Communal and National Land 1968
Rural Individual Tenure Holdings 1968

This short additional railway would help put Swaziland's trade on a firmer footing and would facilitate further expansion of secondary and tertiary industries.

AGROFORESTAL ECONOMY:

Maize has been the staple food crop for at least 130 years. Previously, in the 18th and early 19th centuries, Swazi grew sorghum more widely. The main exports originating from the soil have been sugar and timber products over the past decade. In 1968 Africans (who numbered nearly 97% of the population) owned about 94% of the 250,000 acres of maize harvested in the country, 5% of the 38,000 acres under sugarcane, 9% of the 240,000 acres of manmade forests (pine, gum and wattle) and 33% of the 45,000 acres on which cotton was grown. Private European farmers produced most of the remaining maize, sugar and cotton, and shared the woodland with CDC – the Commonwealth Development Corporation – whose Usutu Forest and Gege Plantation cover 115,000 acres.

The dichotomy between subsistence agriculture, in some places still at the shifting cultivation stage, and intensive land use for cash cropping, with farms changing hands at prices exceeding R200 per acre, thus follows racial lines for the most part, as a legacy of the past. Exceptions such as the 130 Swazi irrigators on the CDC-run settlement scheme at Vuvulane (F9) and about 40 Swazi who are pineapple growers at Mpetseni (N3) or dairy farmers at Luyengo (N3) are immensely important as pace-setters of agricultural progress for their fellow-countrymen whose standards of living are rising, albeit slowly, so that more are discovering they have "the will to want" – in the expressive phrase of Kirsh (1962). Industry in the towns absorbs many of those "awakened" but rural dwellers must also keep up with the times, otherwise the grave imbalances in Swaziland's economic structure will be perpetuated, not removed. A return to this issue is made on page 274.

Land use changes over the past two decades are summarized in Table 7 and returns from the soil, both in produce and by financial value, are outlined at Tables 8 to 12. The Swaziland Government (1950-1966) Annual Reports and the sample surveys of Batson (1952) and Holleman (1964) have been supplemented, to arrive at this material, from Ministry of Agriculture files and unpublished findings of R. I'Ons. In detail there are bound to be errors, especially as regards Communal and National Land, where no comprehensive agricultural census has yet been held, but the general trends brought out are unquestionably a true reflexion of agroforestal progress.

These tables show that greatly increased production has been won recently from Swaziland's soil, the receipts from fields and orchards having almost doubled between 1964 and 1967. But there has been markedly less improvement in earnings from Communal and National Land (CNL) than from Individual Tenure Holdings (ITH – all private farms, plus CDC concerns and rural mission property). It seems likely too that the immediate future will be a period chiefly of entrenching progress made. The increases since 1950 of the area under maize (more than 17,000 acres per annum: but see note (d) in Table 8) and of the irrigated area (4,000 acres per annum) may well not be maintained.

The size of the average ITH property is about 1,400 acres, of which some 70 acres are ploughed. On rural CNL the mean per homestead – or family village – is just over 8 acres cultivated and at most 6 acres temporarily fallow (but perhaps as little as 3 to 4 acres), with 50 to 60 acres of communal grazing.

Stocking rates are heavy on CNL unimproved pastures – even with the fallow only 4 acres per animal unit. Across most of the Upper Middleveld CNL this is reduced to 3 or 2 acres per animal unit. In contrast ITH has 9 acres per animal unit. But even on private ranchland, vegetation communities that may be regarded as "virgin" (lightning-fire and game climaxes) are giving way as bush encroaches and the herbage is depleted because of maldistribution of the stock. The introduction of improved pastures is making little headway. Paddocking is not universal on ITH, rare on CNL, and even where fences have been built rotational grazing is not usually rigorously and scientifically practised.

The overstocking that has been a problem for the last 40 years – Pim (1932) and Evans (1932) were early chroniclers – on the tribal domain is as yet nowhere near solution, but empathy mixes with Ministry of Agriculture exasperation, for the Swazi revere their cattle, which are Nguni type (Zebu crosses), and traditionalists – the majority among homestead heads – do not agree to culling of herds except for ritual purposes or for bride-price or at the King's command. However, the channelling of surplus oxen to abattoirs through the Golela (Z9) and Impala (G8) ranches, which are one-way "holding grounds" covering 100 square miles, is becoming accepted.

Some European-owned herds are reared for quality beef, Africander, Brahmin and Hereford breeds being preferred. Nonetheless the annual turnover (slaughterings and exports, not natural deaths) of ITH cattle at about 14% is not very much better than the 10% on CNL. About half the dairy produce – milk, cream, butter – originates from CNL and half from ITH.

Sheep-rearing is confined to the Highveld and its margins, to which transhumance takes place for the winter from summer pastures even higher up on Transvaal plateaux. Almost all these flocks are Transvaal-owned, and the movement has gradually diminished since Doveton (1937) recorded over 800,000 acres as "trek sheep farms". Scarcely 250,000 acres could now be so described.

The most stable – though both quite new – and lucrative agroforestal activities in Swaziland, the growing of sugarcane and of pine trees, are for ecological reasons well separated, spatially. Moreover both are tied to works which process the raw produce. Expansion of cane culture beyond 15 or 20 road miles from either Ubombo or Mhlume factory is not possible because of prohibitive transport costs, and although longer timber hauls are made to Bunya pulpmill and sawmills the economic radius for logs is not much greater. The 1967 sterling devaluation affected sugar and woodpulp, but both should be able to weather its repercussions without too much hardship.

Away from cane fields and pine forests agriculture remains very much in a state of flux. The current boom in cotton seems likely to endure, but its monoculture gives cause for concern. Citrus, despite its third place among field and orchard crops in financial rewards, does not face a bright future, being threatened by poor world prices coupled with windscar and, on oranges, the aftermath of greening disease, which have rendered almost half the pick in recent years unfit for export to Europe.

Among other cash crops, rice is entirely dependent upon the present artificially-inflated Republic of South Africa price structure, pineapple expansion appeared certain until the cannery at Malkerns again went bankrupt in 1968, and all other commercial cropping is so small-scale that it makes no impact on Swaziland's economy. Modest increases in tobacco growing in the Cool Middleveld and a start to tea planting on the wetter Highveld are probable in the near future.

As to the subsistence sector, maize self-sufficiency campaigns started in 1964. Between 1962 and 1965 maize imports, chiefly from the Transvaal, averaged 18,000 tons annually, one third to one half of the local production. In the next three years imports fell to little more than 12,000 tons per annum, thanks partly to the bumper harvest of about 69,000 tons of grain in

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TABLE 7

Land Use 1950-1968

THOUSAND ACRES (a)	SWAZILAND					CNL	ITH
	1950	1960	1964	1967	1968	1968	1968
Field and Orchard Crops (b)	190	280	300	370	390	290	100
Temporary Fallow and Older Clearings (c)	200	260	260	240	230	210	20
Forest and Woodland (d)	200	290	320	330	340	80	260
Permanent Grazing (e)	3,500	3,240	3,170	3,100	3,080	1,630	1,450
Nonagricultural Land (f)	210	230	250	260	260	130	130
TOTAL	4,300	4,300	4,300	4,300	4,300	2,340	1,960

NOTES:
(a) Entries are to nearest 10. Estimated 1950-1967 and provisional 1968.
(b) Itemized in Tables 8 and 9. New statistical basis 1967 on is partly responsible for the large increase 1964–1967.
(c) Imprecisely defined. Farmers consider fallow as reverting to permanent grazing after 3 to 10 years. Holleman (1964) probably overestimates this category, although it is true that a decrease since his survey date (1960) has taken place. Fallow as internationally defined for decennial FAO censuses, with less than 5 years since cultivation, may by 1968 have dropped to 140,000 acres.
(d) Including indigenous timber. Plantation trees itemized in Table 10.
(e) Unimproved pasture. For species see Table 6.
(f) Roads, railways, airstrips, buildings, stream channels and manmade waste ground. Seasonal marshes and rocky places are counted as permanent grazing. Underestimated by Holleman (1964).

ABBREVIATIONS: CNL is Communal and National Land, ITH Individual Tenure Holdings, in this and subsequent tables.

TABLE 8

Field and Orchard Crops

THOUSAND ACRES (a)	MAIN 1968 LOCALITY (b)	SWAZILAND 1950	1960	1964	1967	1968	CNL 1967	ITH 1967
Beans	Highveld	7	5	5	6	7	5	1
Citrus (c)	Eastern LV	1	4	6	6	6	N	6
Cotton	Western LV	2	23	28	44	45	15	29
Groundnuts	Upper MV	3	6	4	6	6	5	1
Maize (d)	Upper MV	110	170	185	220	240	206	14
Pineapples (e)	Upper MV	N	1	1	2	2	N	2
Rice	Western LV	N	6	6	6	7	N	6
Sorghum	Western LV	47	29	20	23	22	19	4
Sugarcane (e)	Eastern LV	N	17	30	38	38	N	38
Other (f)	Highveld	20	19	15	19	19	15	4
TOTAL (d)	Upper MV	190	280	300	370	390	265	105

NOTES:
(a) N means less than 500 acres. Estimates 1950-1967 and provisional 1968.
(b) Abbreviations LV Lowveld and MV Middleveld. The Lower Middleveld does not stand out as a major cropping area but cotton is well-established there. Lubombo Range grows principally maize.
(c) Of about 600,000 commercial orchard trees 65% were orange and 35% grapefruit in 1968: at most 10,000 trees, divided between CNL and ITH, are not commercial.
(d) New series 1967 onwards, affecting particularly maize, whose acreage had undoubtedly been underestimated previously.
(e) Africans produced 25% of pineapples and 5% of sugar in 1968 but this was nearly all from ITH.
(f) In approximate order of 1968 acreage these are mixed vegetables, pumpkins (excluding the frequent interplantings with maize), improved pasture, potatoes, tobacco, sesame, yams, bananas, jugo, wheat, avocados, mung, vigna, soya, manioc, oats, pecans, sisal, apples etc. Tung orchards and castor and kenaf fields featured in earlier years.

TABLE 8 — Continued.

	Production (g) Swaziland		Yield (h) Swaziland		Gross Income to Farmers (j)			
					ALL PERSONS		AFRICANS	OTHERS
	1964	1967	1964	1967	1964	1967	1967	1967
Beans	0.4	0.7	0.1	0.1	50	80	60	20
Citrus (k)	10	48	1.7	8.0	390	1,460	10	1,450
Cotton (l)	5	13	0.2	0.3	670	1,200	270	930
Groundnuts	0.3	0.6	0.1	0.1	20	40	30	10
Maize	37	69	0.2	0.3	1,130	2,400	2,050	350
Pineapples (m)	6	14	6.0	7.0	70	180	20	160
Rice	7	7	1.2	1.2	680	660	10	650
Sorghum	3	4	0.2	0.2	100	140	110	30
Sugarcane (n)	92	176	3.0	4.6	3,690	5,870	240	5,630
Other	–	–	–	–	500	770	500	270
TOTAL	–	–	–	–	7,300	12,800	3,300	9,500

NOTES:
(g) Thousand tons, each of 2,000 pounds; the short ton is used throughout this memoir.
(h) Tons per acre per annum over total area planted.
(j) Thousand rands, to nearest 10. Trevino (1965) considers R 1,200,000 to have been subsistence sector in 1964. Of 1967 production by Africans perhaps R 1,400,000 was subsistence and R 1,900,000 monetary sector.
(k) Low in 1964 as many orchards not then mature.
(l) Production and yield of seed cotton.
(m) Swazi at Mpetseni not yet producing to capacity: see note (c) above.
(n) Production and yield of sucrose: value to planters, not mills.

TABLE 9

Irrigated Crops

	AREA (a)		PRODUCTION (b)		YIELD (c)		GROSS INCOME (d)	
	1964	1967	1964	1967	1964	1967	1964	1967
Citrus	6	6	10	48	1.7	8.0	390	1,460
Cotton (e)	2	7	1	4	0.5	0.6	140	390
Maize	5	5	4	5	0.8	1.0	120	180
Rice	6	6	7	7	1.2	1.2	680	660
Sugarcane (f)	30	38	92	176	3.0	4.6	3,690	5,870
Other (g)	9	8	–	–	–	–	380	640
TOTAL	58	70	–	–	–	–	5,400	9,200

NOTES:
(a) Thousand acres planted. Was 4,000 acres in 1950 and 28,000 acres in 1960. Provisional estimate for 1968 is 75,000 acres, of which at most 9,000 acres or 12% belongs to Africans.
(b) Thousand tons, each of 2,000 pounds. Citrus low in 1964 as many orchards not then mature.
(c) Tons per acre per annum over total area planted.
(d) To farmers, in thousands of rands.
(e) Production and yield of seed cotton.
(f) Production and yield of sucrose: value to planters, not mills.
(g) Potatoes, beans, other vegetables, improved pasture, bananas, wheat, avocados, oats etc.

TABLE 10

Forest and Woodland

THOUSAND ACRES	SWAZILAND				CNL	ITH
	1950	1960	1964	1967	1967	1967
Gum: Eucalyptus saligna etc.	4	15	18	26	1	25
Pine: Pinus patula etc.	30	140	172	180	6	174
Poplar: Populus deltoides	0	1	1	1	0	1
Wattle: Acacia mollissima (a)	36	34	29	23	13	10
Indigenous forest (b)	130	100	100	100	60	40
TOTAL PLANTED TREES	70	190	220	230	20	210

Gross Income from Timber Products (c)

		TO AFRICANS	TO OTHERS
1964	1967	1967	1967
5,900	7,100	250 (d)	6,850

NOTES:
(a) Wattle mainly Upper Middleveld, rest Highveld.
(b) Roughly estimated. Areas of manmade forest are much more accurate.
(c) Thousand rands, all values estimated. Products mainly woodpulp (about 100,000 tons in 1967) and sawn logs.
(d) Perhaps R 100,000 subsistence sector and R 150,000 monetary sector.

TABLE 11

Livestock

THOUSAND HEAD	ALL OWNERS				AFRICANS	OTHERS
	1950	1960	1964	1967	1967	1967
Cattle	420	520	540	500	410	90
Goats	110	200	250	240	236	4
Sheep (a)	160	170	130	100	30	70
Equines (b)	20	20	20	20	18	2
Pigs	10	10	10	10	9	1
ANIMAL UNITS (c)	470	600	621	573	468	105

THOUSAND RANDS	GROSS INCOME TO PASTORALISTS			
	ALL PERSONS		AFRICANS	OTHERS
	1964	1967	1967	1967
Beef (d)	3,520	4,170	2,640	1,530
Other Animal Products (e)	280	430	310	120
TOTAL (f)	3,800	4,600	2,950	1,650

NOTES:

(a) Including trek sheep, which decreased from 140,000 in 1960 to 60,000 in 1967.

(b) Mostly donkeys.

(c) 10 cattle to 50 goats, sheep, equines or pigs. All data are from annual veterinary censuses, rounded. About 52,000 animal units owned by Africans graze in ITH, the rest on CNL.

(d) Died, slaughtered and exported on the hoof. Values conjectural.

(e) Milk, cream, butter, hides, wool, mohair, skins, button, pork, offal, bonemeal, etc. Values estimated.

(f) Trevino (1965) considers R 1,300,000 to have been subsistence sector in 1964. Of 1968 production by Africans R 1,600,000 was perhaps subsistence and R 1,350,000 monetary sector.

TABLE 12

Income from the Soil

GROSS REVENUE TO FARMS AND FORESTS (a)		THOUSAND RANDS 1964	1967	RANDS PER ACRE 1964	1967
Fields and Orchards		7,300	12,800	24	33
Forests and Woodlots		5,900	7,100	19	22
Unimproved Pasture		3,800	4,600	1.2	1.5
TOTAL (b)		17,000	24,500	4.5	6.4
To Africans:	Subsistence	2,600	3,100 (c)	2.5	3.2
To Africans:	Monetary	2,500	3,400 (c)		
To Others:	Monetary (d)	12,900	18,000	7	10
FIELDS AND ORCHARDS SUBDIVIDED					
Raingrown Crops		1,900	3,600	8	12
Irrigated Crops		5,400	9,200	93	132
Of the latter:	Citrus	390	1,460	65	243
	Cotton, seed	140	390	70	56
	Maize	120	180	24	36
	Rice	680	660	113	110
	Sugarcane	3,690	5,870	123	157

NOTES:

(a) Estimated current market value, without deducting production costs.

(b) In respect of 3,790,000 acres in 1964 and 3,800,000 acres in 1967.

(c) Area taken as CNL (and in 1964 Crown Land) fields, woods and permanent grazing plus 20,000 acres of ITH in 1964 which were African-owned farms, and 30,000 acres in 1967. Totals are 2,010,000 acres in 1964 and 2,020,000 acres in 1967.

(d) With negligible subsistence fraction. Area from (b) minus (c) is 1,780,000 acres.

See also footnotes of Tables 8 to 11.

1967, when good rains were exceptionally well distributed (cf. the 1968 preliminary estimate of 50,000 tons).

The parts of the country with about 60% chance or greater of summer drought (see Map 4) were excised from the maize autarky drive after 1966. There, in the Lowveld, the only sure way to avoid maize failure is by irrigating, but for such a relatively low-return crop this is uneconomic without capital assistance to bring the water to fields. Provided initial "priming of the pump" is possible, the long-term outlook for Swazi irrigators of food crops is good.

A survey of present water use is made on pages 55 to 61, and other novel farming techniques which pose problems are also treated later. They include the planning of crop rotations, where proved necessary, and the integration of livestock with arable systems, for despite the long list of crops that are or could be cultivated in the country little real "mixed farming" is carried on. Not least of agricultural difficulties is the smallness of purchasing power for perishable products within 50 or 100 miles of their origin. Future agroforestal patterns will of course depend on a complex of physical (notably soil), economic and social considerations and the choice of steps that will lead to progress, not stagnation, is all-important. That choice, and how wide it is, becomes one theme for discussion in the final Chapter — see especially pages 287 and 288.

INDUSTRIES:

Farming and mining, both in the process of diversification, form the bases for primary and secondary industry in Swaziland. The tertiary sector is now fairly advanced too. Jones (1968) records the enumeration of workers in Government and in community, business and personal service as 40% of the total 1966 labour force — cf. about one sixth in 1957. Before the advent of sugar-milling in 1958 manufactured commodities comprised the following, with their 1957 export values — chipboard R 740,000; canned pineapples R 230,000; butter R 180,000; furniture, doors, shooks and other timber products R 50,000; mohair textiles R 30,000; tung oil R 20,000; bonemeal R 10,000.

In 1967 more than R 9,500,000 worth of export sugar was made at Ubombo and Mhlume. The local market consumed R 1,300,000 worth in addition. Woodpulp to the value of R 5,500,000 was processed at Bunya (factory built 1960) and miscellaneous timber products, mostly from Peak Timbers (D4), canned and packed beef from Matsapa (M4) meat works, canned fruit from Malkerns and ginned cotton were each by 1967 industries in the R 600,000 to R 1,800,000 annual earnings bracket.

The cotton ginnery was the first firm on Matsapa industrial site, laid out in 1964 and linked to rail in 1965. As well as meat-packing (with an abattoir to slaughter 25,000 cattle annually) other industries attracted there include brewing, confectionery, brick-making etc. For the internal retail trade, maize mills at Manzini and (much smaller concerns) Goedgegun, Stegi, Ngonini (B5) etc. had an output in 1968 of about 10,000 tons meal — selling price R 600,000. The Tshaneni (E8) rice mill sends paddy to the Transvaal and dehusked rice to Natal's Indian community.

Although older established (see page 11) than others, the mining industry is still purely extractive. In 1967 it realized about R 17,400,000 — iron ore R 11,300,000; asbestos R 5,900,000; coal R 180,000; kaolin R 20,000.

The proportion of the investment in mining and manufacturing companies which was profferred from Swaziland is negligible. All were started with British (notably CDC), South African, Japanese, American, Norwegian, etc. capital and knowhow.

Lack of industrialization south of the Usutu River led to the recognition of "depressed area" status for Shiselweni when the administrative Districts were reduced from six to four in 1963. Shiselweni is the only District which has had an officially constituted Development Committee. By 1968 glimmerings of progress were Goedgegun's first sawmill (about 25,000 acres are being planted with gum trees, which will double Swaziland's existing acreage) and plans for a revival of tobacco growing. Zameni (W3) jaggery production has got off to a very slow start. Tortuous, often steep road alignments in Shiselweni render bulk transport expensive, so further reducing the District's capacity to export. In 1967 it had 26% of the country's population but only 5% share of foreign trade income.

Much of the 50 megawatts (MW) capacity for electricity generation in Swaziland depends upon water supplies. The national power stations at Dwaleni and Magoduza (combined 24 MW, will be 30 MW by 1970) are mainly hydroelectric, with diesel firming. Since construction began in 1963 all the centre and parts of northeast Swaziland have been connected to their grid. The largest single remaining private installation is an 8 MW steam plant at Havelock.

WATER USE:

One measure of the importance of a waterwork (canal, pump etc.) is the gross transmission rate of which it is capable, but in Swaziland several such works are operated at levels considerably below maximum capacity, and the concept of "maximum use" is preferable in establishing their size ranking. Even maximum use could be defined variously. One reasonable way appears to be the greatest cumulative flow during a single calendar month, that has passed from a river to the waterwork concerned. Further refinements made below are (a) that for ease of comparison the monthly rate is multiplied by 12, so becoming equivalent to an annual one, (b) that canals etc. which have fallen into desuetude (by 1968) are disregarded and (c) that the monthly record starts in 1957, the year of the first comprehensive census of irrigators by the writer and colleagues.

The maximum use of water, thus specified, by all owners of canals, furrows, pipelines, rams, pumps and other offtakes from rivers in the country is about 1,780,000 acre-feet per annum. Of this total, however, some 690,000 acre-feet per annum is nonconsumptive, almost all of it for hydroelectric power, leaving 1,090,000 potentially consumable, subdivided into 50,000 for houses and gardens; 20,000 for livestock; 40,000 for industry (the largest inflow to one factory being Bunya pulpmill's 4,000 acre-feet per annum); and 980,000 acre-feet per annum for irrigation (upon which attention is focussed in Tables 13 and 14 and Map 8).

To these users must be added upstream Transvaal schemes (capacity about 300,000 acre-feet per annum by 1970, more for industry than for irrigation), giving close on 1,400,000 acre-feet per annum as the total draught tapped down to Swaziland's eastern border, out of (see page 35) the 3,700,000 acre-feet annual undisturbed flow. Thompson (1964) states that little more than 60% of the total runoff will ever be utilizable, even with major storage, due to the flood characteristics of the rivers. Structures already operative could thus cope with 63% of the maximum possible sustained draught.

Slightly different proportions, those of 1968 irrigation maximum use to 60% of undisturbed mean flow (both within Swaziland), are as follows, by subcatchments – Lomati 28%: Komati 126%: Umbeluzi 77%: Little Usutu 37%: Great Usutu above Filmerton 154%: Ngwempisi 25%: Assegai 48%: entire Usutu basin above Abercorn 73%: Ingwavuma 72%: all of Swaziland 980,000 acre-feet per annum out of 1,320,000 extractable or 74%. As non-irrigators are excluded, the position is in reality even graver than this.

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TABLE 13

Water Abstractions 1963-1968

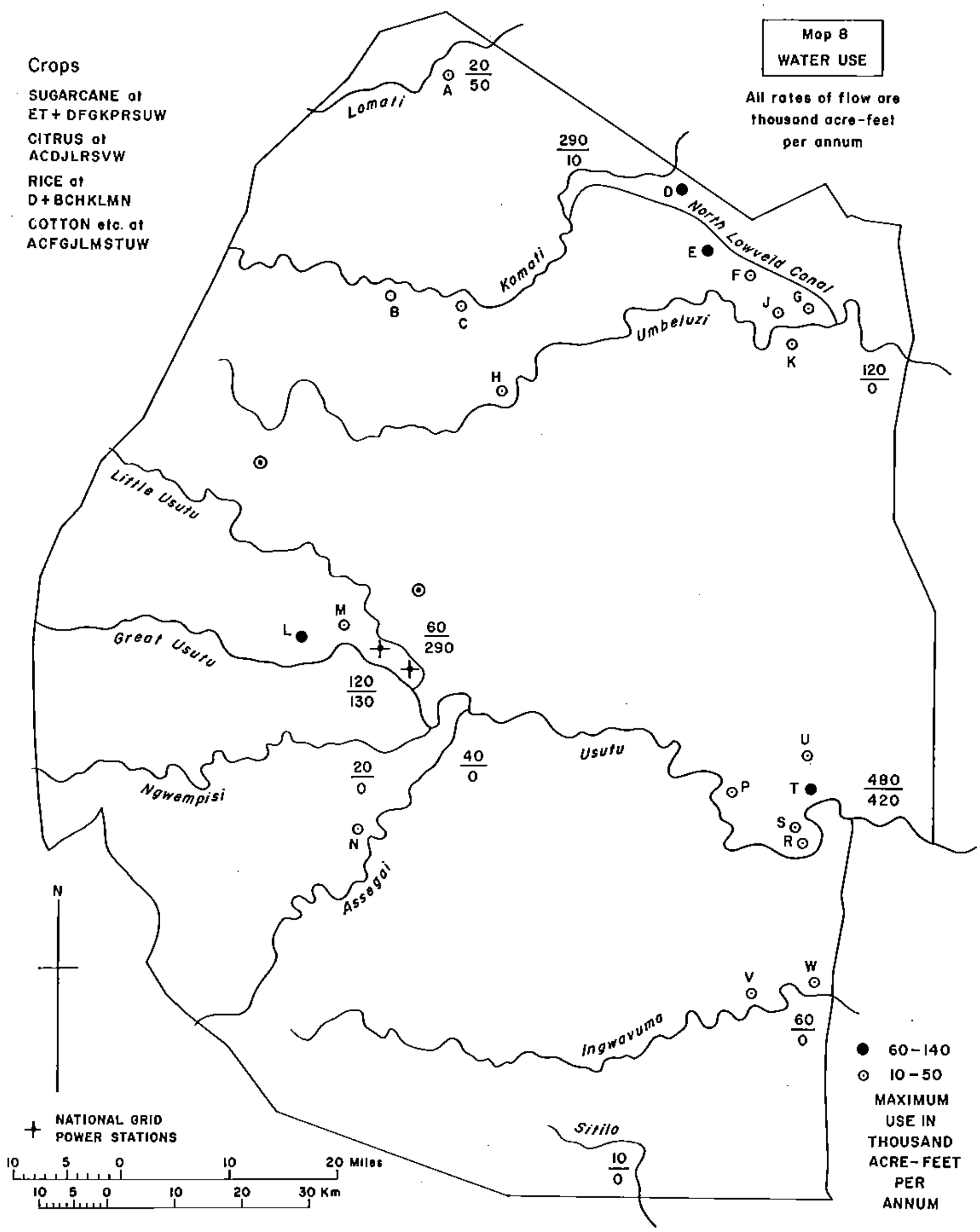
MAXIMUM USE (a) IN ACRE-FEET PER ANNUM, BY RIVER BASINS OF ORIGIN	For Irrigation 1963	For Irrigation 1968	For hydroelectricity 1963	For hydroelectricity 1968
Lomati-Komati	230,000	310,000	60,000	60,000
Umbeluzi	20,000	120,000	0	0
Usutu	410,000	480,000	100,000	420,000 (b)
Ingwavuma-Pongola	40,000	70,000	0	0
TOTAL (c)	700,000	980,000	160,000	480,000

NOTES:

(a) Maximum use means greatest cumulative flow in one month during the time from 1957 to the year concerned, through works (canals, pumps, etc.) within Swaziland and still operating by the end of the period. All data rounded: 1963 from census, 1968 provisional.

(b) National grid 340,000 and private HEP plants 80,000.

(c) Abstractions in Nkalishane and Tembi basins are negligible.



Key to Numbering

480 IRRIGATION
420 HYDROELECTRICITY

Maximum Use = Greatest flow in one month during the period 1957–1968 through works (canals, pumps etc.) within Swaziland still operating by 1968

Irrigation

480 MAXIMUM USE, BY ENTIRE RIVER BASINS

Hydroelectricity

420 MAXIMUM USE, ALL NON-CONSUMPTIVE

MAIN IRRIGATION SCHEMES

(P) = Pumped, rest gravity

A NGONINI	G TAMBANKULU	N RICELANDS
B VERGELEGEN	H DUMISA	P BAR J (P)
C EDENVALLEY	J TAMBANK.(P)	R MKIWANE
D TSHANENI	K UMBELUZI (P)	S REN
E MHLUME	L MALKERNS	T UBOMBO (P)
F VUVULANE	M CALAISVALE	U UBOMBO
		V MOLEMO (P)
		W CANTERBURY

TABLE 14

Duty of Water at Maximum Use on Irrigation Schemes

		Irrigated Area NETT ACRES		Maximum Use (a) ACRE-FEET PER ANNUM		INCHES (b)	
(1)	BY RIVER BASINS OF ORIGIN	1963	1968	1963	1968	1963	1968
	Lomati-Komati	18,000	29,000	230,000	310,000	13	11
	Umbeluzi (c)	2,000	8,000	20,000	120,000	10	15
	Usutu	29,000	34,000	410,000	480,000	14	14
	Ingwavuma-Pongola	3,000	6,000	40,000	70,000	13	12
	TOTAL (d)	52,000	77,000	700,000	980,000	14	13
(2)	BY SUBCATCHMENTS		1968		1968		1968
	Lomati		2,000		20,000		10
	Komati (land in Komati basin)		9,000		110,000		12
	Komati (e)		18,000		180,000		10
	Little Usutu (f)		3,000		56,000		19
	Great Usutu above Filmerton (g)		9,000		120,000		13
	Ngwempisi-Assegai (f)		3,000		57,000		19
	Usutu below Sidvokodvo		19,000		247,000		13
(3)	BY MAIN CANALS		1968		1968		1968
	North Lowveld (h)		23,000		245,000		11
	Big Bend (j)		14,000		165,000		12
	Malkerns (k)		7,000		80,000		11
	Subtotal of these three (l)		44,000		490,000		11

TABLE 14 – Continued

(4)	BY SIZE OF PROJECT (m)	1968	1968	1968
	Large: 20 Schemes on Map 8	57,000	720,000	13
	Small: about 230 Schemes	20,000	260,000	13

NOTES:

(a) As Table 13, note (a).

(b) Per month on the irrigated area. Larger than crop water need (highest monthly evapotranspiration is about 9 inches) because of transmission losses and, at places, bad husbandry. 13 inches monthly = 55 acres per continuous cusec. Without storage the best that run-of-river irrigators can achieve at peak requirement is 80 acres per cusec. See page 24 for the duty with year-round storage.

(c) Only large basin with worse duty of water in 1968 than in 1963, because of recent introduction of rice at Dumisa (H6) and Umbeluzi Estate (G9).

(d) 1963 from census, 1968 provisional. Latter acreage is 2,000 more than figure given at Table 9, an unimportant discrepancy due to upward rounding here.

(e) Land in Umbeluzi basin watered from North Lowveld Canal.

(f) Poor duty of water because much rice relative to the other crops.

(g) Only subcatchment where irrigation is on the decline. In 1963 water was applied to about 11,000 acres, with maximum use 135,000 acre-feet per annum. Since then rice, citrus, improved pasture have all decreased.

(h) Total commandable area at least 48,000 acres.

(j) Includes booster pumping (about 75,000 acre-feet per annum maximal) at Ubombo. Commandable area, by gravity, is at least 19,000 acres.

(k) Includes additions (less than 10,000 acre-feet per annum) from furrows led out of minor tributaries within the scheme. Commandable area at least 23,000 acres, spilling northwards into Little Usutu catchment.

(l) Duty better than national average, mainly through economy of scale.

(m) Headings of previous page apply.

It is, moreover, simplistic to consider only block annual water needs and flows. Dams in the high Transvaal, each with on average 20,000 acre-feet per annum assured flow (Nooitgedacht on the Komati, Westo on the Great Usutu, Jericho on the Mpame, an Ngwempisi tributary), coupled with Swaziland's own 50,000 acre-feet per annum reservoirs, are not nearly copious enough to permit low-flow-season offtakes matching those in summer. Furthermore the South African dams are designed primarily to supplement Vaal basin abstractions westwards.

Again referring to 4% of time, as on page 35, the calculations of Thompson (1964) show that in the "dry fortnight" – assuming it coincides across all catchments – the undisturbed flow in the rivers was moving at a rate of only 1,700 acre-feet daily. Lowveld farmers, contending with daily evapotranspiration of 0.2 to 0.3 inch in late winter over some 50,000 irrigated acres, already feel the pinch. They have had difficulty especially along the Ingwavuma, Usutu and Umbeluzi* in wheedling a trickle of water into their canals and pumps on several occasions over the last five years, although each time after a few days the supply resumed.

These portents of future water shortages, along with the desire of the Government and Swaziland Electricity Board to rationalize water allocations in basins crossing the borders of the Republic of South Africa and Mozambique, led to the first of a series of Tripartite Water Conferences in 1967. Downstream of Swaziland the main new water developments are municipal, for Lourenco Marques, and agricultural.

Another complication arises from the seasonal demand for water. As Figure 5 indicates, this varies from region to region, and it is different for such contrasting farming systems as cane growing, citriculture, riziculture and mixed cropping with rotated annuals. Brook (1965) provides estimates of monthly water requirements for nine Lowveld and Middleveld crops. The total evapotranspiration (i.e. the need for rain-cum-irrigation, taking percentage canopy into account) ranges from 14 inches for beans in the Upper Middleveld (watered May-August) via 30-32 inches for Lowveld cotton (October-March) or maize (October-February) to 66-68 inches for Lowveld sugarcane and improved pasture (all year) or rice (September-February). Each crop growing in summer has a December or January maximum requirement of between 7 and 9 inches monthly, except rice for which, even with good husbandry, as much as 18 inches of water may be wanted in October, to top up bunded basins.

The use of water by irrigators is thus spread over the year and abstractions must never, so far, have reached at one time the 80,000 acre-feet per month which has been cited. In this sense "maximum use" is acknowledged to be a fiction: this does not invalidate it as a convenient theoretical gauge of irrigation development. The effect of fluctuations under the ceiling of maximum demand is to reduce water offtakes, frequently well below system capacities. These considerations improve somewhat the gloomy prospect that is emerging.

But they are almost the only hopeful sparks, dimmed by comparison with yet more provisos and caveats, such as the following six:

(a) Hydroelectric stations must be absolutely sure of receiving the large quantities of water their penstocks require. This penalizes upstream development to the benefit of downstream irrigators who, either by design or incidentally, are bound to receive the power plants' throughput.

(b) Water supplies are depleted by the transpiration from manmade forests which replace sparse grassland. To Swaziland's 240,000 acres of planted timber must be added a similar area in upper basins on the Transvaal Highveld. The trend of gauge readings is

*The Komati barrage at the Kukuku (D7) offtake of the North Lowveld Canal regularizes that river's flow more efficiently than smaller weirs on the other trunk streams.

steeply downward for the Poponyane and Lambongwenya Rivers whose headstream catchments have been entirely afforested since 1948, as compared with runoff from virtually unchanged montane areas also in the northwest – e.g. the Upper Umbeluzi. If much the same ratio of afforestation to loss of possible irrigated land obtains as in Cape Province, where Banks and Kromhout (1963) provisionally equate 100 acres timbered to 10 acres irrigated, then 50,000 acres of potential fields and orchards have already been jeopardized. Of course a cost-benefit study might reveal that additional returns from such an area would not exceed the advantage to be gained by forestry. Table 8 suggests that they may be akin, gross 1967 earnings being R 190 per acre of sugarcane and citrus combined, versus R 220 per wooded 10 acres.

(c) The prevailing inefficiency of irrigation canals and distributaries is alarming but the cost would be high to line or pipe every one to eliminate seepage through their walls or beds of soil or broken rock. (The reverse of this coin is greater return flow from unlined channels to the rivers for re-use).

(d) Prices are currently good for rice, a very water-intensive crop which has become popular on small to medium "instant" irrigation schemes, often using not contour basins but the cheap, tremendously wasteful hillside flooding technique, wherein only 10% to 20% of water from the river is eventually transpired by the rice crop.

(e) Fear of being caught without water has been partly responsible for the small growth rate recently of Usutu basin irrigation schemes – only 5,000 extra acres 1963-1968 with actual retrenchment in places, notably at Malkerns and Calaisvale. This compares with 20,000 extra acres in the same quinquennium elsewhere. A United Nations Development Program team have begun to make a feasibility study, due to finish in 1970, of the water potential in the Usutu basin, Swaziland section.

(f) The three minor categories of water use, domestic and industrial and pastoral, with only 10% of the present consumptive capacity, may well develop with maturation of the economy, particularly urbanization. However, although industry's quota may need to be raised, it will not exceed 20% in any major catchment for the foreseeable future.

Aware of these ramifications, the Government in 1968 established a Water Apportionment Board to tackle many of the problems that will arise from having too little water, or an excess of irrigable land. It is already known that good damsites abound. Hydrologists and engineers in Government and the UNDP Usutu project will have to decide the order in which, on technical evidence, reservoir construction should be planned. To assist them soil survey results are vital, and pages 197 to 222 deal in detail with irrigability.

DEMOGRAPHY AND SOCIOLOGY:

Although the subject of this memoir is land, the people who work it are crucial to the cause of raising agroforestal productivity and living standards. Jones (1968) makes a comprehensive survey of the population from data obtained at the 1966 census, which was the first full head count there had been in Swaziland. Previous censuses, back to 1904, were by assembly and are known to have resulted in underestimates. Most of the following is taken from Jones (1968) although some figures for dates earlier than 1966 have the Swaziland Government (1907-1965) Annual Reports as their source and F.T. Russell has provided some later statistics.

The disseminated pattern of living to which the Swazi are traditionally accustomed is still the rule throughout the land, both on CNL and on rural ITH. Of Swazi villages only Lobamba, the residence of the Queen Mother, has more than 150 huts and most homesteads are self-contained family (agnate) units with an average of 7 or 8 occupants. Buildings are simple — grass "beehive" houses or wattle-and-daub or uncut stone or rough brick structures, roofed with thatch or corrugated iron. Rural homesteads are separated from each other by hundreds, or at least scores, of yards.

But the export drive, better education and other factors are encouraging urbanization. Lobamba itself will assuredly be transformed in the near future, as it was proclaimed in 1967 the seat of Parliament, although Mbabane retains meanwhile other functions of a capital, including the judiciary, ministries and civil service departments.

Mbabane has been the administrative headquarters since 1902. Manzini, then called Bremersdorp, was the capital 1890-1902: it remains the commercial hub of Swaziland. Both these towns are growing fast. Each had about 8,000 inhabitants in 1962, with suburban and periurban* fringes, but 15,000 (Mbabane) and 17,000 (Manzini) by 1966. Matsapa industrial estate boosts the Manzini total.

Nine other concentrations of population house 2,000 to 5,000 persons each, the largest numbers being at Havelock, Stegi and Goedgegun — the latter two, along with Mbabane and Manzini, are District Commissioners' posts. Smaller centres comprise Big Bend, Bunya, Hlambenyatsi, Hlatikulu, Mhlume and Piggs Peak. With another 15 hamlets (marked on Map 10) which perform services for their neighbourhoods, having say a general store, butchery, mission school, perhaps garage or clinic, all "nucleated settlement" in Swaziland accounted for 75,000 out of the 392,000 people enumerated at the 1966 census. The remaining 317,000 may be termed "dispersed" and occupy about 6,570 square miles, giving a rural mean density of 48 per square mile. The nucleated density was 500 and the national average 58 per square mile in 1966.

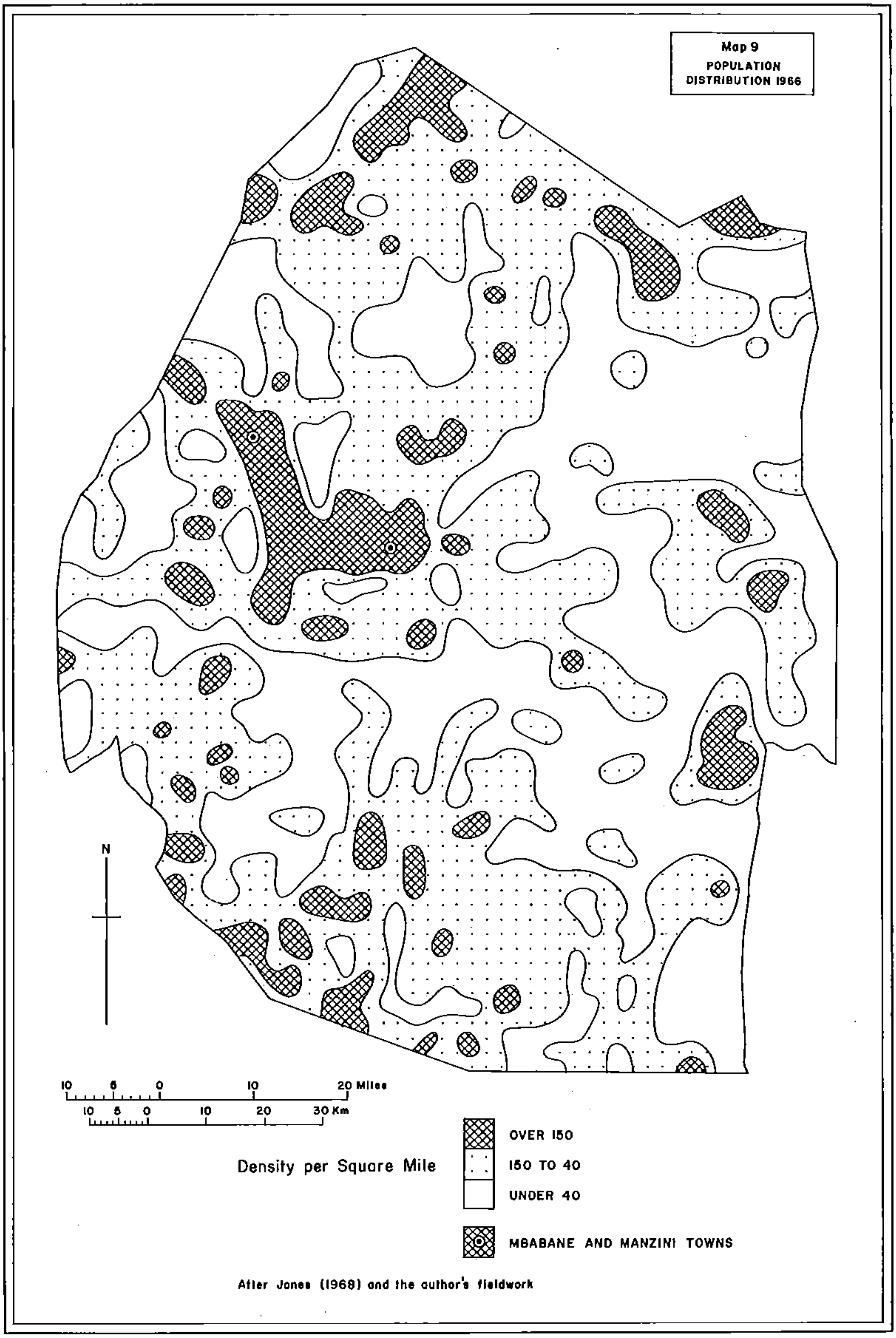
For rough comparison (remembering the incomplete coverage prior to 1966) at the 1904 census 85,000 persons were found and at the 1936 census 157,000. The annual increase of population is now 2.8% as computed by Jones (1968), mostly due to an excess of births over deaths although a fraction comes from nett immigration. On this basis the 1970 population will be almost 440,000 and the projection for 1985, assuming constant fertility, is over 700,000.

Of the 1966 total about 352,000 were Swazi. Members of the Zulu, Tonga, Shangane, Nyasa, Xosa, Sotho and other African ethnic groups numbered 26,000: Europeans 9,000: Coloureds 5,000.

The dispersed component of the population is unevenly distributed, being most closely packed — 300 to 400 per square mile — in widely scattered Enumeration Areas (EAs) of the 1966 census, including Gege (U2), Dwalile (Q1), Salem (U5), Mbukwane (W3), several adjacent EAs of the Ezulwini and Umtilane valleys, Lomahasheni (E9) and Palati (N0). In general, rural dwellers congregate in the three fairly flat areas of the Upper Middleveld (see page 10), along Highveld valleys and, discontinuously, on the Lubombo crest. But as Map 9 shows there are many pockets elsewhere of relatively heavy density. The northern third has fewer people per unit area, and rather more concentration at nodes, than the rest of the country.

However, the overriding factor determining gaps in the network of homesteads has been the 1907 partition. Table 15 compares, by region and subregion, the CNL and ITH shares of the populace. All ITH has only half the population pressure of all CNL, and rural ITH about a quarter. While the Upper Middleveld stands out as the most densely populated subregion in both tenurial categories, the sparsest subregions are Eastern Lowveld (CNL) and Lubombo (ITH). The CNL pattern of habitation reflects drought hazard and proportion of steepland,

*Used in the Southern African sense of outlying nuclei of population, usually dormitory suburbs.



Map 9
POPULATION
DISTRIBUTION 1966
N
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
Density per Square Mile
OVER 150
150 TO 40
UNDER 40
MBABANE AND MANZINI TOWNS
After Jones (1968) and the author's fieldwork

TABLE 15

Regional Population 1966

	Persons (a)			Square Miles (b)			Density (c)		
	CNL	ITH	All	CNL	ITH	All	CNL	ITH	All
Highveld	65,000	48,000	113,000	770	1,230	2,000	84	39	57
Middleveld	135,000	28,000	163,000	1,190	590	1,780	113	48	92
Upper Middleveld	82,000	21,000	103,000	540	290	830	152	73	24
Lower Middleveld	53,000	7,000	60,000	650	300	950	82	24	63
Lowveld	64,000	32,000	96,000	1,420	980	2,400	45	33	40
Western Lowveld	44,000	17,000	61,000	910	540	1,450	48	31	42
Eastern Lowveld	20,000	15,000	35,000	510	440	950	39	34	37
Lubombo Range	16,000	4,000	20,000	270	270	540	60	15	37
TOTAL (d)	279,000	113,000	392,000	3,650	3,070	6,720	76	37	58

NOTES:

(a) Population differs slightly from the official de jure total of 395,000 because of rounding.

(b) Regions are as mapped during the NSR, therefore do not tally in area with calculations by Jones (1968) from entire EAs. He makes the country 6,700 square miles (to nearest 10) of which Highveld 1,940: Middleveld 1,780: Lowveld 2,470: Lubombo 510. Considering that regions merge into one another, often over several miles, these disparities are trifling. To bring populations into line small revisions of them were also made.

(c) Per square mile.

(d) Dispersed CNL had 259,000 people on 3,610 square miles, density 72. Dispersed ITH had 58,000 on 2,960 square miles, density 20.

whereas irrigation schemes in the Eastern Lowveld raise ITH density there above that of both Western Lowveld and Lower Middleveld as well as Lubombo Range.

The four Districts and their 1966 populations are Hhohho 100,000: Lubombo 83,000: Manzini 106,000: Shiselweni 103,000. There has been no formal machinery for local government below this level but 150 chiefs, responsible to the King, are the traditional authorities in CNL, with an average there of nearly 2,000 subjects to each chiefdom.

Some other demographic characteristics in 1966 were a ratio of 95 males to every 100 females, a low median age — about 17, and a high number of temporary absentees among the de jure inhabitants — about 20,000 or 5% (they included some 7,000 workers on short contracts in the gold mines of Johannesburg and environs).

Employment for wages within Swaziland has increased dramatically during the past decade. In 1957 there were less than 10,000 paid jobs, in 1968 at least 60,000. The majority are held by unskilled labourers who work for a while then return to subsistence farming for a while. This inefficient, pernicious system of "migrant labour" benefits neither town nor countryside, but has become so much the norm that stamping it out will involve a revolution in employers' attitudes to e.g. training and housing, and employees' attitudes to work, money and land.

In the 1966 census the number of "farmers and farm managers" counted was 2,340 of whom 1,950 were African, 320 European and 70 Coloured. The extent of ITH absentee landlordism can be judged from the fact that on more than 1,000 properties belonging to non-Africans there were at most 390 owners in charge of farming operations.

Subsistence sector cultivators were excluded from this occupational class but even so the low number of African commercial farmers does not appear to square with e.g. the membership in 1966 of Farmers Associations (3,250 were Africans) or the known cotton-growers of that year, who included more than 2,700 Africans. By adding allied occupations to "farmer" the 1966 African total can be bolstered to about 2,500 men and 300 women. The additions, most of whom can be expected to sell some produce from land that they farm, comprise wholesale and retail proprietors, millers, tanners and male spinners, weavers and brewers. Some of the 750 herbalists and witchdoctors doubtless farm for profit too. Pushing the number up further, say to 5,000 African cash-crop growers on CNL in 1968, still leaves 30,000 dispersed CNL homesteads firmly relegated to being purely subsistence producers.

The number of Africans in Farmers Associations reached 4,000 in 1968 and 2,300 Swazi were then participants in the Master Farmer Scheme, begun in 1965. According to one impartial observer, some have attained very high standards of husbandry — Stevens (1967) — and where they have led there is no reason why others should not succeed. Farm and forest money-earning employees (outdoor, excluding agroforestal processing workers) numbered about 21,000 in 1966, more than a third of the total labour force then.

About 57% of all adults profess Christianity and in 1962 some 28% of rural Africans over 9 years old were literate, as against 64% of townsfolk. By 1967 the number of African university graduates (by no means all Swazi) had reached 150: at the same date 440 Europeans and Coloureds held degrees. Secondary education is currently causing much concern, for high wastage rates mean that very few Africans pass out from fifth and sixth forms annually — the total of all races was less than 200 in 1967. There has been a deliberate shift in the emphasis of development spending since 1965 away from the infrastructure, as noted on page 42, and into education.

Agriculture is particularly affected by the shortage of highly skilled local staff, but since its needs are not so blatantly apparent as the lack of urban-administrative personnel, priority has had to be given to leadership and management courses in awarding the 70 to 100 foreign scholarships available annually since 1963. Within Swaziland, however, the new agricultural college at Luyengo, opened in 1965 and now taking in 40 diploma students each year, is expected to make major contributions soon to rural development.

Swazi nationalism, though not rampant, is sensitive understandably to the presence of all who are not of the Swazi ethnic group. Zulu and other African immigrants are classed with Europeans and Coloureds by xenophobes. All non-Swazi form 10% of the total population but 23% of urban dwellers (in Mbabane and Manzini) and about 20% of cash income employees. In 1963 Swazi wage earners were making R 20 each per month on average, non-Swazi over R 50 per month. Nkonyane (1968) states that wages and rations supplied to employees in agriculture are now running at R 20 per month to Africans, more than R 200 to Europeans. In mining and quarrying the differential is R 40 Africans and R 300 Europeans. Bridging the gap between haves and have-nots is an imperative task, not only for the sake of prosperity, but also for national peace and amity.

CORES AND PERIPHERY:

The localities at which economic activity is concentrated in Swaziland are plotted on Map 10. The distribution of components in the space economy immediately suggests that the uneven spread of wealth and of relatively large, modern enterprises can be represented by a cartographic division into growth points or Cores which are "islands of development" set within a Periphery that is the "sea" of traditional ways and mainly subsistence sector production.

Fair, Murdoch and Jones (1968) elaborate on the Core-Periphery duality. Recognition of these two utterly dissimilar elements in the economic landscape stems from a synthesis of other dichotomies – urban-rural, monetary-subsistent, white-black (this transiently, one hopes), ITH-CNL and, it is not premature to divulge, high versus lower land capability for agriculture and forestry. The rivers, as sources of irrigation and power, and the physiographic regions also have effects on the position, shape and size of each Core.

A Primate Core stands out, embodying Mbabane and Manzini as well as the iron mining, woodpulp and other industries of West-Central Swaziland and – not by coincidence – the tribal heartland including Lobamba, Lozita (M4, the King's village) and all other royal domiciles, but one, of the last 145 years.

Three Subsidiary Cores, or Resource Outposts, are more specialist in character, the East-Central and North-East owing their existence to irrigated sugarcane while the North-West is dominated by asbestos and timber. The Periphery is not a featureless backdrop physically, but its economic drabness is underlined by comparing (see Table 16) its area, 84% of Swaziland, with the weak contribution it makes to national primary and secondary production – cash value 11% in 1966. Per unit area the Cores are, by this yardstick, more than 40 times as affluent as the Periphery, and per head of population nearly 30 times. About 22% of Africans in 1966 lived in the Cores, but 65% of Europeans and Coloureds.

Among developing countries, Swaziland is, by virtue of having acquired the Cores, and especially a Primate Core, at the stage which Rostow (1960) terms Preconditions for Take-Off and Friedmann (1966) the Transitional Economy, manifested geographically by a single national centre whose growth far outstrips that in the rest of the state, necessarily, so that it can inject financial subsidies and equalizatory services into its Periphery. Once that is done and subcentres thrive the country is able to launch into the Industrial Economy of Friedmann, or the Take-Off as designated by Rostow.

Houghton (1964) has applied Rostow's model to the Republic of South Africa and is

To page 70

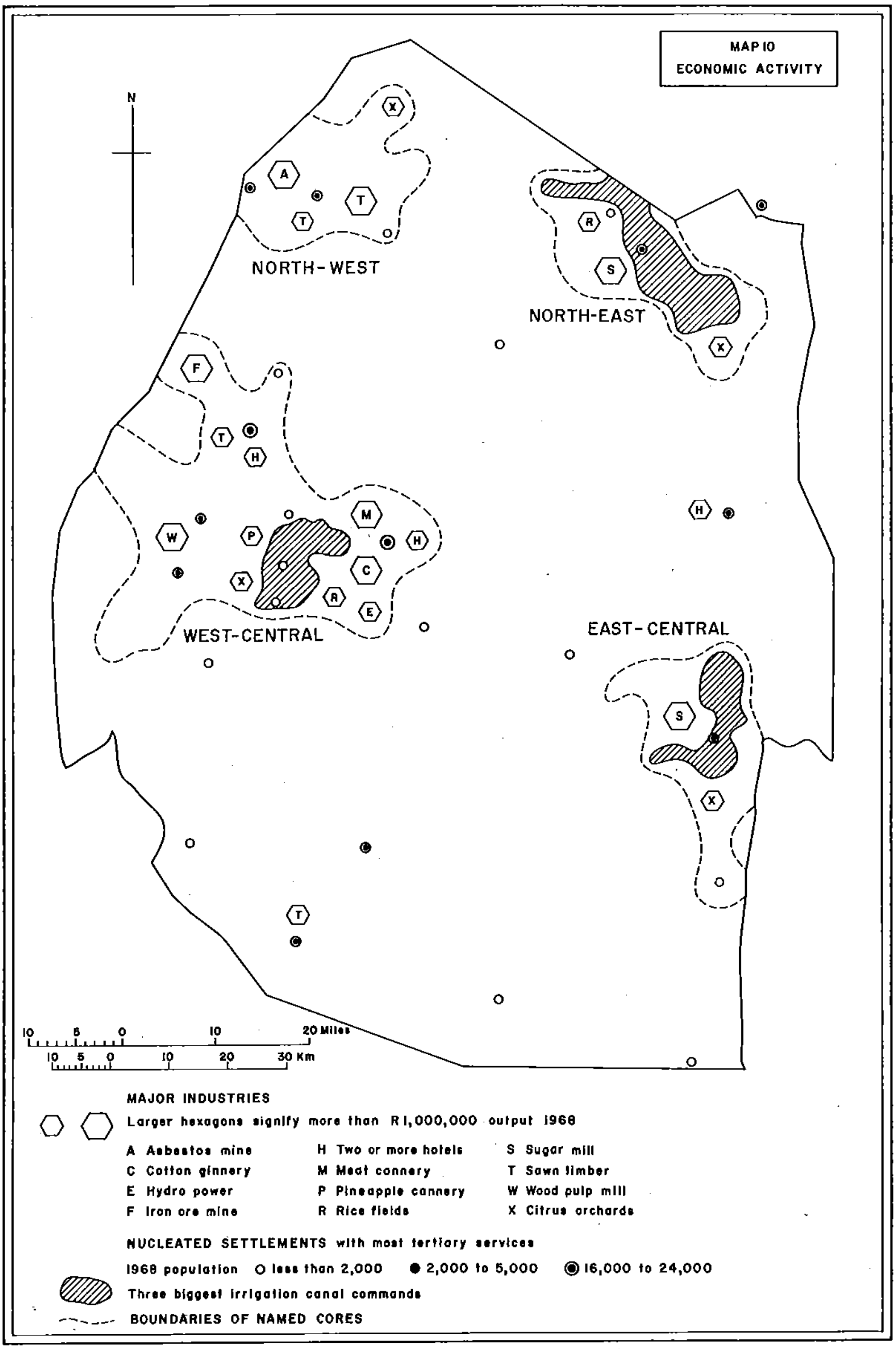

MAP 10
ECONOMIC ACTIVITY
N
NORTH-WEST
NORTH-EAST
WEST-CENTRAL
EAST-CENTRAL
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
MAJOR INDUSTRIES
Larger hexagons signify more than R1,000,000 output 1968
A Asbestos mine
C Cotton ginnery
E Hydro power
F Iron ore mine
H Two or more hotels
M Meat cannery
P Pineapple cannery
R Rice fields
S Sugar mill
T Sawn timber
W Wood pulp mill
X Citrus orchards
NUCLEATED SETTLEMENTS with most tertiary services
1968 population ○ less than 2,000 ● 2,000 to 5,000 ◉ 16,000 to 24,000
Three biggest irrigation canal commands
BOUNDARIES OF NAMED CORES

TABLE 16

Cores and Periphery

		POPULATION IN 1966	SQUARE MILES (a)	DENSITY PER SQUARE MILE	PRODUCTION (b)
Primate Core:	West-Central	55,000	510	104	19
Subsidiary Cores:		37,000	580	63	21
	North-West	14,000	190	74	7
	North-East	13,000	190	68	7
	East-Central	10,000	200	50	7
Four Cores		92,000	1,090	84	40
Periphery		300,000	5,630	53	5
TOTAL		392,000	6,720	58	45

	Nucleated Settlement			Dispersed			
	POPULATION IN 1966	SQUARE MILES	DENSITY PER SQUARE MILE	POPULATION IN 1966	SQUARE MILES	DENSITY PER S.M.	NUCLEATION (c)
Primate Core	40,000	60	670	15,000	450	33	72%
Subsidiary Cores	15,000	30	500	22,000	550	40	41%
Four Cores	55,000	90	610	37,000	1,000	37	60%
Periphery	20,000	60	330	280,000	5,570	50	7%
TOTAL	75,000	150	500	317,000	6,570	48	19%

TABLE 16 – Continued

NOTES:

(a) As in Table 15, the areas here (measured on the 1:125,000 Soil Map) diverge from those of, in this case, Fair et al (1968) who give 1,030 square miles of Cores: West-Central 420: North-West 160: North-East 210: East-Central 240. The first two exclude corridors to Kadake and Ngonini which are deemed exclaves. The last two take in much ordinary ranchland. Their Periphery covers 5,670 square miles. Again the differences are traceable to delimitation by EAs, for convenience, on the part of Fair et al.

(b) Million rands in 1966 of agroforestal products, minerals and manufactured goods – from Fair, Murdoch and Jones (1968).

(c) Percentage nucleated out of total (nucleated plus dispersed) population.

of the opinion that there the Preconditions occupied the period 1820-1933, the Take-Off 1933-1945 and since then the Drive to Maturity has been in progress. It in turn is succeeded by the Age of High Mass Consumption, just attained in North America, according to Rostow. Swaziland may thus be less than 40 years behind South Africa: this is of course an economic, not a political time-scale.

Table 16 brings out demographic and economic features of these five zones and may be read in conjunction with Tables 32 and 54 wherein their soils and land capability classes are listed. Change is inherent in the Core-Periphery concept. Before 1938 none of the flanking resource-rich tracts aspired to Core status. The Lowveld outposts have done so only in the past decade. Which parts of the Periphery will be the next to join a Core? Will Cores coalesce? What are the chances that a fifth Core comes into being, and where? Pointers in these directions are made on pages 274 and 275.

Chapter 2

SOILS

Survey, Classification and Geographical Distribution

SOIL SERIES AND SOIL SET:

Soil surveying in Swaziland started in the 1950s with the discovery and identification of the fundamental units in pedological taxonomy, soil series. D'Hoore (1965) calls the series "the lowest conceptual soil category of the genetic classification". A standard definition during the early years of Swaziland soil work was that of Kellogg et al (1951): "The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile ... and developed from a particular type of parent material. The soils within a series are essentially homogeneous in all soil profile characteristics ... and in such features as slope, stoniness, degree of erosion, topographic position and depth to bedrock". The gaps in this quotation referred to permissible textural variations which have since been discarded as unsound, or unnecessary to stipulate, by soil surveyors, including the Americans themselves.

Series classification systematizes information about real soils occurring in nature, of course, but it became confusing to use the same word for a volume of say 20 cubic yards of soil in situ as for a descriptive account of all like soils over hundreds of square miles. The useful terms pedon, as defined by Smith et al (1960), and polypedon – Simonson (1962) – clarify this issue. A few square yards with one series is one pedon and a larger single area where variation does not transgress allowable limits for that series is one polypedon.

Other amendments of Smith et al (1960) narrow the concept in that neither rock without pedogenetic differentiae nor attributes of terrain, such as slope and landform element, nor anthropomorphic features in soils are considered by them to be adequate criteria for establishing series. This authoritative edict, which began to be implemented in the United States and elsewhere, would have served to reduce the number of previously defined series in areas with complete or near-complete soil survey coverage had it not been for further fissiparous decisions taken since, and dealt with by Kellogg (1967): an example is discussed on page 150. The fast-moving pedological scene will undoubtedly revolve so that yet more changes in the thinking about series result.

But Swaziland's soils had already been mapped before the 1967 modifications in America were published. It will be one task for the future to assess their full implications. Indeed not until 1963 did the writer consciously seek to restrict recognition of new series to soils that satisfied the stringent 1960 pedological terms of reference. None of the 90 series found prior to that date has been discarded, but several marginal cases of "redundancy", for example among those series originally ascribed exclusively to the Lubombo Range, have been reinvestigated and the soils assigned diagnostic properties emphasizing their internal not external characteristics. Should it be warranted, joining series together in the future will be a relatively easy matter.

Notwithstanding the embargo when defining series, there is no interdiction on using landscape terminology in explanatory references to them, e.g. Alicedale series never occurs in the Lowveld but Canterbury series almost invariably does, and Bona series occupies a lower river terrace but no other geomorphological site.

When mapping, the coincidence of many series with particular landforms has been exploited to draw soil boundaries. In Swaziland as elsewhere, however, a polypedon of a series rarely covers as much as 10 acres and the customary inclusions, to a maximum of 15% or 20% of the area, are made of other soils within the demarcated limits of a series. More than about 20% of different soil requires the mapping of a soil complex or mosaic, if a few readily distinguishable series are concerned (these devices have not been needed often in Swaziland), or of a higher-level soil cartographical unit.

Similar and/or sequential series may be arranged taxonomically in various ways. The soil family is a purely pedogenetic grouping, while the soil association or catena stresses pedoclimatic and slope-soil relationships among series between crests and valley bottoms. The family is no more easily mapped than its constituent series and associations or catenas, while in many places not hard to delineate, usually include such divergent soils that the user of maps so produced must be wary in interpreting them.

Both these perfectly sound concepts were considered at an early stage (1956) of soil geography in Swaziland, but were rejected for mapping — though not necessarily for classification purposes — in favour of the soil set as envisaged by N.H. Taylor and I.J. Pohlen and their colleagues of the New Zealand Soil Bureau (1954).

A Swaziland Soil Survey set is a straightforward assemblage, in mappable form, of (a) soil series that are alike in their morphology and in the practical use that can be made of them and (b) other geographically associated soils — either named series within the set, or fragments of other known series, or pedons representing no defined unit — which may be very different but cannot, at the scale employed, be indicated separately.

The aim has been to keep head (b) to a minimum and often (a) accounts for 70% to 80% of the area designated as one set. The kindred series are usually pedogenetically related but, it must be emphasized, need not be — for instance, both calcareous and noncalcareous series occur in some sets where the lime content is subordinate to other features, such as Lithosol status or presence of a pan.

Because Swaziland soil sets are tools of applied pedology their definition is incomplete without an allusion to the reasons for which they are mapped. Conceivably sets comprising different ranges of series could be erected for specific users — irrigators, dryland farmers, ranchers, builders, road engineers ... archeologists, potters, dental caries specialists. In fact, however, the first Swaziland amalgamations of series, made in terms of their irrigability, have proved of value in so many other dealings, from assessing the potential for raingrown crops to making valuations of land expropriated for public purposes, that they have been allowed to stand without alteration: the simpler solution but, when one contemplates alternatives, probably the wiser.

In Mozambique there is a growing interest in soil sets, but the country nearest Swaziland which has a national soil map showing sets is Lesotho. There, the essence of the explanation by Carroll and Bascomb (1967) states that "sets are flexible groupings of soils with like profiles: they can be broadly defined in terms of a modal soil and variations from it — Taylor and Pohlen (1962)". The main difference between the Lesotho and Swaziland approaches has been that their 1:125,000 soil map contains sets, associations of sets and units that are given names not at set level but higher in the Lesotho soil hierarchy. Rather than sets, associations are mapped by the Republic of South Africa pedologists. Loxton and M'Vicar (1965) propose that they resolve the series ambiguity by talking and writing of mapped series as consociations.

RECORD OF SOIL CARTOGRAPHY:

In Swaziland individual soil series have been indicated on detailed and some semi-detailed soil maps, notably by Baillie (1968). Most published or otherwise reproduced semi-detailed maps show soil sets, with series noted only on original field sheets, often aerial photographs at about twice the linear scale of the final maps. Soil sets, without reference to series even during fieldwork, are the map legend units for reconnaissance surveys, while soil groups or other high-order categories of classification are portrayed on both exploratory maps, made from only a few observations, and national sketch maps (in the context of Swaziland, fitting a foolscap page) whose compilation entails generalizing all more intensive studies and elsewhere extrapolating, guided by exploratory mapping.

The density of field inspections and final map scales appropriate to the various types of soil surveys are illustrated at Maps 11 to 14, in whose captions numbers of examinations of the soil and scales overlap generously, for no hard and fast rules can be made on these matters. Complexity of the soil pattern and purpose of the survey govern choice of pit or augerhole sites. Gratuitous exposed profiles in road and rail cuttings or along gullies and bluff banks are of course investigated. Four or five feet depth of soil is normally studied at each site, and on research plots routine borings are sunk to seven feet.

Soil survey travel has varied from foot traverses, for detailed mapping, and journeys by Landrover fitted with a tenth-mile trip speedometer, to sorties by light aircraft with the object of filling in blanks on reconnaissance and exploratory maps, representing areas inaccessible to vehicles, such as Makotangeni and, until recently, most of the Assegai valley floor downstream to Elwandeni. The soil survey team normally comprises the writer and P. Bembe, field assistant since 1955, with one to three other members. Resident soil surveyor colleagues have been I.C. Baillie (1965-1968) and J.P. Andriesse (1958-1960).

Geometric grids have been used to select observation sites in the case of many detailed surveys (for all research plots a square pattern with 50 yards north-south and east-west between each augerhole was adopted) and on reconnaissance too if gently sloping open grassland or parkland was known to cover the whole area concerned. Usually, however, reconnaissance is a matter of following roads, tracks and the cattle-trails or sled-paths which criss-cross most areas, making occasional detours from them.

Field sheets are aerial photographs at scales between 1:2,000 (these being enlargements) and 1:40,000. The country has twice been completely flown (black-and-white) at approximately 1:30,000 contact scale, in 1947 and 1961. The quality of the latter photographs is so excellent that resolution is not impaired until X8 linear enlarging. In addition the 1:50,000 topocadastral maps produced by E. Murdoch (1963) have proved invaluable for plotting set boundaries during the National Soil Reconnaissance, especially when reduced photographically — see further on pages 78 and 79.

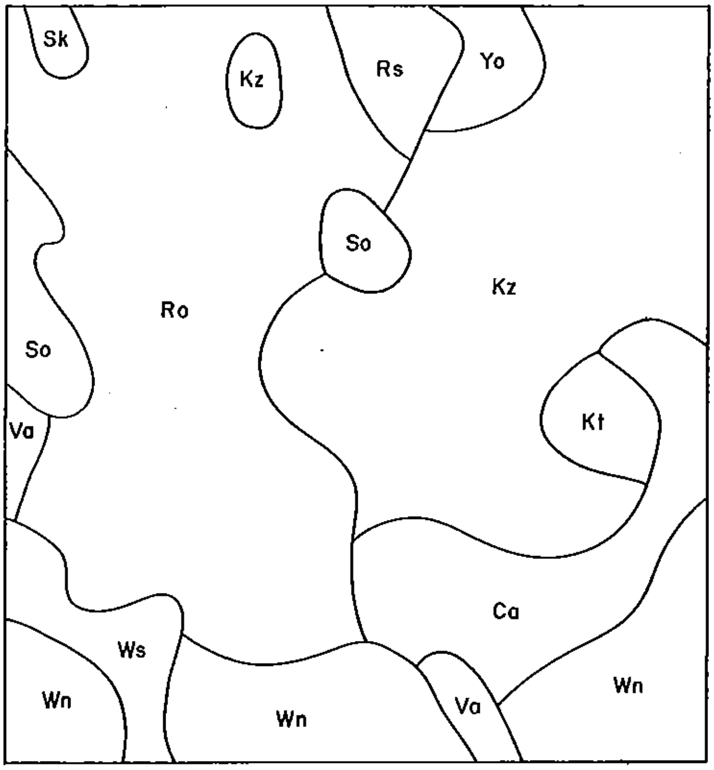
The topocadastrals incorporate all the high-standard physical information, notably 50 feet contours and every minor stream and drainageline, printed on the 1:50,000 Directorate of Overseas Surveys (1955-1960) official topographic maps, whose Second Editions began to appear recently. Geological Survey maps have also been available, within the range of 1:20,000 to 1:100,000 scale, as an aid and all other large-scale cartography that comes to hand is consulted. Estate plans have made soil mapping in the manmade forests and on sugar farms a speedy, locationally very accurate procedure. For the use of colour air photography see pages 150 to 152.

Soil samples have to date been taken for analysis at about 1,400 places, a mean of one

To page 78

MAP II

DETAILED SOIL SURVEY



Mapping Unit SERIES or Phase of Series

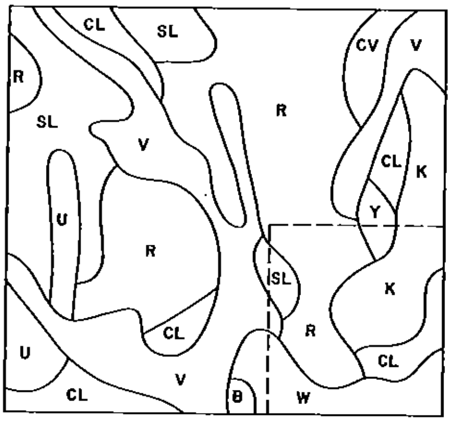
Inspections one per 0·5 to 60 acres

Scales 1:2,000 to 1:40,000

Example above — Series on 0·5 square mile of Ubombo (R9) at 1:12,000

MAP 12

SEMIDETAILED SOIL SURVEY



Mapping Unit SET or (if pattern simple) Series

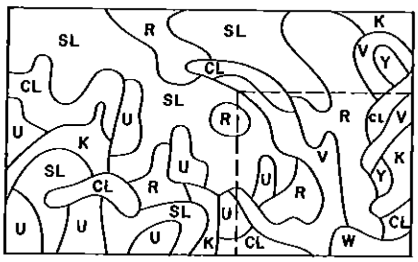
Inspections one per 30 to 400 acres

Scales 1:20,000 to 1:100,000

Example, left — Sets on 3 square miles at 1:50,000 — Dashed lines mark Map 11

MAP 13

RECONNAISSANCE SOIL SURVEY



Mapping Unit SET

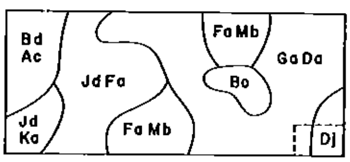
Inspections one per 0·3 to 4 square miles

Scales 1:60,000 to 1:250,000 — Kellogg et al (1951) take this kind of mapping to 1:500,000 — Nosin and Petrov (1965) cite 1:100,000 to 1:300,000 as "medium"-scale.

Example, left — Sets on excerpt of 10 square miles from the accompanying 1:125,000 Soil Map — Dashed lines mark Map 12

MAP 14

EXPLORATORY SOIL SURVEY



Mapping Unit GROUP or other broad division

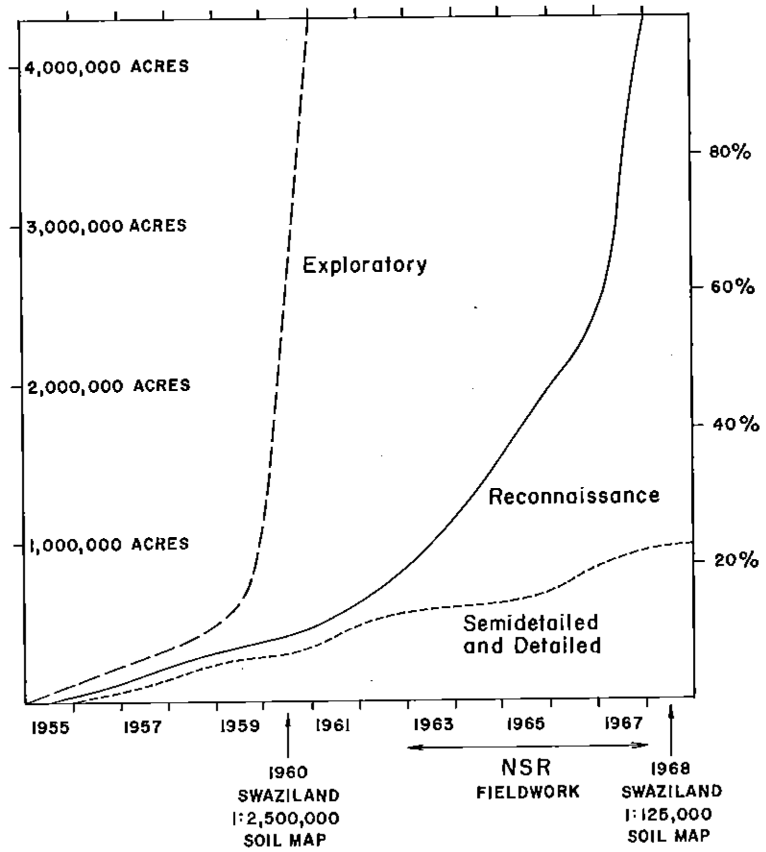
Inspections one per 2 to 100 square miles

Scales 1:100,000 to 1:8,000,000 plus

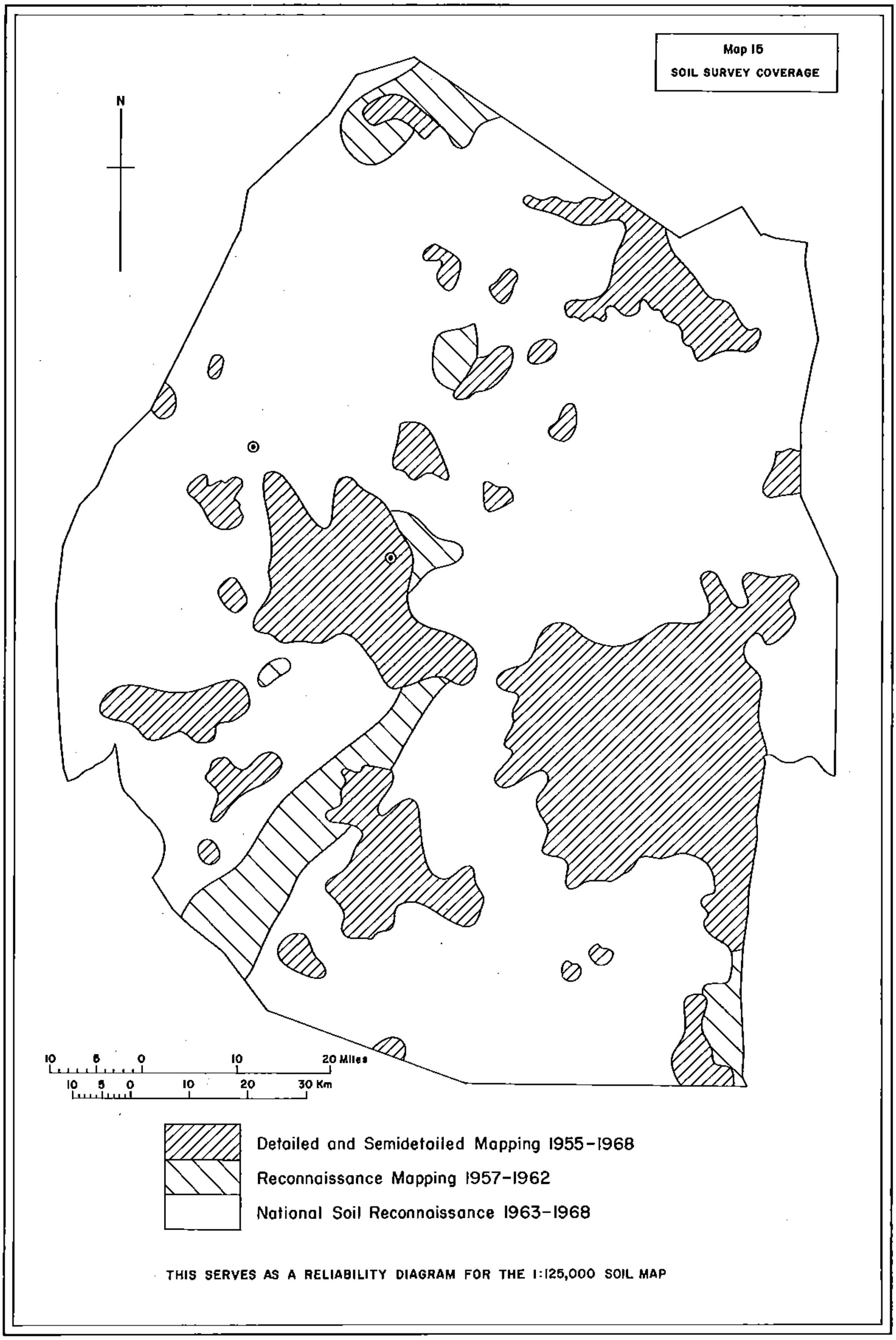
Example, left — Groups on excerpt of 200 square miles from Map 16 at 1:1,000,000 — Band across whole of Lowveld — Dashed lines mark Map 13

FIGURE 7

Chronological Chart of Soil Surveys



NSR = National Soil Reconnaissance.



Map 15
SOIL SURVEY COVERAGE

THIS SERVES AS A RELIABILITY DIAGRAM FOR THE 1:125,000 SOIL MAP site per 3,000 acres, excluding experiment panels for which P. Jackson and L.A. Whelan have since 1964 analysed many hundred additional samples at Malkerns Research Station laboratory. Before the chemistry section at Malkerns was operational, organizations in Britain, the Republic of South Africa and Holland had tested about 1,200 samples. Determinations done in Swaziland total 1,300 and in connection with crop yield correlations treated on pages 223 to 245 another 1,400 specimens of soil were analysed from 1965 to 1967 by African Explosives and Chemical Industries, Johannesburg. On pages 127 to 150 results of these supporting studies are summarized and commented upon. Without them interpreting soil maps of all scales, and judging the value to the user of each unit mapped, would be much more difficult.

The rate of progress achieved in producing soil maps is indicated at Figure 7, and Map 15 gives the coverage of each kind of survey – detailed, semidetailed, reconnaissance.

The first phase of pedological investigation (1955-1958) saw the completion of a semidetailed survey in the Lower Usutu Basin (South) and involved the establishment of 40 soil series in 16 soil sets, as described in the memoir by Murdoch and Andriesse (1964). There was then a period (1958-1960) devoted to exploratory surveys over the rest of Swaziland, definition of another 35 series, increase in the number of sets to 28 and the evolution of land capability classes for farm and regional planning. This was followed by the production of national sketch maps (1960-1963), initially at the very small scale of 1:2,500,000 – a contribution to the Soil Map of Africa by D'Hoore (1964) – then at 1:1,000,000. The latter scale was used for both soil groups (see Map 16) and broad land capability zones.

Simultaneously a proliferation of detailed studies, the vast majority unpublished, took place to meet requests by developing estates and by extension staff responsible for agricultural improvement schemes in portions of Swazi Area. In 1960 the number of these small surveys done was 17, in 1961 there were 20, in 1962 – including remapping in great detail at research stations – 25 and in 1963 another 18. This and later ad hoc mapping has been undertaken free of charge, the only requirement from the farmers being that they have the necessary soil pits dug. Their active interest both at the survey stage and subsequently in reporting on crop performance in relation to specific soils and Land Classes has been extremely gratifying and has kept soil survey in Swaziland geared to practical agricultural needs and problems.

NATIONAL SOIL RECONNAISSANCE:

The years 1963-1965 witnessed the inception of the National Soil Reconnaissance (NSR) as a result of which the sets over the whole country have been identified to fill the accompanying 1:125,000 Soil Map. In areas outside the 570,000 acres having detailed and semidetailed soil surveys at the start of the NSR there were several alternative lines of action open, namely:

(a) Utilize existing reconnaissance maps. These covered in 1963 about 240,000 acres, mostly around Manzini and in the Lomati and Assegai valleys, the latter partly observed from the air. They could be adapted easily to show soil sets in exactly the same way as in the later reconnaissance mapping.

(b) Plan future detailed surveys so that gaps in coverage – especially areas expected to be of high potential agriculturally – could be plugged as far as possible. This was achieved very satisfactorily in the Usutu basin, where from 1965 to 1967 detailed and semidetailed mapping by I.C. Baillie added over 200,000 acres to the 570,000 mentioned above: reference Baillie (1968). With his minor surveys beyond the Usutu watersheds and the writer's more intensive mapping during the same years 900,000 acres or 21% of

Swaziland had detailed or semidetailed soil maps by the time NSR fieldwork finished in 1967, as shown on Map 15.

(c) Do reconnaissance work on an "even-spread" system, trying to keep the density of soil observations fairly constant over wide swathes of country. This meant frequent excursions off Landrover tracks, but was accomplished throughout Shiselweni District, with the help of B. Gumede and his associates at the Goedgegun extension office, and also across the Lowveld in a broad band from Lukhula (L9) to Dumezulu (M7), all round Nkambeni (F7) Hill – aided by CDC agronomists on ranchland eastwards – and in a few other zones, together making just under 1,500,000 acres by the end of 1966. The 1:30,000 air photos were taken along, but normally field sheets were topocadastral reductions at about 1:75,000. It was extremely valuable in 1967 to treat likewise land belonging to the main pine tree growers, at their request. The 200,000 acres surveyed at Usutu Forest, Peak Timbers and Ruby Creek (E3) greatly increased knowledge of Highveld soils.

(d) Spot soils by plane. The cost ruled out helicopter sorties and even fixed-wing aircraft runs were strictly limited by funds available. But an hour of low circling and weaving over an area adjacent to one already mapped meant at least 10,000 more acres with soil sets demarcated. Assegai valley ground checks revealed that accuracy of the surveying was reasonable, so two main blocks were flown, centred on Ngomane (G8) and Gundwini (N5), some 60,000 acres in all.

(e) Traverse all roads and the faster tracks. Immediate environs of every route not examined under previous heads were thus charted: possibly 500,000 acres. Topocadastral reductions to 1:100,000 were used.

(f) Gather data relating to the soil sets at "points" – usually fields. The 350 maize and cotton demonstration plots 1957-1966, with soils sampled by local extension personnel, were all plotted.

(g) For the rest, interpret air photos. This was necessary in 1967-1968 to do away with the remaining "holes" in the 1:125,000 map. Few portions of the colour aerial photographs (see page 150) were left blank after (a) to (e), therefore essentially this consisted of examining the now-familiar patterns on the 1961 black-and-white 1:30,000 contact prints. By subtraction, nearly 1,000,000 acres fall in this residue, but it includes a high proportion of rocky and poor land and few patches of either developed or as yet undeveloped first class soil.

Because of the various methods used to arrive at the 1:125,000 Soil Map the complexity of boundaries and of interlocking parcels of land mapped might be expected to vary from one section of it to another. However, without sacrificing too much detail regarding best known areas, every effort has been made to smooth out this uneven effect and to give prominence to intricate, indented soil patterns only where they obviously are in character. Conversely lack of boundaries means that a simple array of sets exists and not, in general, that such expanses were unvisited.

Upon the scale of a soil map, as of any other, depends the minimum size and breadth of areas that it is convenient to show. At 1:125,000 the object is to depict single occurrences of a soil set (or Land Class) down to about 40 acres in extent: 20 acres cannot be portrayed, with legibility of the colour chip. The minimum constriction or ribbon of one mapped block that can be indicated is about 130 yards wide at 1:125,000 – less than one millimetre – although for any sinuous fairly long distance 160 yards is perhaps the limit. Some bottomland strips and a few thin belts of soil elsewhere have been distorted to permit their delineation as separate parcels, but normally any alien soils less than 100 yards wide have been combined with or apportioned among neighbouring sets.

With the NSR, the writer's share of soil mapping in Swaziland rose to 92% or 3,940,000 acres. The contributions of others, mostly in detailed and semidetailed surveys, so mere acreage is an inadequate measure of their worth, comprise 220,000 acres by I.C. Baillie; 80,000 acres by J.P. Andriesse; and in the northern Lowveld 60,000 acres by Kockott (1958). Tanis (1960), Harris (1961), Vincent and Hawkins (1965).

Along the country's borders good agreement has been registered with the few soil maps, at scales of 1:500,000 or larger, which impinge – i.e. those of Myre and Ripado (1953) and Barradas (1962) on the Mozambique frontier and of Beater (1962) at Pongola, from Onverwacht (Z7) to Zulu (Z8). Maud (1966) draws comparisons between Transvaal Lowveld sugar cane soils and Swaziland series.

BROADER SOIL MAPPING UNITS:

To provide a frame of reference into which Swaziland's soil sets and series fit, and to introduce and briefly discuss some of the pedological terms used later in this Chapter, the relevant higher mapping units of the Soil Map of Africa are described below. From 1958 to 1963 the author, with about 70 other soil cartographers, contributed material to J.L. D'Hoore, Director of the Service Pédologique Interafricain (SPI – at Yangambi, Congo and later Ghent, Belgium) for incorporation in his African map. A version at 1:25,000,000 was published in 1960 and the 1:5,000,000 edition appeared in 1964 as the culmination of CCTA-FAO Joint Project Eleven.

D'Hoore (1964) states that "so far as it has been feasible the elements of the legend are separated by genetic criteria" and the Soil Map of Africa key, though not strictly a taxonomic catalogue, gives the best, most harmoniously acceptable current descriptions of the continent's main soils. The Achilles heel of the classification is, however, its deliberate vagueness, which Young (1968) singles out for attack in an otherwise sympathetic critical essay.

The soil groups and subgroups of Van Der Merwe (1940) have not proved difficult to assign to SPI mapping units – see Van Der Merwe (1962). The system of Gouveia and Azevedo (1955) also fits well. Both these pedologists were participants in the soil survey of Angola, whence the first report volume by Botelho Da Costa et al (1959) was of great significance to soil classification in Africa – see also page 83.

Aspects of the American "Seventh Approximation" to a soil classificatory system – Smith et al (1960) and Kellogg (1967) – are treated mainly on pages 146-150 and 156-167. Parts of it are not especially useful in Swaziland (nobody claims that they should be), but the stimulus of the many new pedological ideas is most salutary.

The confusion that has arisen in tropical and subtropical soil studies owing to indiscriminate bandying about of vocabulary borrowed from temperate zones is to be deplored. Perhaps the worst example still extant is horizon nomenclature. A and B and C in the original Russian connotation – Glinka (1927) – or in pre-1960 American parlance simply do not apply to many Swaziland soils. For want of better-known expressions they are used on suffrance at places hereafter, more particularly where ambiguity is least likely to result.

Much less anomalous codes for horizons by Whiteside (1959) and Fitzpatrick (1967) will probably not, because of their very thoroughness and prolixity, come into ordinary use: but the compromise proposals of Van Baren et al (1967) could do so. Their interim report mentions three new master horizons – to add to what they call the "traditional" A B C O R – namely E (eluvial) and G (gleyed) and K (calcareous). The G would resuscitate that of Vysotski (1931) more or less. In addition a manageable total of 20 explanatory suffixes is provided. Because this is still a draft plan, however, it too is eschewed here. Naming Swaziland soil horizons must await the final list of approved international designations.

Because the classification of D'Hoore (1964) does not set out to be absolutely comprehensive it is not surprising to find that some Swaziland soil series cannot be comfortably accommodated in his framework. But the number of incompatible misfits is gratifyingly low. Much commoner is failure to place a soil squarely in an SPI group (i.e. to classify it as an "orthic" member) but success in describing it as an "intergrade" between two groups, or very rarely among three. This comes about because soil is a continuum and a criterion that proves good for distinguishing 4 out of 5 pairs of soils (of polypedons that is) may be a central, characteristic of both the fifth pair. It may even in some instances not be stretching the interpretation of observed facts to affirm that a certain soil is "ABC intergrade to DEF" as against another which is "UVW intergrade from XYZ". There are examples of both on pages 105 to 126. An "extrograde" to non-soil is a further possibility. But the simplest link "intergrade" used adverbially is neutral and safe and more frequently resorted to. In the event, niches are found for all named series.

Taken in the same order as that of D'Hoore (1964) the kinds of soil mapped in Swaziland are as follows. The writer's comments and minor amendments to definitions, for use locally, are indicated in parentheses.

A – RAW MINERAL SOILS:

Bare rock and rock debris: indurated materials, either "solid" or broken down by mainly physical processes to coarse rubble.

Aa – Rock rich in ferromagnesian minerals. Separated from other geological formations as they are potentially excellent sources for plant nutrients. (Comprise in Swaziland outcrops of dolerite and occasionally basalt, gabbro, amphibolite, serpentinite, epidiorite; usually there is interstitial soil between loose spheroidally-weathering dolerite boulders).

Ab – Ferruginous Crust. Secondary deposits in various materials, e.g. weathering products of rocks or accumulation horizons of paleosols or alluvium, enriched with residual or imported sesquioxides and subsequently indurated: main binding agents are crystalline iron oxides. (Intact cuirasses of this nature are rare in Swaziland).

Ac – Rock, undifferentiated. Granite or gneiss predominantly throughout Africa. (The generalisation holds good in Swaziland, plus ignimbrite. Outcrops in situ are commoner than scree or talus. Intermittently hollows or crevices are filled by soil, either autochthonous or, in valley bottoms, transported. It is unclear whether the SPI unit permits mingled soil, coarse detritus and rock or not. The mixture is very common throughout Swaziland, except in parts of the Lowveld, and because all of it is put into this group for area measurement purposes (Figure 9 refers) an overestimate of the percentage of Raw Mineral Soils, vis à vis the very small subcontinental share, may well have resulted).

B – WEAKLY DEVELOPED SOILS:

These have in common a low level of profile development, reflected in lack of strong differentiation between horizons. Since the map legend item Ba – Lithosols on lava – is absent from Swaziland it does not appear here. Likewise all other irrelevant soil groups are omitted.

Bb – Lithosol on rock rich in ferromagnesian minerals. Solid substratum is within 30 cm (12 inches) of the soil surface. Usually, in Africa, on moderate to steep slopes of subhumid to semiarid regions. (Mostly derived from dolerite in Swaziland, sometimes the other basic rocks mentioned under Aa. Even where soil is 18 or 24 inches deep there may be no horizonation other than perhaps a more humic top, so doubling the extreme depth limit for this unit locally could be recommended. The mode for Swaziland examples is 9 to 15 inches of solum. However, it must be admitted that with more than 7 to 10 inches soil there are often clues as to which more developed group the profile is tending towards, and the range from Lithosol intergrade Vertisol to Lithosol intergrade Fersialitic Soil is encountered).

Bc – Lithosol on Ferruginous Crust. Hard iron pan lies within 30 cm (12 inches): this soil from cuirasse debris is mapped only between latitudes 17^{o} north and south. (In Swaziland products from weathering of sheet ironstone tend to be removed downslope and accumulations of soil on iron pans are either colluvial or in other ways not strictly lithosolic: nonetheless, they are placed here, grading into Sol Lessivé or Fersialitic Soil or a Kaolisol).

Bd – Lithosol, undifferentiated. Again solid rock must be within 30 cm (12 inches) of the land surface. (Usually quartzose in Swaziland, so depths exceeding 30 inches are perfectly feasible, as with the Ranker soils of Europe which have no counterparts in the SPI list: almost trebling the stipulation of 12 inches could be advocated, to provide a necessary link with the Regosol category: the skeletal elements from coarse parent materials certainly give rise to transitional forms between Bd and Bh. Remarks made under Bb regarding trend of profile development apply in this case also, and Lithosol intergrade Fersialitic Soil or Lithosol intergrade Kaolisol are distinguishable among well-drained profiles: in addition, where the gradient becomes more gentle, less runoff and more percolation induce a degree of hydromorphism, either ordinary (of bottomlands) or planosolic, if slopes are long and wide enough – as in parts of the Lower Middleveld and Western Lowveld).

Bh – Regosol. This one-word description is after Marbut (1923) and others: the SPI calls the group "Weakly developed soils on loose sediments not recently deposited" and maps as such many areas with ancient littoral sand dunes. (Very deep profiles high in coarse particles and yet without clear pedogenetic horizons are admissible too: they are derived in Swaziland from arenaceous rocks – thick quartz veins, siliceous grits, even fine-sandy sediments. See La and Lk below for Ferralitic Soil intergrade Regosol).

Bo – Juvenile Soil on river and lake alluvium. Parent material is heterogeneous and still being deposited intermittently: D'Hoore (1964) notes that "the absence of well-developed horizons is mainly due to brevity of the soil-forming period". (Very little is lacustrine, almost all fluviatile in Swaziland. Moreover fortunately rather uniform accumulations on each of several river terraces are the rule, as against the complexes of randomly stratified drifts reported from much of Africa. Note that only well-drained alluvium is dealt with here: marshy valley floors come into N Hydromorphic Soils).

C – CALCIMORPHIC SOILS:

Influenced by the presence of large quantities of relatively soluble calcium compounds, notably carbonate and sulphate: have an appreciable amount of free lime at all depths and high bivalent cation contents in the exchange complex, with mainly 2:1 lattice clay minerals such as montmorillonite.

Ca – Rendzina. Classed in the Seventh Approximation order of Mollisols, so characterized by thick dark surface layer with narrow carbon-nitrogen ratio. (Whether Swaziland possesses these soils sensu stricto is debatable: however, Lithosol and Vertisol groups contain members that may be described as intergrade to Rendzina).

D – VERTISOLS:

The dark top at least 20 cm (8 inches) thick is nevertheless usually low in organic matter. Calcareous accumulations are frequent, permeability is poor, effects of mechanical reworking are discernible (dry season cracks, slickensides, maybe gilgai relief) and structural units are coarse blocks or prisms, unless there is "self-mulching" at the surface. Normally weatherable mineral reserves are good, clay minerals are 2:1 and cation exchange capacity (CEC) is high and more than half base-saturated. (SPI has not used the term Sialitic Soil, applied to Vertisols by Botelho Da Costa et al (1959) to complete the neat succession they describe as one proceeds from wet to fairly dry tropical regions – Ferralitico, Fersialitico, Sialitico – and to serve as a reminder that in Vertisols no silicon has been lost, iron is unobstrusive and montmorillonite and allied minerals are not broken down to simpler constituents. Thompson (1965) confines Sialitic to unleached soils other than Vertisols).

Da – Lithomorphic Vertisol from rock rich in ferromagnesian minerals. Definition as above: lateral displacement by solifluction is permitted, so the actual underlying rock may not be basic. (Basalt and dolerite areas of Swaziland, especially in the Lowveld. Surface soil usually granular and seldom crusty under natural vegetation, i.e. Regur of Dudal (1963) rather than his Margalite).

Db – Lithomorphic Vertisol from calcareous rock. Definition as above. (Exceedingly uncommon in Swaziland).

Dj – Topomorphic Vertisol. In lowlying depressions where sluggish external drainage aggravates effects of internal impermeability. (Colluvial-cum-alluvial accretions of gully wash in Swaziland, for the most part Lowveld: may be higher up than bottomlands if there has been very recent rejuvenation. Vertisol intergrade Solodized Solonetz is the main transitional form).

F – PSEUDOPODZOLIC SOILS:

Ostensibly the horizonation is of ABC type, with the surface layer containing less than 20% clay clearly or abruptly separated at 40 to 90 cm (15 to 36 inches) depth from a textural B with twice (or more) the topsoil's amount of clay and an exchange complex that is more than half base-saturated. Kaolinite and illite are the chief clay minerals and mottles or iron concretions may occur.

Fa – Sol Lessivé. Developed in subhumid temperate climatic regions. (Swaziland representatives are all influenced by colluviation and hydromorphism: moreover they are almost confined to Western Lowveld pediments, definitely subtropical. This puts the alternative SPI designation of "Highveld Pseudopodzolic" out of court. Loxton (1960) invented the term and is currently attempting to repeal it, for not only Swaziland but also Natal and the Cape Province have good examples of soils virtually identical to those on the Transvaal Highveld Plateaux. Carroll and Bascomb (1967) prefer the unadorned Claypan Soil. Equally brief, Duplex Form is used by Aircraft Operating Company Technical Services (1967): briefest of all is the old portmanteau Planosol of e.g. Thorp and Smith (1949). Colloquially in Swaziland this group, the Solodized Solonetz which interdigitate with it and the Lithosols on Ferruginous Crust are called "Two-Deck Soils". Finally, the relationship to Sol Lessivé in France, Canada and elsewhere is nebulous).

G — BROWN AND REDDISH BROWN SOILS OF ARID AND SEMIARID REGIONS:

Darkened by organic matter which is, however, small in quantity (usually less than 1% carbon). Contain appreciable amounts of 2:1 clays and weatherable minerals and often free lime. The CEC is medium to high, more than half base-saturated in the subsoil.

Gb — Brown Soil (intertropical). Generally mean annual rainfall is less than 20 inches, though basic parent rock or impeded external drainage favour Brown Soil's development in moister areas. Organic matter content is low but well distributed down the profile. (Soils of brown or red colour from basalt and dolerite in the Lowveld belong either to this category or to Jb Fersialitic Soil. There are also some intergrades to Eutrophic Brown Soil and connections with Lithosols and Vertisols. Murdoch and Andriesse (1964) equate Swaziland representatives to Krasnozems of Afanasiev (1928), Rotlehms of Vageler (1930), Brunigra of Gibb et al (1952) and soils that Milne (1936) describes as Nonlaterized Red Earths).

H — EUTROPHIC BROWN SOILS:

Rich in humus and plant nutrients, mean annual rainfall 28 to about 67 inches. Often relatively young soils either on alluvium or in rejuvenated valleys. Sand and clay mineralogy and base status are comparable to head G above.

Hb — Eutrophic Brown Soil on rock rich in ferromagnesian minerals. Limited to undulating terrain. (Basic parent materials in the Swaziland Middleveld and Highveld give rise to such soils on occasion, usually associated with Ferrisols: but the onset of degradation is rapid and soluble constituents are leached out to produce Ferralitic or at best Fersialitic Soils in most localities. Lowveld transitions to Brown Soil have already been noted).

J — FERSIALITIC SOILS:

Alternative name Sols Ferrugineux Tropicaux: the shorter anglicization from Fersialitico is adopted here. Clay mainly kaolinite and CEC rather low, though subsoil base saturation exceeding 40% is normal. Frequently separation of free iron oxides leads either to their removal from the profile or to their precipitation as spots or concretions. Depth is seldom more than 250 cm (about 8 feet) to solid rock.

Ja — Fersialitic Soil on loose sediment. Sandy parent material begets a solum without marked textural changes. (Some alluvium along Swaziland's biggest rivers may well have reached this pedogenetic stage).

Jb — Fersialitic Soil from rock rich in férromagnesian minerals. Alteration of parent material and consequent liberation of iron may cause pan formation within the profile. (Commonest per se in the moister Lowveld: under drier conditions grades toward Brown Soil or lies adjacent to Lithomorphic Vertisol).

Jc — Fersialitic Soil from crystalline acid rock. More quartz and less clay than the preceding: easier leaching may allow textural B horizon to appear. (Bd Lithosol intergrade Jc covers much of the Lower Middleveld. Older landscapes are in wetter areas so Kaolisols rather than Fersialitic Soils are found and "pure" Jc profiles that are permeable have a restricted distribution, almost entirely below 1,500 feet altitude).

Jd — Fersialitic Soil, undifferentiated. Association with various kinds of Lithosol is widespread. (Ditto in Swaziland. Mixing of parent material, due to basic dykes and veins within Western Lowveld granite or gneiss masses, encourages formation of soil that is intermediate in its features between Jb and Jc: this is best accommodated here. For Red Ferralitic Soils that have some Fersialitic attributes see under Ln).

K and L – KAOLISOLS:

Useful term which is not part of the SPI nomenclature but was coined by Sys (1958) to embrace all soils at or proceeding towards the final end-point of intense weathering and leaching within the humid tropics. As D'Hoore (1964) remarks on page 102 the nature of the parent rock becomes much less important at and beyond this juncture in the sequence of map units. Kaolisols are virtually confined to the Upper Middleveld and Highveld).

K – FERRISOLS:

These soils whose development is retarded by youth are distinguished from more mature Ferralitic neighbours by stronger structure, higher base status and greater fertility. The climate is wetter than the average for Eutrophic Brown Soil: otherwise pedogenetic factors in respect of both are similar. Kaolinite usually dominates the clay fraction and the reserve of weatherable minerals seldom reaches 10% of the fine sand. CEC exceeds 15 milliequivalents per 100 grams (me) in subsoil clay, which is less than half base-saturated.

Ka – Humic Ferrisol. With more than 2% organic carbon in the surface layer to 10 cm (4 inches). Recorded mostly in the equatorial belt of Africa above 5,300 feet altitude. (Uncertain correlation with some Upper Middleveld soils).

Kb – Ferrisol on rock rich in ferromagnesian minerals. Chemically the closest of Ferrisols to Fersialitic standards. (Observed here and there in small pockets of the Upper Middleveld and Highveld, frequently just below or amid bouldery Aa terrain. Eutrophic intergrades occur).

Kc – Ferrisol, undifferentiated. At lower elevations than Ka, but still normally in rolling or steep country. (There are important occurrences of soils answering this description in most respects wherever Upper Middleveld parent material is "intermediate" (see pages 15 and 16) and the topography favourable, notably on retreating slopes working fairly rapidly back, often through colluvial deposits, to more resistant crests. Passage from Lithosol or to Ferralitic Soil is postulated for marginal members of this unit).

L – FERRALITIC SOILS:

Most extensive batch of map legend units, excepting Desert and Semidesert, in Africa. Often very deep with diffuse transitions between horizons that are only slightly differentiated. No clay skins coat subsoil aggregates and consistence is normally friable, porous: the 1:1 lattice clays predominate and gibbsite is common. Little or no weatherable mineral reserve. The CEC of the clay is nearly always less than 20 me, not more than 40% base-saturated. (Deeply emplaced stonelines often act as indicators in Swaziland, particularly for Ln – see below. Many Upper Middleveld and Highveld soils 60 or more inches thick, resting on quartz stonelines, have undergone ferralitization. These "pebble markers" – so named by Jennings and Brink (1961) – may be multiple, with junctions and partings. Very deepset ones are seemingly geomorphic features, not attributable to faunal action. But the presence of stonelines of the latter type, almost certainly formed very much as Nye (1954) outlines, is also suspected – more so in Ferralitic than in other soils. Any shallow stoneline, whose upper surface is encountered by 50 cm (20 inches) depth, must at least in part result from selective sifting by ants, termites etc. of fine earth).

La – Yellow Ferralitic Soil on loose sediment. Topsoil is poor in humus: less than 15% clay below one metre (39 inches) depth. (In acid rock districts of the Upper Middleveld and Highveld this group is present, if deeply preweathered rotten saprolite can be counted as "loose sediment" – in such cases has Regosol as well as Ferralitic affinities. However, Swaziland possesses none of this kind of soil on sediment in the normal sense of laterally moved material).

Lc – Yellow Ferralitic Soil, undifferentiated. Often forms in the debris of ancient cuirasses. (Lower retreating slopes of Swaziland's high rainfall areas are mantled by Yellow Ferralitic Soil, and intergrades to Bd Lithosol have been noted. Distinctive "Yellow-on-Red Ferralitic" profiles with the colours merging at 18 to 36 inches depth could be included here or at Ln; they are usually higher up the catena than plain yellow Lc soils).

Lk – Red Ferralitic Soil on loose sediment. Munsell (1954) colour chart 5YR or redder, otherwise the La criteria hold good. (Coarse acid rocks with sporadic basic intrusions in the Highveld engender soils of this type, not very different save in hue from La: also intergrade Regosol. Last sentence of La paragraph applies here too).

Lm – Red Ferralitic Soil from rock rich in ferromagnesian minerals. Clay content is generally high: unlike other Ferralitic Soils these frequently exhibit a structural B horizon. (Rare in Swaziland, but carried by e.g. Usushwane gabbro where unadulterated with more siliceous material: confined to the Highveld).

Ln – Red Ferralitic Soil, undifferentiated. Often in reworked, local transported lixivium that has been affected by several pedogenetic cycles and may date from Early Tertiary, or previous, erosion surfaces: typically high in the present-day topographic sequence. (The specification that bases should not exceed 40% of exchangeable cations needs to be modified for soils with particularly low CEC values – less than 8 or 7 me per clay fraction – which are nonetheless dominated by calcium and magnesium rather than hydrogen: conventional methods of describing base status have neglected the aluminium ion and Leroux (1965) believes this may be the cause of these discrepancies: the soils concerned look and behave as if they were Ferralitic. Middleveld intergrades to Fersialitic Soil are fairly common, and in the classification of Francophone Africa many would fit among Sols Faiblement Ferralitiques – Aubert (1964). There are also, infrequently, Lithosolic counterparts of these normally very deep Ln profiles).

Ls – Humic Ferralitic Soil. As with Ka Ferrisols, more than 2% organic carbon in the top 10 cm (4 inches) is stipulated. (Sizeable areas of Swaziland soils already mentioned, especially at Lc and Lm and Ln, qualify for this category but the writer is loth to separate them at the prescribed humus content: it is close to their mode rather than being at a "slack" in the continuum, which is where good boundaries between soils should be. To equate these with profiles having 5% to 7% of carbon, truly Humic Ferralitic, seems unwise. Aubert and Segalen (1966) put the threshold at 7% organic matter or about 4% organic carbon – arguably a more realistic figure).

M – HALOMORPHIC SOILS:

Morphology is mainly due to the presence in the profile of soluble salts and/or exchangeable sodium to an extent that nutrient imbalance and physiological drought adversely affect the metabolism of vegetation other than halophytes.

Ma – Solonetz and Solodized Solonetz. These two groups are listed for convenience in one SPI cartographic unit. Sodium accounts for more than 15% of the CEC in part or all of the textural B horizon. The surface layer is generally alkaline in the case of the unleached Solonetz, but acid in Solodized Solonetz, which is desodifying from the top downwards. (The latter is common in the Western Lowveld, associated with Sol Lessivé upslope. Where sodium fails to reach 15% of T value in the sandy clay subsoil there is the option to classify as a Vertisol influenced by halomorphism and, usually, colluviation).

Mb — Saline Soil and Alkali Soil. Again grouped for ease of mapping, the former have salt concentrations exceeding 4 mmhos* while throughout the latter the sodium adsorption ratio is over 15%: combination gives Saline-Alkali Soil. (Both Saline Soil and, less frequently, the combination are found in the Swaziland Lowveld, entirely manmade as a result of irrigation malpractices: happily the total area of Mb remains small, however).

N and O — OTHER SOILS:

Na — Mineral Hydromorphic Soil. Influenced by permanent or seasonal waterlogging but not a Vertisol. Gleyed in at least one horizon. (Outside the Lowveld this takes the place of Topomorphic Vertisols along most stream banks. In the dissected landscapes concerned there is normally a very clearcut division between bottomland and other soils. Lithosol and other intergrades occur. Furthermore Sol Lessivé has a claim to relationship with seasonally damp Na soils).

Nb — Organic Hydromorphic Soil. Over 18% carbon, or 12% if sandy: usually papyrus or bango-reed swamps in Africa. (The only Swaziland approximations are confined to a few Highveld vales above 3,700 feet altitude where fen peat has built up from old sedge and water-grass beds).

Oa — Mountain and hill peat. Not hydromorphic but like Nb contains more than 18% organic carbon, or more than 12% if sandy. (Measurable — but usually square yards rather than square miles — on and near Highveld granite tors above 4,000 feet).

EXPLORATORY SOIL MAPS TO 1963:

The provisional compilation at 1:1,000,000 scale which was intended to show the SPI units of 1963 is reproduced here, as Map 16. The key refers to J.L. D'Hoore's fourth draft and there are a few minor differences from the final (sixth draft) legend outlined above. A synthesis of this small-scale vignette — which clearly could now, after the NSR, be much improved — and the 1:125,000 Soil Map of sets will be a useful future Swaziland Soil Survey undertaking.

Earlier Murdoch (1961) had issued a very tentative 1:2,500,000 representation of SPI third draft units (7 are shown compared with 14 names on Map 16 and the 33 that make up the list above), along with single-value diagrammatic maps showing isopleths of pH in water and of organic matter, both for topsoils. When drawn these last two were thought of as "correct" only in a highly generalized manner. With the same limitation — serious enough — it can be said that further researches have not invalidated either of them.

WAYS IN WHICH SETS AND SERIES WILL BE DESCRIBED:

To date 107 soil series in 34 soil sets have been identified in Swaziland. Very few, if any, new sets remain to be distinguished within the self-imposed bounds (see page 72) of grouping series primarily according to irrigability. At least 25 additional unnamed series are known to exist but they cover tiny areas and can safely be disregarded in this thesis.

To page 93

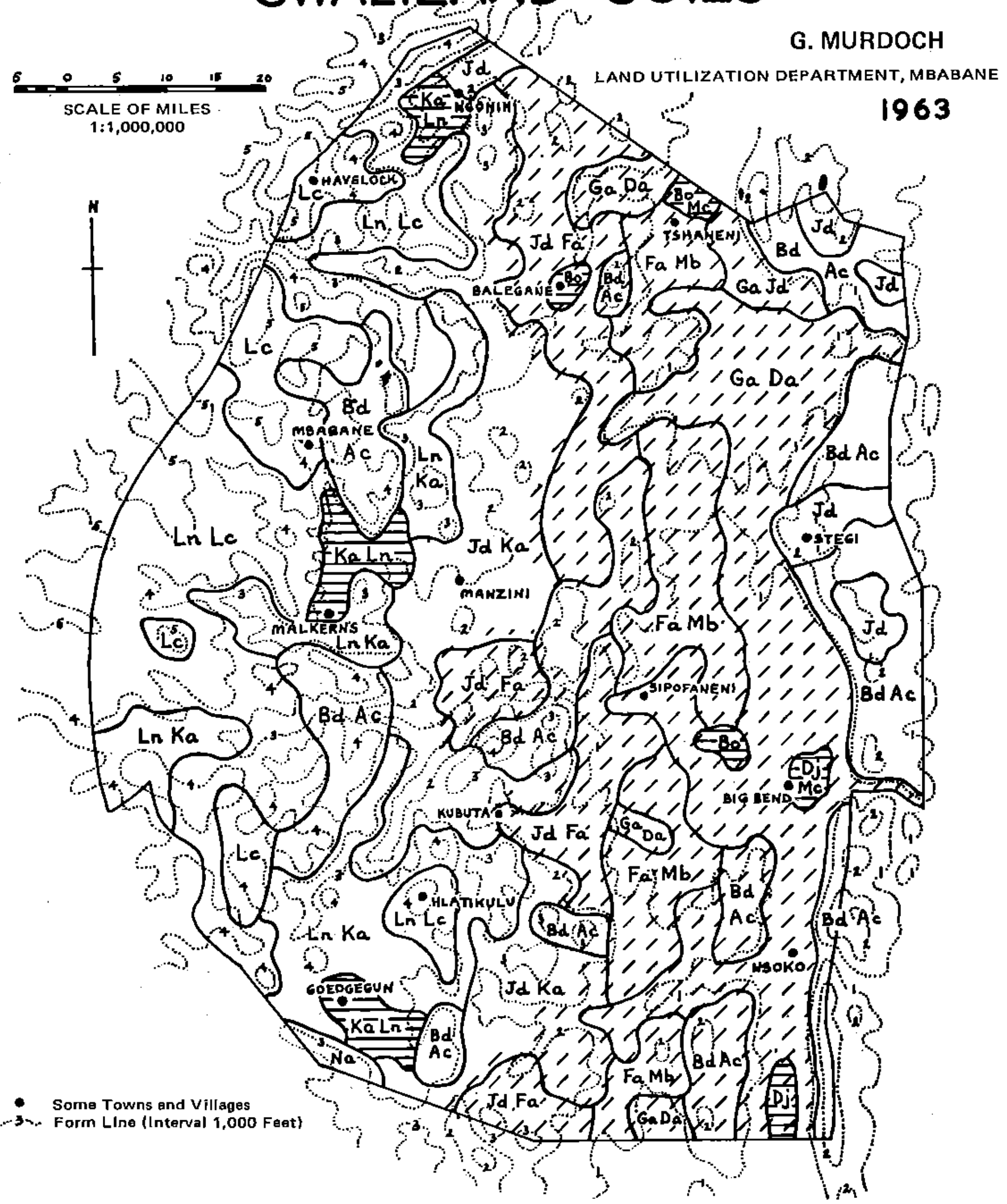
*Millimhos per cm at 25°C — electrical conductivity of the saturation extract.

Map 16

SWAZILAND SOILS

G. MURDOCH
LAND UTILIZATION DEPARTMENT, MBABANE

1963



NOMENCLATURE (Soil Map of Africa, Legend to the 4th Draft)

Ac	Rock and Rock Debris	Jd	Fersiallitic Soils
Bd	Lithosols (Skeletal Soils)	Ka	Kaolisols — Ferrisolic
Bo	Juvenile Soils — Alluvium	Lc	Kaolisols — Yellow Ferrallitic
Da	Vertisols — Lithomorphic Origin	Ln	Kaolisols — Red Ferrallitic
Dj	Vertisols — Topographic Depressions	Mb	Halomorphic Soils — Solodized
Fa	Sols Lessives (Pseudopodzolic)	Mc	Halomorphic Soils — Saline
Ga	Red-brown Soils of the Subarid Tropics	Na	Mineral Hydromorphic Soils

Rock outcrops (Ac) and Lithosols (Bd) absent or rare: elsewhere common.

Bottomland Hydromorphic Soils usually calcareous, often Vertisols (Dj).

Numbers of Swaziland Soil Series
in Soil Map of Africa Units

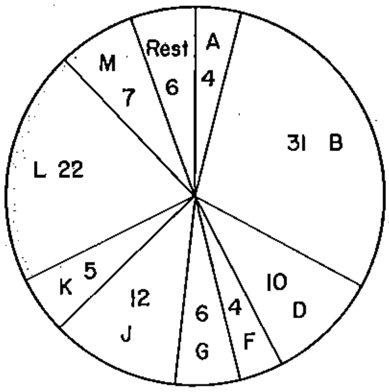


FIGURE 8.

% Areas of Swaziland Soil Series
in Soil Map of Africa Units

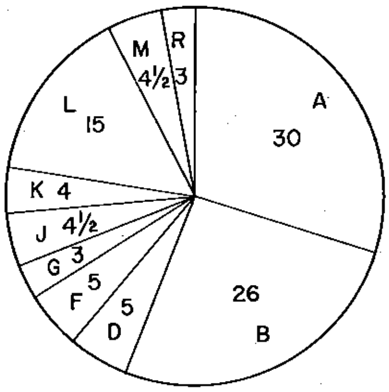


FIGURE 9

% Areas of SPI Units in Mainland Africa
South of Equator – from D'Hoore (1964)

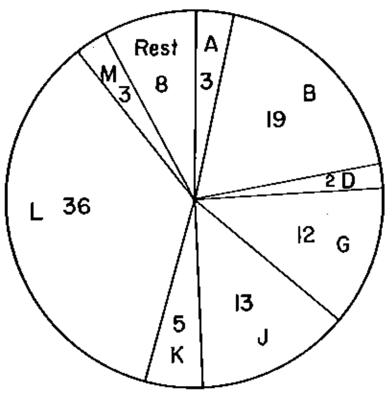


FIGURE 10

FIGURE II

Swaziland Soil Series – Whether Orthic in SPI Groups or Intergrade

Orthic here means belonging wholly to one
of the Soil Map of Africa groups cited below

KEY TO NUMERALS

1+2=3

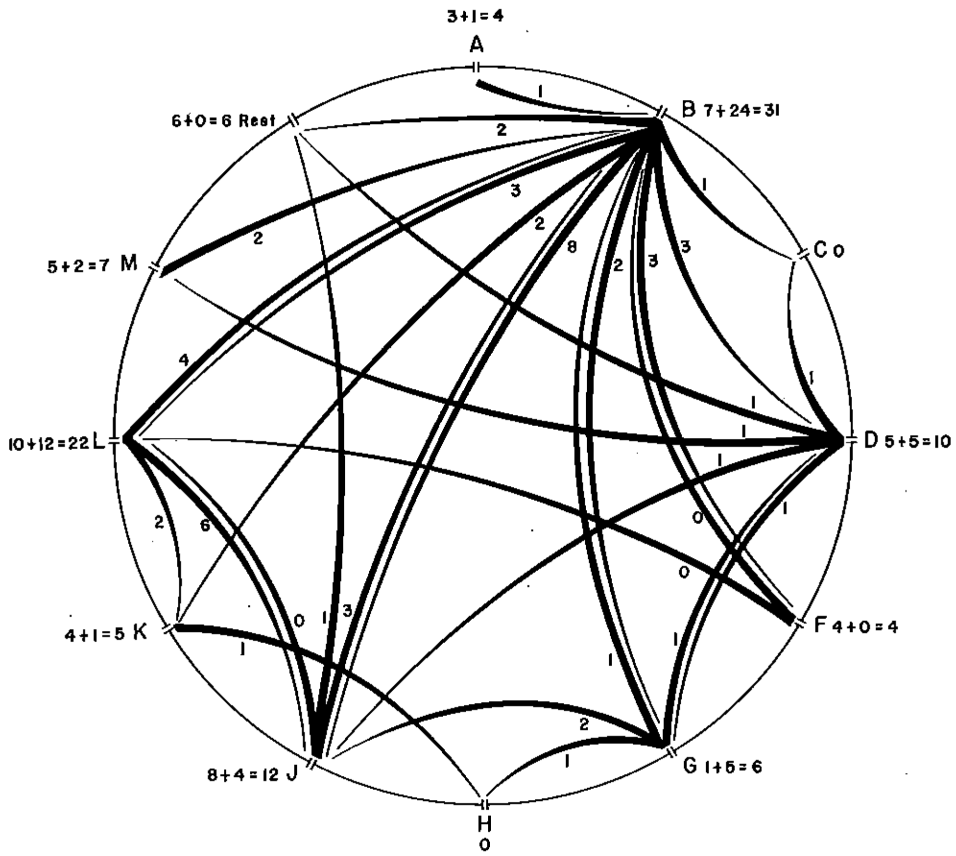
No. of series which are orthic

No. of series which are intergrade

Total no. of series in group

X —— Y
This soil would be in X group
but intergrade towards, or
perhaps from, Y group

In circle O = unnamed series



ALL SERIES 53 Orthic + 54 Intergrade = 107 Total

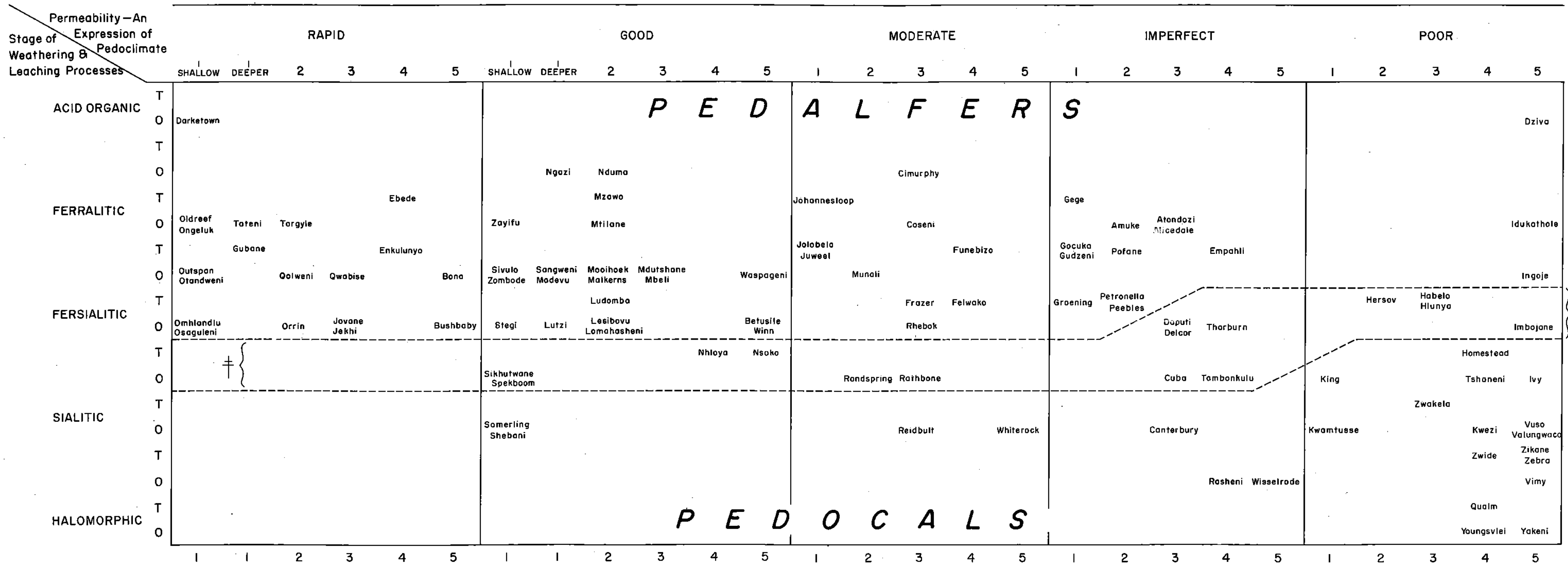
KEY TO GROUPS

A Raw Mineral Soils
B Weakly Developed Soils
C Calcimorphic Soils
D Vertisols
F Pseudopodzolic Soils
G Brown Soils
H Eutrophic Brown Soils
J Fersialitic Soils
K Ferrisols
L Ferrallitic Soils
M Halomorphic Soils
Rest Gleys + Organic Soils

FIGURE 12

SWAZILAND SOIL SERIES — RELATIONSHIPS BETWEEN PEDOGENESIS, PERMEABILITY AND GEOMORPHOLOGY.

Note: The modal placings of series are shown: some may span a range, especially of positions on short slopes, so filling many apparent gaps in the grid.



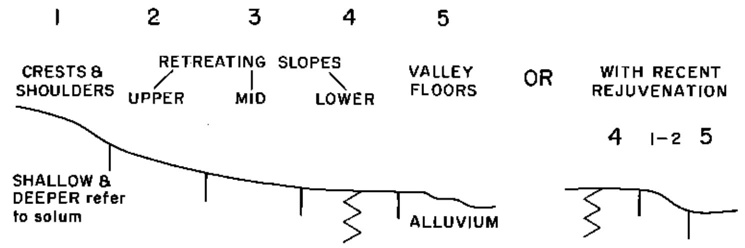
T = Two Deck

O = Other KINDS OF HORIZONATION

╪ PEDALFER — PEDOCAL TRANSITION BELT

Series excluded: Gongola, Ungabolima, Umbeluzi, Upcountry and Xulwane.

USUAL TOPOGRAPHIC SITUATION



NUMBER OF SERIES (TOTAL HERE 102)

PEDALFERS.....64	SITE 1 SHALLOW...15	PERMY. RAPID.....19
PEDOCALS.....23	1 DEEPER*....15	GOOD.....27
TRANSITIONAL.....15	2.....19	MODERATE.....14
	3.....19	IMPERFECT.....19
TWO-DECK.....30	4.....15	POOR.....23
	5.....19	

*All/soils with moderate to poor drainage are included.

Soil sets are designated by letters* of the alphabet, plus in 16 cases qualifying regional names, e.g. C (Highveld) and C (Lowveld), which may when convenient be shortened to e.g. CH set and CL set. Series within each set begin with the same letter. This serves well as a mnemonic but means that several series do not follow the tradition of being called after place-names. Series nomenclature has been popularized within Swaziland at every opportunity, and many progressive farmers know and use the series names relevant to their own fields.

The series are arranged in order of Soil Map of Africa units on the next few pages, and Figures 8 to 11 summarize the distribution revealed. About half the series are in two broad groups, Weakly Developed Soils and Ferralitic Soils, but in terms of area Raw Mineral Soils surpass them. Half the series are orthic, as far as one or other of the broad groups is concerned, the remainder being intergrades between them: the orthic acreage is however 64% of the total, thanks mainly to the considerable extent of rocky land, all classified as Raw Mineral Soil.

Another way of representing relationships between the series, not only pedologically, in the narrow sense, but also as regards their position in the landscape is afforded by Figure 12, which brings out the enormous range in soil chemistry and morphology, from Darketown to Yakeni series across the diagram. Catenary links and the preponderance of noncalcareous series (pedalfers) are also well portrayed.

None of the distillations of soil series features made up to page 96 is precise or comprehensive enough to permit their identification by someone new to Swaziland or not versed in the local soil survey's history and activities. For such a person, geographer or interested layman, the analytical key at pages 96 to 102 has been constructed, on the same lines as the conventional guides to botanical genera and species. The only esoteric ability needed to use the key are familiarity with horizonation and soil texturing and an appreciation of region and subregion boundaries. Reading the key in conjunction with Figure 12 is advised.

The most adequate presentation of soil sets may well be in alphabetical order: this is done on pages 105-126, which are also an index to series. The definitions of sets, which it will be recalled are not necessarily pedogenetic entities, have more value than the very concise data regarding series in the index.

The modal characteristics and ranges in morphology of 40 principal series are the subject of lengthier accounts, with full profile descriptions as recommended by Kellogg et al (1951) and Crompton (1960), which may be consulted in Murdoch and Andriesse (1964) or Baillie and Murdoch (1968). For the remaining series, whose total area is only about one quarter of Swaziland, excluding U set terrain, the information given in the alphabetical index is considered a sufficient guide to both profile features and other significant properties.

Soil analyses have helped enormously in placing series in or between Soil Map of Africa units. For the 52 most-tested series, with from 3 to 66 sampled profiles (from 4 to 88 topsoils) each, the data dispersed among pages 105-126 are collated and discussed on pages 127 to 146, special reference being made there to inherent soil fertility.

SERIES LISTED ACCORDING TO SOIL MAP OF AFRICA UNITS:

Reference D'Hoore (1964)

Aa – Rock rich in ferromagnesian minerals: UPCOUNTRY series (intergrade Ac)
Ab – Ferruginous Crust: GONGOLA series (intergrade Bc)

*Unrelated to letters used for SPI units on pages 81 to 87.

Ac – Rock, undifferentiated: UNGABOLIMA series (with pockets of sedentary soil): UMBELUZI series (with pockets of colluvial-alluvial soil): see also Aa (Upcountry series)

Bb – Lithosol on rock rich in ferromagnesian minerals: SOMERLING series (intergrade Ca): SHEBANI series (intergrade Da with lime pan): SPEKBOOM series (intergrade Da without lime pan): SIKHUTWANE series (intergrade Gb): STEGI series (intergrade Jb)

Bc – Lithosol on Ferruginous Crust: GOCUKA series (greyish intergrade Fa): GEGE series (greyish intergrade Lc): GROENING series (reddish intergrade Jd): GUNZENI series (reddish intergrade Kc): GUBANE series (intergrade Bh): see also Ab (Gongola series)

Bd – Lithosol, undifferentiated: OTANDWENI series: ORRIN series (greyish coarse sandy intergrade Jc): OSAGULENI series (reddish coarse sandy intergrade Jd): OMHLAND-LU series (fine sandy intergrade Jd): OUTSPAN series (intergrade Kc): OLDREEF series (intergrade Lc): ONGELUK series (intergrade Ln): PEEBLES series (intergrade Fa with stoneline): PETRONELLA series (intergrade Fa without stoneline): POFANE series (intergrade Na): see also Jd (Frazer and Lutzi series), Lc (Zayifu series), Ln (Zombode series) and Ma (Zwakela series)

Bh – Regosol: ENKULUNYO series (sandy): EBEDE series (gravelly): EMPAHLI series (intergrade Na): see also Bc (Gubane series), Jc (Jovane series), La (Torgyle series) and Lk (Tateni series)

Bo – Juvenile Soil on river and lake alluvium: XULWANE series (flood plain gravel): BONA series (lower terrace, coarse sandy): BUSHBABY series (lower terrace, fine sandy): BETUSILE series (lower terrace, medium texture intergrade Ja): WISSELRODE series (upper terrace, heavy texture intergrade Dj): WHITEROCK series (upper terrace, with lime pan, medium texture intergrade Gb): WASPAGENI series (upper terrace, with pebble beds, medium texture intergrade Ja): WINN series (upper terrace, without lime or pebbles, medium texture intergrade Ja): see also Gb (Nsoko series), Ma (Zebra series), and Na (Ingoje and Ivy series)

Ca – Rendzina: see Bb (Somerling series) and Da (Canterbury series)

Da – Lithomorphic Vertisol: KWEZI series: KWAMTUSSE series (with lime pan): KING series (with surface leached): CANTERBURY series (intergrade Ca): CUBA series (intergrade Gb): TAMBANKULU series (intergrade Jb): TSHANENI series (intergrade Na): see also Bb (Shebani and Spekboom series) and Gb (Rasheni series)

Dj – Topomorphic Vertisol: VALUMGWACO series: VUSO series (with leached surface): VIMY series (intergrade Mb): see also Bo (Wisselrode series)

Fa – Sol Lessivé: HERSOV series (coarse sandy surface, abruptly on grey and red sandy clay pan): HABELO series (coarse sandy surface, abruptly on grey and yellow sandy clay pan): HLUNYA series (fine sandy surface, abruptly on sandy clay pan): HOME-STEAD series (transition from surface horizon to sandy clay pan more gradual): see also Bc (Gocuka series) and Bd (Peebles and Petronella series)

Gb – Brown Soil: NHLOYA series (colluvial sandy top): NSOKO series (alluvial Bo sandy top): RASHENI series (intergrade Da): REIDBULT series (intergrade Hb): ROND-SPRING series (intergrade Jb): RATHBONE series (intergrade Jb with more hydrated iron oxides at depth): see also Bb (Sikhutwane series), Bo (Whiterock series) and Da (Cuba series).

Hb – Eutrophic Brown Soil: see Gb (Reidbult series) and Kb (Sangweni series): may also be related to Gb (Rondspring and Rathbone series)

Ja – Fersialitic Soil on loose sediment: see Bo (Betusile, Waspageni and Winn series)

Jb – Fersialitic Soil from rock rich in ferromagnesian minerals: RHEBOK series: see also Bb (Stegi series), Da (Tambankulu series) and Gb (Rondspring and Rathbone series)

Jc – Fersialitic Soil from acid crystalline rock: JEKHI series: JOVANE series (intergrade Bh): DELCOR series (yellow with soft iron pan, heavy texture intergrade Jd): DAPUTI series (yellow with soft iron pan, light texture intergrade Jd): see also Bd (Orrin series)

Jd – Fersialitic Soil, undifferentiated: LESIBOVU series: LOMAHASHENI series (humic top): LUDOMBA series (colluvial sandy top): LUTZI series (intergrade Bd): FELWAKO series (with soft iron pan): FRAZER series (with soft iron pan, intergrade Bd): THORBURN series (intergrade Na): see also Bc (Groening series), Bd (Osaguleni and Omhlandlu series), Jc (Delcor and Daputi series) and Ln (Mooihoek, Mzawo, Mdutshane, Funebizo, Jolobela and Juweel series)

Kb – Ferrisol on rock rich in ferromagnesian minerals: MADEVU series (red): SIVULO series (orange or yellow): SANGWENI series (dark brown intergrade Hb)

Kc – Ferrisol, undifferentiated: MALKERNS series: MUNALI series (with subsurface compact layer of heavy texture): see also Bc (Gudzeni series), Bd (Outspan series) and Ln (Mbeli series)

La – Yellow Ferralitic Soil on loose sediment: TORGYLE series (intergrade Bh): possibly Lc (Ngazi series) substratum would qualify as "loose sediment"

Lc – Yellow Ferralitic Soil, undifferentiated: QWABISE series (gravelly): ATONDOZI series (light texture with soft iron pan): ALICEDALE series (medium texture with soft iron pan): AMUKE series (medium texture without pan): NDUMA series (very deep, yellow on red intergrade Ln): NGAZI series (not so deep, yellow on red intergrade Ln): ZAYIFU series (intergrade Bd): see also Bc (Gege series) and Bd (Oldreef series)

Lk – Red Ferralitic Soil on loose sediment: TATENI series (intergrade Bh)

Lm – Red Ferralitic Soil from rock rich in ferromagnesian minerals: COSENI series (intergrade Kb): CIMURPHY series (black top, so in appearance intergrade Ls)

Ln – Red Ferralitic Soil, undifferentiated: QOLWENI series (gravelly): JOHANNESLOOP series (with thick stoneline): MTILANE series (with thin stoneline): MOOIHOEK series (intergrade Jd), MZAWO series (intergrade Jd with colluvial sandy top), MDUTSHANE series (intergrade Jd with more hydrated iron oxides, sandy loam), MBELI series (intergrade Kc with more hydrated iron oxides, clay loam): FUNEBIZO series (intergrade Jd with soft iron pan): JOLOBELA series (intergrade Jd with thick stoneline, gravelly): JUWEEL series (intergrade Jd with thick stoneline, not gravelly): ZOMBODE series (intergrade Bd): see also Bd (Ongeluk series) and Lc (Nduma and Ngazi series)

Ls – See Lm (Cimurphy series): several other Ferralitic Soils are marginal to this unit: discussion about humus on page 86 refers.

Ma – Solonetz and Solodized Solonetz: QUALM series (Solonetz): ZWIDE series (Solodized Solonetz): ZWAKELA series (Solodized Solonetz intergrade Bd): ZEBRA series (Solodized Solonetz with alluvial Bo sandy top): ZIKANE series (Solodized Solonetz intergrade Mb)

Mb – Saline Soil and Alkali Soil: YOUNGSVLEI series (from Vertisols): YAKENI series (from Na Mineral Hydromorphic Soils): see also Dj (Vimy series) and Ma (Zikane series)

Na – Mineral Hydromorphic Soil: IDUKATHOLE series (light texture): IMBOJANE series (heavy texture, at waterholes and wallows): INGOJE series (heavy texture, fluviatile Bo origin): IVY series (heavy texture, lacustrine Bo origin): see also Bd (Pofane series), Bh (Empahli series), Da (Tshaneni series) and Jd (Thorburn series)

Nb -- Organic Hydromorphic Soil: DZIVA series

Oa – Mountain and hill peat: DARKETOWN series

ANALYTICAL KEY TO SWAZILAND SOIL SERIES:

Procedure: To identify a soil profile in a vertical cut to rock (or at least to about 150 cm depth), read Categories I to V and place the soil in the first appropriate bracket, e.g. a bottomland with discontinuous soil mantle will be I and not III: then within the chosen category examine descriptions, again in numerical order, until one that fits is encountered.

Cm are used in the key and in the index on pages 105 to 126. In fact the metric system would have been employed throughout this memoir – e.g. for altitudes, areas and climatic elements – were it not that local opinion favours the old units.

For the terms "fersialitic" and "ferralitic" see pages 84 and 85 respectively: furthermore soil reaction, as measured in the field, is a reasonably good guide. Diagnostic horizons of most Ferralitic Soils in Swaziland are in the range pH 4.0 to pH 5.5 whereas for most Fersialitic Soils the range is pH 5.5 to pH 6.8 – laboratory determinations of pH in water confirm.

Iron concretions and iron pan can be either "soft" or "hard" i.e. respectively penetrable or impenetrable by vigorous roots: this is roughly equivalent in the case of iron pan to perforable or not pierced by a Jarrett auger of 10 cm bore. A soil lacking free lime is a "pedalfer" while a "pedocal" is visibly calcareous: "pedalfer-pedocal transition" means traces of free lime may be detectable.

Soil colours are after Munsell (1954) except for rare tints and replacement of their "yellowish red" by "orange" – much as Oyama et al (1967) advocate.

The word "usually" followed by a region or subregion name means that about 70% to 100% of the area covered by the series is in the zone concerned, whereas "often" means about 50% to 70% is in that physiographic division. Regional abbreviations are as in Table 2.

Although intergrades between SPI units cannot be avoided, it is assumed that intergrades between series can. They will be identifiable for discarding either from pit morphology or by making several soil inspections and omitting any which are not satisfactorily replicated. Even so some soils will lie outside the confines of this key – perhaps as many as 20% of the profiles selected, but hopefully fewer.

Categories: Empirically chosen for convenience: no pedogenetic significance.

I – Soil Mantle Discontinuous

II – Soil Weakly Horizonated and Very Shallow (usually less than 40 cm to rock, either weathering or fresh, that is not soft)

III – Soil Restricted to Bottomlands and River Terraces

IV – Soil Two-Deck (top of light to medium texture overlies, usually abruptly, either clay pan or iron pan or thick stoneline)

V – Soil Not in Categories I or II or III or IV

Soil Series:

I – SOIL MANTLE DISCONTINUOUS: Basis for series differentiation nature of interruption.

Sporadic deposits of soil as alluvium along rocky valley floors

101 – UMBELUZI series

Sedentary soil as matrix between boulders

102 – UPCOUNTRY series (often HV)

Thin sedentary soil in pockets amid hard rock outcrops

103 – UNGOBOLIMA series

Thin soil in pockets on hard iron pan

104 – GONGOLA series

II – SOIL WEAKLY HORIZONATED AND VERY SHALLOW: Basis for series differentiation – modal texture, colour and leaching stage of diagnostic horizon.

Sand: black top, peaty

201 – DARKETON series (in HV only)

Sand: grey top

202 – OTANDWENI series (often WL)

Loamy sand: yellowish grey at 20 cm

203 – OLDREEF series (usually HV)

Loamy sand to sandy loam: reddish brown at 20 cm

204 – OUTSPAN series (often LR)

Sandy loam: yellow or orange with high fine sand at 20 cm

205 – OMHLANDLU series (usually WL)

Sandy loam: red at 20 cm

206 – OSAGULENI series (often WL)

Loam: orange or pale red at 20 cm

207 – ONGELUK series (usually HV)

Loam: dark brown top, pedocal

208 – SOMERLING series (usually EL)

Loam to clay loam: dark brown at 20 cm, pedalfer

209 – STEGI series (usually LR)

Loam to clay loam: black top, pedalfer-pedocal transition

210 – SPEKBOOM series (often LM)

Loam to clay loam: black top, pedocal with hard lime pan

211 – SHEBANI series (usually EL)

Clay loam: dark red at 20 cm, pedalfer-pedocal transition

212 – SIKHUTWANE series (usually EL)

III – SOIL OF BOTTOMLANDS AND RIVER TERRACES: Not in Categories I or II: Basis for series differentiation – modal texture, colour, depth and leaching stage of diagnostic layer.

Bouldary gravel: white to pale brown top

301 – XULWANE series

Bouldary loam; orange at 130 cm

302 – WASPAGENI series (often LV)

Gravelly sand: pale brown top

303 – BONA series (often LV)

Gravelly clay: mottled top

304 – IVY series (in WL only)

Sand to loamy sand: mottled at 60 cm

305 – IDUKATHOLE series

Loamy sand: yellowish brown or pale brown top, high fine sand

306 – BUSHBABY series

Sandy loam: brown top, high fine sand

307 – BETUSILE series (often LV)

Sandy loam: for series with alluvial wash see Zebra 414 and Nsoko 415

Loam: orange at 130 cm

308 – WINN series

Loam: orange at 40 but not 130 cm

309 – WHITEROCK series (in LV only)

Clay loam: brown at 40 cm

310 – WISSELRODE series (in LV only)

Clay loam: mottled at 60 cm

311 – INGOJE series

Sandy clay: dark grey at 80 cm, has thin sandy loam covering

312 – ZIKANE series (usually WL)

Sandy clay: black at 40 cm and peaty

313 – DZIVA series (in HV only)

Clay: grey top

314 – IMBOJANE series (often LR)

Clay: dark grey at 40 cm and sodic (brack)

315 – YAKENI series

Clay: dark brown at 40 cm and sodic (brack), dispersed

316 – YOUNGSVLEI series (in LV only)

Clay: dark brown at 40 cm, sodic but blocky structure retained

317 – VIMY series (in LV only)

Clay: black top, calcareous throughout

318 – VALUMGWACO series (often EL)

Clay: black top, noncalcareous to 50 cm

319 – VUSO series (often MV)

IV – SOIL TWO-DECK: Not in Categories I or II or III: Basis for series differentiation – nature of lower diagnostic horizon for each set, as outlined in (A) to (J) below, followed by modal texture, colour and depth of upper diagnostic horizon for each series.

(A) Thick stoneline on red subsoil – J (Highveld) set
(B) Red clay – N (Lowveld) set
(C) Red loam – L set or M set: Ludomba and Mzawo series only
(D) Soft iron concretions, often soft iron pan – F set
(E) Hard iron concretions, usually hard iron pan – G set or E set
(F) Mottled sandy clay – H set or E set
(G) Mottled layer, thinner or coarser than (F) – P set or E set

(H) Dark grey sandy clay on lime accumulation zone – Z (Lowveld) set

(J) Olive-drab sandy clay, sodic (brack) and alkaline – Q (Lowveld) set

Gravelly sand: pale grey at 80 cm

401 – EBEDE series (often LM)

Gravelly sand: pale grey at 20 but not 80 cm

402 – GUBANE series

Gravelly loam: reddish grey and compact at 20 cm

403 – JOLOBELA series (often HV)

Sand: pale grey at 80 cm

404 – ENKULUNYO series (often WL)

Sand: pale mottled at 80 cm

405 – EMPAHLI series (often LM)

Loamy sand: yellowish grey at 20 cm with (J) below

406 – QUALM series (in WL only)

Loamy sand: yellowish grey at 20 cm, high fine sand, over (F)

407 – HLUNYA series (usually WL)

Loamy sand: grey at 20 cm with (F) below

408 – HABELO series (usually WL)

Loamy sand: grey at 20 cm with (G) mottled sandy clay below

409 – PETRONELLA series

Loamy sand: grey at 20 cm over (G) mottled weathering rock

410 – POFANE series (often LM)

Loamy sand: grey at 20 cm with (E) below

411 – GOCUKA series

Loamy sand: dark grey at 20 cm

412 – GEGE series (usually HV)

Loamy sand: reddish brown at 20 cm

413 – GROENING series (usually LR)

Sandy loam: pale brown top, high fine sand, over (H)

414 – ZEBRA series (usually WL)

Sandy loam: brown top, high fine sand, over (B)

415 – NSOKO series (usually EL)

Sandy loam: brown at 20 cm with (G) below

416 – PEEBLES series (often LM)

Sandy loam: greyish brown top over fersialitic (C)

417 – LUDOMBA series (usually WL)

Sandy loam: grey top over ferralitic to fersialitic (C)

418 – MZAWO series (usually MV)

Sandy loam: dark grey top and by 80 cm hard rock

419 – ZWAKELA series (usually WL)

Sandy loam: dark grey top and at 80 cm (H) pan

420 – ZWIDE series (usually WL)

Sandy loam: reddish grey at 20 cm

421 – HERSOV series (usually LV)

Sandy loam: orange at 40 cm

422 – FRAZER series

Loam: grey at 60 cm

423 – HOMESTEAD series (usually WL)

Loam: brown at 20 cm

424 – NHLOYA series (usually WL)

Loam: dark grey and compact at 20 cm

425 – JUWEEL series (often HV)

Loam: dark brown and compact at 20 cm

426 – JOHANNESLOOP series (usually HV)

Loam: orange at 100 cm

427 – FUNEZIBO series (usually UM)

Loam: orange at 40 cm but (D) by 100 cm

428 – FELWAKO series (often WL)

Loam: orange at 40 cm but (E) by 100 cm

429 – GUDZENI series (often UM)

V – SOIL NOT IN CATEGORIES I TO IV: Basis for series differentiation – modal texture, colour, depth and leaching stage of diagnostic horizon.

Bouldery loam: red at 60 cm

501 – MADEVU series (often UM)

Gravelly sand: reddish grey at 60 cm

502 – JOVANE series (often WL)

Gravelly loam: yellow or orange at 130 cm

503 – QWABISE series (usually HV)

Gravelly loam: red at 130 cm

504 – QOLWENI series (usually HV)

Loamy sand: greyish yellow at 20 cm, soft iron pan by 80 cm

505 – ATONDOZI series (often HV)

Loamy sand to sandy loam: yellowish grey at 20 cm, no pan

506 – TORGYLE series (usually HV)

Loamy sand to sandy loam: reddish grey at 20 cm

507 – TATENI series (usually HV)

Sandy loam: greyish brown at 40 cm and orange at 130 cm

508 – JEKHI series (often WL)

Sandy loam: greyish brown at 40 cm, weathering rock by 90 cm

509 – ORRIN series (often MV)

Sandy loam: yellow at 60 cm

510 – DAPUTI series (usually LV)

Sandy loam to loam: orange at 130 cm

511 – MDUTSHANE series (often UM)

Sandy loam to loam: pale red at 130 cm

512 – MOOIHOEK series (often UM)

Loam: yellow at 80 cm with soft iron pan below 120 cm

513 – ALICEDALE series (often HV)

Loam: yellow at 80 cm without iron pan

514 – AMUKE series (usually HV)

Loam: reddish orange at 130 cm

515 – NDUMA series (usually HV)

Loam: reddish orange at 40 cm but not 130 cm

516 – NGAZI series (usually HV)

Loam: red at 130 cm with thin stoneline in top 90 cm

517 – MTILANE series (usually UM)

Loam: red at 130 cm, no stoneline in top 90 cm, ferralitic to fersialitic

518 – MALKERNS series (usually UM)

Loam: red at 130 cm, no stoneline, fersialitic

519 – LESIBOVU series (often WL)

Loam: red at 20 but not 130 cm, fersialitic

520 – LUTZI series (often WL)

Loam to clay loam: red at 20 but not 130 cm, ferralitic

521 – ZOMBODE series (often HV)

Loam to clay loam: orange at 20 but not 130 cm

522 – ZAYIFU series (often HV)

Clay loam: yellowish brown at 60 cm, soft iron pan below 120 cm

523 – DELCOR series (usually EL)

Clay loam: yellowish brown or orange at 60 cm, no pan

524 – SIVULO series (often HV)

Clay loam: orange at 130 cm

525 – MBELI series (often UM)

Clay loam: mottled orange and grey at 130 cm

526 – THORBURN series (often WL)

Clay loam: red at 130 cm, fersialitic with humic top

527 – LOMAHASHENI series (usually LR)

Clay loam: dark red at 40 cm but not 130 cm, with soft iron pan

528 – RHEBOK series (usually EL)

Clay loam: dark red at 40 but not 130 cm, no pan

529 – RONDSPRING series (usually EL)

Clay loam: dark brown and compact at 20 cm, red at 130 cm

530 – MUNALI series (usually UM)

Clay loam: dark brown at 20 cm, weathering rock by 100 cm

531 – SANGWENI series (often HV)

Clay loam to clay: red at 130 cm, ferralitic with humic top

532 – CIMURPHY series (usually HV)

Clay loam to clay: dark brown at 130 cm, ferralitic

533 – COSENI series (usually HV)

Clay: dark orange at 130 cm

534 – RASHENI series (in LV only)

Clay: dark red at 60 cm, pedocal

535 – REIDBULT series (in LV only)

Clay: dark red at 130 cm, pedalfer-pedocal transition

536 – RATHBONE series (usually EL)

Clay: dark brown at 40 cm, pedocal

537 – CANTERBURY series (usually EL)

Clay: dark brown at 40 cm, pedalfer-pedocal transition

538 – CUBA series (usually EL)

Clay: mottled at 130 cm

539 – TSHANENI series (usually EL)

Clay: dark grey at 60 cm, over soft iron pan

540 – TAMBANKULU series (usually EL)

Clay: black at 40 cm, pedalfer-pedocal transition

541 – KING series (often MV)

Clay: black at 40 cm, pedocal with hard lime pan

542 – KWAMTUSSE series (usually EL)

Clay: black at 40 cm, pedocal without hard lime pan

543 – KWEZI series (usually EL)

ALPHABETICAL INDEX OF SETS AND SERIES:

In the following annotated definitions, which supersede those of Murdoch and Baillie (1966), the features indicated as appertaining to a set are shared by all its component series unless there is a statement to the contrary. The numbers after series names relate to the analytical key above. The two-letter abbreviations employed for series come next, then 15 internal and external soil characteristics are catalogued for each series (including the set descriptions): they are

SPI Mapping Unit	Humus	Acidity
Depth	Horizonation	Permeability
Colour	Whether Two-Deck	Parent Material
Texture	Lime	Landform
Structure	Salinity and Alkalinity	Region

Approximately the above sequence is often followed in listing these characteristics, although for some sets departures are obligatory or expedient: and in describing certain soils further traits are adduced, such as consistency, whether inundated or not, etc. References to lime, salinity, alkalinity and acidity are omitted if already implied under SPI Mapping Unit. The abbreviation p.m. stands for parent material. On the whole less space is devoted to sets which are rare or of low agricultural value than to common soils sought after by farmers.

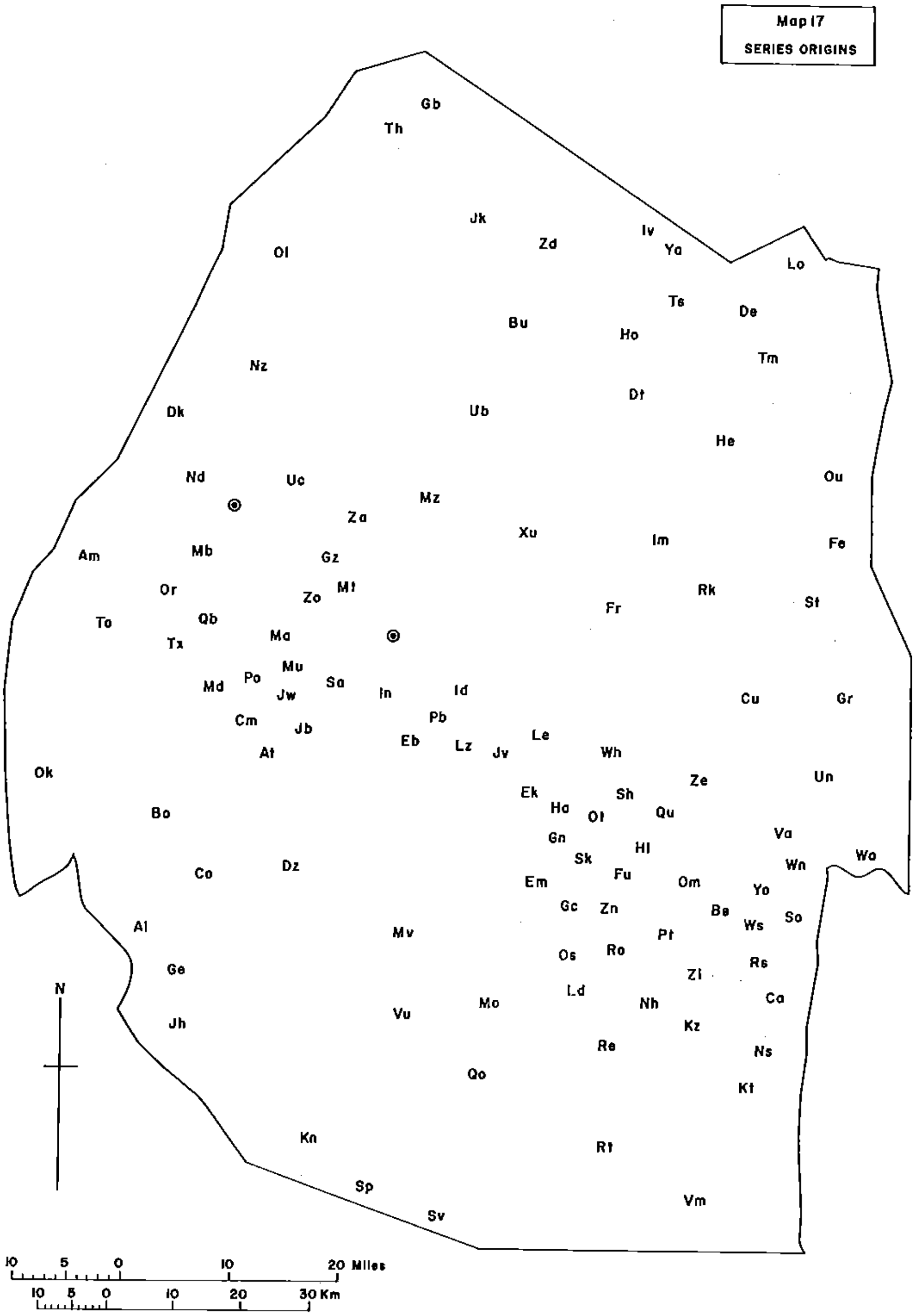
Within a set the first-named series is considered the epitome or mode: it is usually more extensive than other members of that set, although it may not have an absolute majority of the area (does not in 9 sets).

Modal depths, textures and other morphological parameters are quoted here – as was the case in the analytical key – much more often than extremes or ranges. This is partly because, from all the profile examinations of a set or series, modes may stand out starkly, but also – it must be admitted – because precise demarcations between series are so difficult. Predetermined limits cannot be employed: the nature of the continuum forbids that. And so a good dividing line, say one metre depth to hard rock, in one area may turn out to be modal for a readily distinguishable series in another. Until very detailed soil studies establish the best points, for each criterion of differentiation, at which to place series boundaries, it is considered more profitable to concentrate on the middle, typical, most important parts of the pedological spectrum and to leave the ends loose meantime. A statistical study of series variability is presented in Table 23 on page 147.

Peculiarities of the shapes and sizes of parcels of land within each set are noted: see also the 1:125,000 Soil Map. From it the acreages of sets, by regions and subregions, have been obtained. Acreages of series are best estimates. The places where series were first set up are plotted on Map 17.

For the 53 series of which 4 or more profiles have been sampled and analysed fully, annexes give a resume of the laboratory results – median in every case. Abbreviations used around the annexes are as follows:

Top	Surface 15 to 20 cm of soil: sole diagnostic horizon if there is no Sub
Sub	Soil at about 70 or 80 cm depth: diagnostic (or if Two-Deck lower diagnostic) horizon
No	Number of samples
CS	Coarse sand, 2.0 to 0.2 mm, percentage by weight
FS	Fine sand, 200 to 20 microns, percentage by weight
Si	Silt, 20 to 2 microns, percentage by weight
Cl	Clay, less than 2 microns, percentage by weight
pHW	Reaction, pH in water, usually with liquid: soil ratio 5
pHK	Reaction, pH in normal potassium chloride, usually with liquid: soil ratio 3
OC	Organic carbon, percentage by weight of fine earth (sands and silt and clay)
TN	Total nitrogen, percentage by weight of fine earth
Ca	Calcium, exchangeable milliequivalents per 100 g fine earth
Mg	Magnesium, exchangeable milliequivalents per 100 g fine earth
K	Potassium, exchangeable milliequivalents per 100 g fine earth
Na	Sodium, exchangeable milliequivalents per 100 g fine earth
Sme	Exchangeable bases (Ca Mg K Na), milliequivalents per 100 g fine earth
Tme	Cation exchange capacity (bases and hydrogen). milliequivalents per 100 g fine earth
V	Base saturation percentage or 100 Sme/Tme
EC	Electrical conductivity of saturation extract, millimhos per cm at 25°C.



LOCALITIES WHERE SERIES WERE FIRST NAMED ARE INDICATED

Abbreviations as in the text — Index of Sets and Series

P Bray method elemental phosphorus, parts per million

Not quite all of these determinations have been done for every sample. In particular Tme values, and therefore also base saturation figures, sometimes result from rather fewer analyses than the number indicated. For an account of analytical methods see page

The term solum is taken as meaning soil proper, not altered rock or any other substratum: in the definition of Jacks and Tavernier (1960) "the part of the earth's crust influenced by climate and vegetation". The solum is the principal object of study in this index.

THE MAXIMUM INFORMATION GIVEN ABOUT A SERIES MAY BE GOT BY

READING THE PARAGRAPH ON THE SET FIRST, THEN THAT ON THE SERIES

A set — Ferralitic Soil (but see also page 139): deep and yellow or yellowish brown: may have dark humic top: horizons merge: imperfect drainage, lower to mid slopes in Highveld and Upper Middleveld: from intermediate p.m. or occasionally acid rock only: scattered, usually small, patches: area 40,000 acres (Highveld 35,000 acres: Upper Middleveld 5,000 acres): slopes over 14% make up 22% of A set.

ALICEDALE series 513 Al — Medium texture: has iron concretions and soft iron pan below 100 cm depth: may become orange and slightly mottled there: very deep profiles, more than 250 cm to hard rock, commoner than for other series in set: normally on lower slopes: area 16,000 acres.

	No	CS	FS	Si	C1	pHW	pHK	OC	TN
Top	15	18	33	17	32	5.2	4.4	2.7	.20
Sub	14	13	42	15	30	5.2	4.4	0.6	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.9	0.8	0.2	0.1	3.0	8.6	35	0.1	3
Sub	0.7	0.5	0.2	0.1	1.5	6.3	24	0.0	1

AMUKE series 514 Am — Iron concretions and iron pan are absent: otherwise morphology as for Alicedale: normally on mid slopes, and sometimes interspersed with U set rocky land: area 13,000 acres.

ATONDOZI series 505 At — Light texture at surface and may be greyish yellow: mottled rather heavier subsoil contains iron concretions and soft iron pan below 70 cm depth: thus marginal to Two-Deck Soil: on lower slopes: area 11,000 acres.

B set — Lower terrace Late Quaternary alluvium along major rivers: deep and pale yellowish brown to brown: light or occasionally medium texture: low in humus: distinct layering often apparent, due to depositional history rather than pedological development: high in weatherable minerals, especially muscovite: currently never or very seldom flooded: commoner in Lowveld than elsewhere but found as high as 4,000 feet: elongated strips often less than 200 yards wide but many miles long: area 50,000 acres (Highveld 3,000 acres: Upper Middleveld 6,000 acres: Lower Middleveld 6,000 acres: Western Lowveld 17,000 acres: Eastern Lowveld 14,000 acres: Lubombo Range 4,000 acres): slopes over 14% make up 2% of B set.

BUSHBABY series 306 Bu — Yellowish brown or pale brown loamy sand top with heavier and coarser bands and lenses: high in rounded fine sand throughout and generally micaceous: very freely permeable: area 34,000 acres: samples of surface soil adequate to characterize solum.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	22	14	66	7	11	6.7	5.6	0.9	0.7

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.0	2.3	0.2	0.3	7.8	8.4	92	0.5	4

BETUSILE series 307 Be – Brown sandy loam or loam top: appreciable fine sand: thin strata of light texture may occur below 40 cm: generally micaceous: good drainage: intergrade towards Fersialitic Soil: area 10,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	10	36	34	10	20	6.5	5.4	1.2	.08
Sub	5	17	59	8	16	6.7	5.8	0.3	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.5	2.4	0.3	0.2	8.4	10.5	80	0.3	9
Sub	4.2	3.1	0.1	0.3	7.7	8.6	90	0.4	3

BONA series 303 Bo – Pale brown medium or coarse sand, transitional to Xulwane series: more apt to experience periodic floods than rest of set: rapid to excessive drainage when watertable is down: area 6,000 acres.

C (Highveld) or CH set – Ferralitic Soil (but see also page 139): deep, nearly always more than 200 cm, and reddish or dark brown: heavy texture: horizons merge: moderately permeable: on mid to lower slopes and from basic crystalline p.m. in the Upper Middleveld as well as Highveld: even farther east is prominent Siqumbile (Y7) outlier: scattered, usually small patches: area 24,000 acres (Highveld 15,000 acres: Upper Middleveld 6,000 acres: Lower Middleveld 3,000 acres): slopes over 14% make up 42% of CH set.

COSENI series 533 Co – Dark brown throughout profile: fairly strong blocky structure: subsoil richer in humus than any other analysed non-peaty series: intergrade from Ferrisol: area 15,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	7	18	16	9	57	6.2	4.8	2.6	.17
Sub	7	16	12	9	63	5.7	4.8	1.3	.09

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.0	1.9	0.6	0.1	7.6	11.8	64	0.2	2
Sub	4.7	1.2	0.3	0.2	6.4	11.2	58	0.1	2

CIMURPHY series 532 Cm – Almost black top normally 30 to 80 cm thick: no more humic, however, than Coseni: red subsoil: weak blocky structure, sometimes approaching apedal : usually on lower slopes: area 9,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	11	22	18	13	47	5.6	5.0	2.6	.17
Sub	10	19	13	12	56	5.8	5.2	0.9	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.3	2.8	0.4	0.2	8.7	16.0	55	0.2	1
Sub	3.8	2.9	0.2	0.2	7.1	12.3	58	0.2	1

C (Lowveld) or CL set – Lithomorphic Vertisol: dark brown with medium, occasionally high, organic matter content: subsoil usually 5YR, always with chroma/value 3/3 or lower:

horizons merge: imperfect drainage: rich in weatherable minerals: from basic crystalline p.m. and frequently between soils of R and K sets, so fairly low catena member: occupies Lowveld-margin valley bottoms at moist end of range, but occurs far up long gentle slopes in Eastern Lowveld south of Nzoto (J9) as quite large blocks: area 97,000 acres (Lower Middleveld 2,000 acres: Western Lowveld 23,000 acres: Eastern Lowveld 68,000 acres: Lubombo Range 4,000 acres): no slopes over 14% mapped.

CANTERBURY series 537 Ca – Blocky clay with tendency towards prismatic structure: top 20 cm may have no free lime, rest of profile invariably calcareous: lime is not hard, often powdery or filamental: modal depth to weathering rock 60 to 90 cm: could be Rendzina intergrade: area 73,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	23	13	26	19	42	6.7	5 2	1.8	.12
Sub	11	24	20	17	39	7.4	6.0	1.2	.09

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	13.4	5.5	0.8	0.6	20.3	22.4	91	0.8	4
Sub	18.0	4.7	0.5	0.6	23.8	23.8	100	0.6	1

CUBA series 538 Cu – Similar to Canterbury but easily visible calcium carbonate completely absent: base saturation nevertheless 100% or nearly so, and traces of very finely divided free lime may be present: Brown Soil intergrade: area 24,000 acres.

D (Highveld) or DH set – Very acid organic soils, black or dark grey: seldom found below 3,800 feet altitude: always in small pockets: area 12,000 acres, entirely on Highveld: slopes over 14% make up 67% of DH set.

DARKETOWN series 201 Dk – Mountain and hill peat, shallow to rock and sandy, with rapid permeability: typically on and just beneath granite tors but also e.g. near cap of Ingwenya (G2) massif: area 8,000 acres.

DZIVA series 313 Dz – Fen peat with sandy clay matrix: pieces of local alluvium: poorly drained: area 4,000 acres.

D (Lowveld) or DL set – Fersialitic Soil: deep, nearly always more than 150 cm, and yellow or yellowish brown: may have dark humic top: horizons merge: traces of free lime permissible in subsoil: imperfectly drained: usually from intermediate p.m. and on lower to mid slopes: scattered small patches: area 7,000 acres (Western Lowveld 1,000 acres: Eastern Lowveld 5,000 acres: Lubombo Range 1,000 acres): no slopes over 14% mapped.

DELCOR series 523 De – Rather heavy texture, mode clay loam: has iron concretions and soft iron pan below 120 cm depth, with red and grey marbling, but is not now truly hydromorphic: commonly derived from ignimbrite colluvium at foot of Lubombo scarp or Cislubombo ridges: area 5,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	5	15	30	15	40	6.7	5.2	2.0	.15
Sub	4	13	26	19	42	6.7	5.5	0.8	.07

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	6.0	4.2	0.5	0.7	11.4	16.3	70	0.5	8
Sub	3.9	2.6	0.4	0.4	7.3	9.8	75	0.2	3

DAPUTI series 510 Dt — Rather light texture, mode sandy loam: soft iron pan below 120 cm but less obstrusive than in Delcor: also more acid p.m. probably: associated in landscape with H set: area 2,000 acres.

E set — Regosol: Two-Deck profile has pale greyish sand or coarser, more than 90 cm thick, over clay or iron pan which is deeper and less conspicuous in its effects on the whole soil than are H or G set bottom decks: acid and extremely low in humus: very quartzose p.m. in fairly flat areas of Western Lowveld and Lower Middleveld: scattered small to medium sized patches: area 50,000 acres (Highveld 2,000 acres: Upper Middleveld 3,000 acres: Lower Middleveld 18,000 acres: Western Lowveld 25,000 acres: Eastern Lowveld 2,000 acres): slopes over 14% make up 2% of E set.

ENKULUNYO series 404 Ek — Deep sand with rapid to excessive drainage: usually on elevated erosion surface remnants: mainly Lowveld: area 31,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	18	62	30	4	4	5.7	4.8	0.5	.04
Sub	12	64	25	7	4	5.6	4.3	0.1	.02

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.0	0.6	0.1	0.1	1.8	3.9	46	0.1	3
Sub	0.8	0.4	0.1	0.3	1.6	2.8	57	0.6	2

EMPAHLI series 405 Em — Soil of marsh margins and flush sites: pale grey top changes to mottled, usually wet, sand before pan is reached: imperfectly drained and intergrade to Mineral Hydromorphic Soil: mainly Middleveld: area 15,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	5	61	28	5	6	5.9	4.8	0.7	.05
Sub	5	72	18	4	6	6.0	4.8	0.2	.02

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.2	0.6	0.1	0.1	2.0	3.4	59	0.1	3
Sub	0.7	0.3	0.1	0.1	1.2	2.5	48	0.1	2

EBEDE series 401 Eb — Gravelly sand, moderately deep, otherwise as Enkulunyo: mainly in Usutu basin: area 4,000 acres.

F set — Either Fersialitic Soil or somewhat more leached: orange with iron concretions and soft iron pan at depth: humus levels generally low: Two-Deck profile but moderately permeable and above hydromorphic influences: intermediate p.m. on lower slopes mainly: small patches well scattered through all regions: area 32,000 acres (Highveld 5,000 acres: Upper Middleveld 10,000 acres: Lower Middleveld 4,000 acres: Western Lowveld 5,000 acres: Eastern Lowveld 3,000 acres: Lubombo Range 5,000 acres): slopes over 14% make up 9% of F set.

FELWAKO series 428 Fe — Fersialitic and usually of medium texture: sesquioxidic layer begins at 60 to 100 cm depth: found on Lubombo and in Western Lowveld mainly: area 13,000 acres: median quantity of particles larger than 2 mm is 20% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	8	28	30	19	23	6.4	5.0	1.3	.09
Sub	7	15	27	18	40	5.9	4.9	0.6	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.7	2.8	0.6	0.2	9.3	11.0	84	0.9	3
Sub	2.0	3.7	0.4	0.4	6.5	9.8	67	2.0	1

FUNEBIZO series 427 Fu – Ferralitic intergrade to Fersialitic Soil: usually medium texture: sesquioxidic layer generally begins at more than 120 cm depth: mostly Middleveld: soil termed Funebizo by Murdoch and Andriesse (1964) would now be put with Felwako or Frazer: area 13,000 acres: median quantity of particles larger than 2 mm is 25% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	12	35	37	12	16	5.5	4.8	1.9	.13
Sub	10	30	26	15	29	5.4	4.7	0.6	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.5	1.6	0.4	0.1	4.6	8.7	53	0.1	2
Sub	3.3	2.4	0.3	0.2	6.2	10.7	58	0.3	1

FRAZER series 422 Fr – Intergrade from Lithosol: rather light texture, mode sandy loam: concretionary material within top 60 cm and hard rock usually reached by 100 cm: not in Highveld: area 6,000 acres.

G set – Outcropping Ferruginous Crust (rare) or buried hard iron concretions, some or all polished, and/or cemented iron pan, whose structure ranges from almost massive to openly cellular, by 80 cm depth: not highly humic: clear horizonation and Two-Deck: beneath pan, which is of very variable thickness, material usually mottled, with heavy or medium texture: often on elevated surfaces or shoulders: concentration of parcels in less than a dozen localities: scattered small patches elsewhere: area 72,000 acres (Highveld 25,000 acres: Upper Middleveld 14,000 acres: Lower Middleveld 11,000 acres: Western Lowveld 14,000 acres: Eastern Lowveld 3,000 acres: Lubombo Range 5,000 acres): slopes over 14% make up 8% of G set.

GOCUKA series 411 Gc – Lithosol intergrade Sol Lessivé: greyish top of light texture on hard iron pan, often vesicular and threaded by loam infills: imperfect drainage: mainly from intermediate p.m. in Western Lowveld and Middleveld: area 32,000 acres: median quantity of particles larger than 2 mm is 47% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	17	55	23	7	15	5.8	4.9	0.8	.05
Sub	15	36	25	10	29	6.3	5.1	0.4	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.6	1.7	0.2	0.2	4.7	7.8	61	0.5	3
Sub	2.3	1.9	0.2	0.5	4.9	8.6	57	0.5	2

GONGOLA series 104 Gn – Ferruginous Crust intergrade towards or from Lithosol: hard slaggy iron pan at or very near ground surface: area 14,000 acres.

GEGE series 432 Ge – Dark grey top of light texture, most humic in set and most acid, Lithosol intergrade Ferralitic Soil: imperfect drainage: often derived from banded ironstone with areanaceous seams: mainly Highveld: area 11,000 acres.

GUBANE series 402 Gb – Pale grey gravelly sand on loose iron concretions or fragmentary hard iron pan: Lithosol intergrade Regosol: extremely low in organic matter: rapidly permeable – pan may have impeded drainage in the past but now does not: typically Lower Middleveld where p.m. has large acid component: area 8,000 acres: median quantity of particles larger than

2 mm is 39% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	6	57	32	5	6	5.3	4.4	0.5	.04
Sub	4	58	31	6	5	5.9	5.3	0.2	.02

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.1	0.3	0.1	0.1	1.6	5.7	28	0.1	9
Sub	1.6	0.8	0.1	0.2	2.7	5.5	49	0.1	5

GUDZENI series 429 Gz – Lithosol intergrade Kaolisol (perhaps Ferrisol): orange or red: medium texture: drainage only slightly impaired: typically Upper Middleveld: area 5,000 acres.

GROENING series 413 Gr – Lithosol intergrade Fersialitic Soil: orange or red counterpart of Gocuka, with lighter top than Gudzeni: imperfect drainage: possibly confined to Lubombo plateau: area 2,000 acres.

H set – Sol Lessivé: Two-Deck with top of light to occasionally medium texture over mottled sandy clay: not highly humic: small amounts of free lime permissible in clay pan: poorly drained: mainly acid p.m. is frequently pedisediment: lower slopes: mostly Western Lowveld, where large blocks are found: elsewhere more elongated valley-side segments: area 217,000 acres or 5% of Swaziland (Upper Middleveld tiny pockets at Cibide (Y4): Lower Middleveld 19,000 acres: Western Lowveld 183,000 acres: Eastern Lowveld 14,000 acres: Lubombo Range 1,000 acres): slopes over 14% make up 1% of H set.

HABELO series 408 Ha – Grey loamy sand abruptly overlies sandy clay which is grey-yellow-orange blotched and often has set in it appreciable numbers of stones (some of them sub-rounded) and iron pisolites: dominant sand fraction coarse: modal depth above pan 30 to 60 cm: perched watertable present for several months in toto annually: area 112,000 acres: median quantity of particles larger than 2 mm is 10% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	26	49	33	6	12	6.0	4.8	0.9	.07
Sub	25	34	22	9	35	6.7	5.1	0.3	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.5	1.3	0.2	0.2	4.2	6.3	67	0.4	3
Sub	4.6	4.8	0.2	0.9	10.5	12.0	88	0.5	1

HLUNYA series 407 Hl – Yellowish grey top with more fine sand than coarse sand: sandy clay pan less stony or gravelly than Habelo, and underdrainage perhaps even poorer: otherwise sub-soils morphologically similar: area 68,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	12	39	42	10	9	6.0	4.5	0.9	.07
Sub	10	30	25	8	37	6.0	4.1	0.3	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.6	1.4	0.2	0.2	4.4	7.6	58	0.4	3
Sub	3.4	3.9	0.2	0.7	8.2	13.7	60	1.0	4

HOMESTEAD series 423 Ho – Grey loam at 50 to 70 cm depth marks horizon boundary, more gradual than in other soils of the set, between top and bottom decks: below 100 cm sandy clay pan is nearly always calcareous and olive-drab in colour: area 22,000 acres.

HERSOV series 421 He – Pinkish grey sandy loam on sandy clay with red mottles prominent in grey matrix of top 60 cm of pan, below which material like Habelo deep subsoil: in Eastern Lowveld derived from granophyre-rhyolite colluvium: small pockets fairly common in Western Lowveld too: area 14,000 acres.

I set – Mineral Hydromorphic Soil, mottled and at surface non-calcareous: may have dark humic top: in ill-drained bottomlands and from mixed p.m. which is usually Late Quaternary alluvium: stratification apparent: elongated strips often less than 200 yards wide but several miles long: area 88,000 acres (Highveld 37,000 acres: Upper Middleveld 35,000 acres: Lower Middleveld 12,000 acres: Western Lowveld 1,000 acres: Lubombo Range 3,000 acres): slopes over 14% make up 15% of I set.

IDUKATHOLE series 305 Id – Texture light in top 50 to 120 cm then medium to heavy below: free lime absent: can grade into Empahli series: not Lowveld: area 45,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	7	50	26	14	10	5.3	4.2	1.4	.09
Sub	3	40	18	10	32	5.6	4.4	0.5	.03

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.2	0.9	0.2	0.1	2.4	6.5	38	0.0	5
Sub	1.8	1.7	0.0	0.2	3.7	6.9	54	0.0	2

INGOJE series 311 In – Texture medium to heavy, with least clay in top: highly gleyed: more organic matter than set average: free lime absent: not Lowveld: area 39,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	9	33	27	20	20	5.5	4.9	1.8	.13
Sub	6	28	20	15	37	6.0	5.1	0.7	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.7	1.0	0.2	0.1	3.0	6.7	45	0.0	1
Sub	2.2	1.5	0.2	0.2	4.1	6.0	68	0.1	2

IMBOJANE series 314 Im – Clay of waterholes, wallows and dried out ponds: often slaty grey matrix colour: may be calcareous at depth: commoner in eastern half of country: area 3,000 acres.

IVY series 304 Iv – Gravelly or pebbly clay of lacustrine origin at Balekazulu (D8): possibly much is old delta deposit: always calcareous at depth: area 1,000 acres.

J (Highveld) or JH set – Dark compact top on thick stoneline in layer at about 30 to 60 cm, underlain by deep red soil or rubefied saprolite: humus moderate: clear horizonation which may be termed Two-Deck for the stoneline acts as a barrier to roots and percolating water just as does clay pan or iron pan: slightly impaired drainage: from intermediate p.m. on elevated surfaces of Middleveld and Highveld: scattered small to medium sized patches: area 92,000 acres (Highveld 70,000 acres: Upper Middleveld 19,000 acres: Lower Middleveld 3,000 acres): slopes over 14% make up 43% of JH set.

JUWEEL series 425 Jw – Ferralitic Soil intergrade Fersialitic Soil: medium texture above and below stoneline: dark grey top: stones mainly from vein quartz: area 55,000 acres: Top and Sub samples for analyses are from over and under stoneline respectively.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	10	39	22	11	28	5.5	4.4	1.7	.12
Sub	9	22	16	15	47	5.3	4.8	0.8	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.3	1.5	0.4	0.1	3.8	5.5	69	0.1	4
Sub	2.7	3.0	0.4	0.1	6.2	10.9	57	0.1	1

JOLOBELA series 403 Jb — As Juweel but horizons other than stoneline have gravelly loam texture and subsoil is usually ferruginous weathering rock, not soil: stoneline itself often thicker than set average: area 28,000 acres: only Top analyses of value: median quantity of particles larger than 2 mm is 40% there.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	9	38	29	7	26	5.3	4.2	1.6	.09

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.5	0.8	0.1	0.0	2.4	9.6	25	0.0	4

JOHANNESLOOP series 426 Jh — Ferralitic Soil: dark brown loam top: stones mostly Mozane quartzite: interleaved shale often gives clay beneath stoneline: usually in southern Highveld: area 9,000 acres.

J (Lowveld) or JL set — Fersialitic Soil: deep, usually more than 150 cm, and light textured: low humus, weak structure: horizons merge: good or rapid drainage: acid (with hint of intermediate) p.m. is often colluvial mantle originating from A3 or A5 granite on upper to mid slopes along Middleveld-Lowveld margin north of Mvangati (R6): marked concentration in two areas centring on Ophir (P7) and Lester to Jekhi (D6): area 45,000 acres (Lower Middleveld 12,000 acres: Western Lowveld 33,000 acres): no slopes over 14% mapped for JL set.

JOVANE series 502 Jv — Intergrade to Regosol: pinkish or reddish grey gravelly sand with incipient horizonation only: area 25,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	5	63	24	6	7	6.2	5.0	0.8	.07
Sub	4	58	22	7	13	5.8	4.6	0.2	.03

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.5	1.0	0.2	0.1	3.8	5.5	69	0.1	4
Sub	2.1	0.9	0.2	0.1	3.3	6.6	50	0.1	2

JEKHI series 508 Jk — Greyish brown top (similar to Orrin surface soil) gradually becoming more orange by 60 or 70 cm depth: modal texture sandy loam, high in coarse sand: commoner in Komati basin than southwards: area 20,000 acres.

K set — Lithomorphic Vertisol: black (or nearly so) cracking clay, normally 50 to 100 cm deep: blocky or prismatic breaking to blocky: despite colour humus content only medium: poor drainage: on lower slopes and from basic p.m. mainly in the Eastern Lowveld: minority of occurrences occupy elevated sites: many elongated parcels, with some larger blocks on almost flat platforms, notably at Dlangibuka (L9): area 70,000 acres (Highveld 1,000 acres: Upper Middleveld 1,000 acres: Lower Middleveld 3,000 acres: Western Lowveld 13,000 acres: Eastern Lowveld 50,000 acres: Lubombo Range 2,000 acres): slopes over 14% make up 1% of K set.

KWEZI series 543 Kz – Calcareous throughout profile: granular surface structure easily destroyed with copious wetting: merges via an olive-drab horizon to weathering rock, usually basalt: mainly Lowveld: area 60,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	18	9	26	17	48	7.5	5.6	1.9	.12
Sub	9	17	16	18	49	8.3	7.0	1.0	.08

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	23.7	9.0	0.6	1.3	34.6	35.8	97	0.8	6
Sub	29.3	12.8	0.4	5.5	48.0	48.0	100	0.8	3

KING series 541 Kn – Slightly acid at surface and to about 70 cm depth below which invariably calcareous band is found: often in Middleveld: area 6,000 acres.

KWAMTUSSE series 542 Kt – Calcareous throughout profile and has indurated lime pan, usually unbroken, in subsoil: mainly Lowveld: area 4,000 acres.

L set – Red Fersialitic Soil: horizons merge, except in Ludomba series: good drainage: from intermediate p.m. which is usually colluvial mantle on upper to mid slopes, although sometimes conjecturally an ancient (perhaps Early Quaternary) river terrace deposit: great number of scattered small patches east of the Upper Middleveld, with some concentrations in lower Lomati valley, parallel to Komati below Avondrust (F6) and at several localities on Lubombo plateau: area 99,000 acres (Lower Middleveld 28,000 acres: Western Lowveld 42,000 acres: Eastern Lowveld 2,000 acres: Lubombo Range 27,000 acres): slopes over 14% make up 3% of L set.

LESIBOVU series 519 Le – Very deep, almost always more than 200 cm, and of medium texture – rather heavier in the subsoil: crumbly to nutty structure, becoming stronger with depth (in contrast to Malkerns): low organic matter: some weatherable minerals: Western Lowveld and Lower Middleveld mainly: area 49,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	59	36	28	11	25	6.0	5.0	1.4	.09
Sub	43	30	20	12	38	6.2	5.1	0.5	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.3	1.7	0.4	0.2	5.6	9.7	58	0.4	2
Sub	2.9	1.8	0.2	0.2	5.1	8.4	60	0.5	1

LOMAHASHENI series 527 Lo – Deep red clay loam: top is darker-coloured and higher in humus than other Swaziland soils of comparable altitude: strong nutty structure: confined to Lubombo plateau: area 26,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	35	10	28	27	35	6.1	5.0	2.9	.20
Sub	27	8	23	23	46	5.9	4.9	1.0	.07

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	5.0	3.8	0.6	0.2	5.6	9.7	58	0.4	2
Sub	3.3	2.9	0.4	0.2	6.8	12.9	53	0.2	1

LUTZI series 520 Lz – Intergrade from Lithosol: least deep soils of set, usually with weathering rock admixture by 100 cm and hard rock by 170 cm: medium texture but sensibly more quartz gravel than Lesibovu: found with latter and possibly transitional to Osaguleni: area 14,000 acres.

LUDOMBA series 417 Ld — Similar to Lesibovu except for greyish brown sandy top, creep from upslope, which rests clearly on red soil: weakly Two-Deck but permeability unimpaired: often Western Lowveld: area 10,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	17	42	38	9	11	6.4	5.2	1.1	.08
Sub	12	30	26	10	34	6.2	4.9	0.5	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.2	1.4	0.3	0.1	5.0	8.0	63	0.5	3
Sub	3.6	2.7	0.2	0.2	6.7	11.5	58	0.4	2

M set — Deep red or orange Kaolisol, usually much more than 300 cm to hard rock: Mdutshane and Mbeli are orange, typically 5YR, other soils in set being redder: moderate to rather low amounts of humus: drainage is good except in Munali: weatherable minerals very low or nil: from mainly colluvial intermediate p.m. on upper and mid slopes, typically below Highveld mountains in Upper Middleveld wide valleys: orange series also occupy lower slopes but have no mottles or iron concretions (watertable has almost certainly not influenced their genesis): concentrated strongly in the three fairly gently sloping Upper Middleveld areas, especially the Centre (Ezulwini-Malkerns-Umtilane): less than 10 smaller nodes, among them Kagwegwe (V5) and Bekinkosi (K5) and south of Wimabe (C4): elsewhere scattered patches: area 198,000 acres or nearly 5% of Swaziland (Highveld 74,000 acres: Upper Middleveld 112,000 acres: Lower Middleveld 12,000 acres): slopes over 14% make up 35% of M set.

MALKERNS series 518 Ma — Ferrisol or possibly merely Ferralitic Soil intergrade to Fersialitic Soil: red, of medium texture with argillic horizon of nutty structure at about 30 to 80 cm depth: below this peds are weak: profile features suggest, with the chemistry, that not only a halt to degradation processes in the pedisediment but even restructuring may have occurred: however, pedogenesis remains problematical: area 80,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	88	33	20	15	32	5.5	4.6	2.0	.14
Sub	66	26	13	15	46	5.5	4.7	0.6	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.2	1.3	0.2	0.1	3.8	7.6	50	0.2	2
Sub	1.6	1.0	0.2	0.1	2.9	5.4	53	0.1	1

MTILANE series 517 Mt — Ferralitic Soil: surface reddish brown or red and medium textured: thin quartz stoneline in top 90 cm below which deep apedal friable red loam: horizon of strong structure absent or vestigial: often interdigitates with Juweel: area 43,000 acres: Top and Sub analyses are respectively over and under stoneline.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	34	48	13	15	24	4.9	4.5	1.6	.10
Sub	20	26	13	15	46	5.2	4.7	0.5	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.0	0.7	0.2	0.1	2.0	6.8	29	0.1	3
Sub	0.8	0.6	0.2	0.1	1.7	4.9	36	0.1	1

MOOIHOEK series 512 Mo – Ferralitic Soil intergrade Fersialitic Soil: pale red and of medium to light texture, mode sandy loam: apedal and friable: often from Pongola System ferruginous sedimentary and metamorphic rocks: mainly in Cool Middleveld and very rare north of Ngwempisi: area 26,000 acres.

	Na	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	20	39	30	11	20	5.5	4.4	1.9	.10
Sub	15	38	16	12	34	5.2	4.3	0.7	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.7	0.8	0.2	0.1	3.8	10.2	37	0.1	4
Sub	1.9	1.0	0.2	0.1	3.2	9.5	34	0.1	2

MDUTSHANE series 511 Md – Ferralitic Soil, probably intergrade Fersialitic Soil: orange and of medium to light texture, mode sandy loam surface, loam at depth: apedal: very friable and permeable considering hydrated state of iron oxides: area 19,000 acres.

	Na	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	34	43	17	14	26	5.4	4.5	1.8	.13
Sub	24	32	15	16	37	5.4	4.6	0.5	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.6	1.0	0.2	0.1	2.9	7.5	38	0.1	2
Sub	1.2	0.6	0.2	0.1	2.1	4.8	45	0.1	1

MBELI series 525 Mb – Ferralitic Soil, possibly intergrade from Ferrisol: orange clay loam: nuciform horizon less marked than in Malkerns: friable and permeable subsoil despite hydration of iron oxides: not on upper slopes: area 12,000 acres.

MADEVU series 510 Mv – Ferrisolic fine earth, similar to Malkerns, but with many large boulders incorporated, some at ground level, of granodiorite and other more basic rocks: development of Upcountry series: area 10,000 acres.

MZAWO series 418 Mz – Grey sandier top 20 to 50 cm thick overlies Mtilane or sometimes Malkerns material: mildly Two-Deck but permeability unimpaired: intermediate p.m. with quartzose rock outcrops in vicinity to provide surface colluvium: commonest around Bekinkosi (K5): area 7,000 acres.

MUNALI series 530 Mu – Ferrisol: red to dark brown loam over clay, the horizon of heavy texture being compact and generally at 20 to 40 cm: downward there is deep friable red loam: pockets between Ross (N4) and Ezulwini: area 1,000 acres.

N (Highveld) or NH set – Ferralitic Soil (but see also page 139): yellow or reddish orange, with gradual colour change at 40 to 90 cm depth: about same level but independent there is occasionally thin quartz stoneline or dotted iron concretion band: dark humic top: good drainage: upper slopes and preweathered or ancient-colluvial intermediate p.m. (though in places acid component is quite high): mostly medium or small sized patches: area 102,000 acres (Highveld 92,000 acres: Upper Middleveld 10,000 acres): slopes over 14% make up 62% of NH set.

NDUMA series 515 Nd – Very deep, ordinarily more than 300 cm: loam, usually becoming clay loam by 100 cm depth: often entirely developed in colluvial overburden: the rare iron concretions include both hard buckshot and soft nodules (some manganiferous), testifying to polygenetic history of this soil: area 74,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	46	28	28	15	29	5.0	4.3	2.7	.18
Sub	33	24	22	16	38	5.2	4.4	0.6	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.0	0.6	0.2	0.1	1.9	8.7	22	0.1	2
Sub	0.9	0.5	0.1	0.1	1.6	9.0	18	0.0	1

NGAZI series 516 Nz – Loam or sometimes sandy loam: shallower than Nduma with thin reddish orange subsoil resting on well rotted rock in situ, as does Tateni, by 130 cm depth: area 28,000 acres.

N (Lowveld) or NL set – Brown light to medium textured soil overlies red clay: not highly humic: good drainage even though morphology is Two-Deck: from intermediate p.m. on mid to lower slopes: few small parcels, nearly all in Western Lowveld south of Usutu: area about 7,000 acres: mapped with R set at 1:125,000 scale.

NHLOYA series 424 Nh – Top normally loam, subsoil very much as in Rathbone or Reidbult series: substratum is basic crystalline rock: area 6,000 acres.

NSOKO series 415 Ns – Top is thin alluvial accretion of Betusile or Winn material, bottom deck as Nhloya: area 1,000 acres.

O set – Lithosol: shallow, often less than 40 cm, and siliceous: light or occasionally medium texture: low in humus: weakly horizonated: rapid drainage: on acid p.m. (hard rock or a quartz stoneline so thick that it can be considered p.m.) of upper slopes and other parts of landscape vulnerable to geologic erosion, such as rejuvenation shoulders: formation of deep, horizonated profile is prevented by continual truncation: found throughout all regions but particularly widespread in Lower Middleveld and Western Lowveld: large to small patches, often following lineaments of steepland just below U set: area 569,000 acres or 13% of Swaziland (Highveld 100,000 acres: Upper Middleveld 77,000 acres: Lower Middleveld 158,000 acres: Western Lowveld 173,000 acres: Eastern Lowveld 9,000 acres: Lubombo Range 52,000 acres): slopes over 14% make up 30% of O set – about 46% of its Highveld-Middleveld-Lubombo portions, but only 5% in Lowveld.

OTANDWENI series 202 Ot – Greyish sand or sometimes loamy sand, high in coarse elements: on hard rock by 30 cm depth: probably shallowest series on average of this set: very common in Western Lowveld: area 220,000 acres: only Top analyses required: median quantity of particles larger than 2 mm is 15% there.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	30	46	38	7	9	6.0	4.8	0.7	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.9	1.0	0.2	0.1	3.2	5.8	56	0.2	4

ORRIN series 509 Or – Intergrade to Fersialitic Soil: greyish brown: light to medium texture with high coarse sand: rooting to about 90 cm usually, giving deepest solum in set, then soft well-weathered rock, which may be rubefied, down to as much as 200 cm locally: commonest in Middleveld and almost absent from Lowveld: area 173,000 acres: median quantity of particles larger than 2 mm is 26% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	50	50	27	9	14	5.8	4.8	1.3	.08
Sub	42	48	23	9	20	5.7	4.7	0.5	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.9	1.0	0.2	0.1	3.2	6.0	54	0.5	3
Sub	1.8	0.9	0.3	0.1	3.1	5.4	58	0.2	1

OLDREEF series 203 Ol — Intergrade to Yellow Ferralitic Soil: usually yellowish grey loamy sand: virtually confined to Highveld where p.m. is granite or acid schist, more indurated than under Torgyle: area 48,000 acres: only Top analyses required.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	8	49	32	9	10	5.7	4.4	2.2	.15

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.0	0.8	0.2	0.0	2.0	4.7	43	0.0	2

OUTSPAN series 204 Ou — Possibly developing towards Ferrisol: usually reddish brown loamy sand or sandy loam: more humic than most other soils in set: best seen on Lubombo plateau with p.m. rhyolite: area 41,000 acres.

ONGELUK series 207 Ok — Intergrade to Red Ferralitic Soil: orange or pale red loam: often on Pongola System interbedded quartzite and ferruginous rocks in southern Highveld: area 36,000 acres: only Top analyses required.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	5	27	44	16	13	5.5	4.7	1.8	.13

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.9	2.6	0.1	0.1	4.7	9.0	52	0.1	3

OMHLANDLU series 205 Om — Intergrade to Fersialitic Soil: yellow and orange: texture light or medium, with high fine sand: probably somewhat deeper than set average: derivation Cave sediments in Lowveld: area 32,000 acres.

OSAGULENI series 206 Os — Intergrade to Fersialitic Soil: reddish sandy loam: deemed a truncated L set profile: mainly Western Lowveld: area 19,000 acres.

P set — Lithosol intergrade to Sol Lessivé or Mineral Hydromorphic Soil: Two-Deck with mottled layer thinner and/or coarser than that in H or ZL sets: neither deep nor humic: imperfectly drained, with occasional perched watertable: in some respects transitional between O and H sets, largely replacing the latter on Middleveld lower slopes: acid or sometimes intermediate p.m. — usually crystalline, not Karroo beds: many small patches, with tendency in Lower Middleveld to be drawn out along valleys: area 77,000 acres (Highveld 10,000 acres: Upper Middleveld 11,000 acres: Lower Middleveld 38,000 acres: Western Lowveld 16,000 acres: Eastern Lowveld 1,000 acres: Lubombo Range 1,000 acres): slopes over 14% make up 14% of P set.

POFANE series 410 Po — Greyish sand to loam for about 30 cm, mode loamy sand, then clear or gradual change to mottled altered rock with some iron concretions: mostly Middleveld: area 40,000 acres: median quantity of particles larger than 2 mm is 29% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	29	52	28	9	11	5.7	4.6	1.0	.06
Sub	13	44	20	11	25	5.3	4.8	0.4	.03

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.8	0.8	0.1	0.1	2.7	5.6	48	0.4	3
Sub	2.5	1.6	0.2	0.2	4.5	7.3	61	0.4	2

PETRONELLA series 416 Pt — Greyish sand to loam for about 30 cm, mode loamy sand, lying abruptly on thin dark-coloured mottled clay loam: mostly Western Lowveld: area 23,000 acres: median quantity of particles larger than 2 mm is 10% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	10	54	30	7	9	6.0	4.9	1.2	.09
Sub	10	35	22	8	35	6.7	5.1	0.5	.07

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.0	1.2	0.4	0.1	4.7	7.2	65	0.3	2
Sub	2.8	2.3	0.2	0.2	5.5	6.9	80	0.4	2

PEEBLES series 409 Pb — Brown sandy loam on moderately thick quartz stoneline on mottled heavy material, clay-enriched weathering rock, with some iron concretions: clear horizonations: hard rock usually reached by 80 to 100 cm: mostly Lower Middleveld: area 14,000 acres.

Q (Highveld) or QH set — Ferralitic Soil (but see also page 139): deep, more than 120 cm: gravelly loam, though top 30 or 40 cm may be almost gravel-free: no concentration of the diffused quartz fragments into a stoneline: rather low in humus: horizons merge: rapidly draining: acid p.m. often pegmatitic granite: upper to mid slopes: less than a dozen main localities, elsewhere scattered pockets: area 146,000 acres (Highveld 92,000 acres: Upper Middleveld 41,000 acres: Lower Middleveld 13,000 acres): slopes over 14% make up 57% of QH set.

QOLWENI series 504 Qo — Greyish at surface, red fine earth in subsoil and often reddish rotten rock: normally mid slopes: area 117,000 acres: median quantity of particles larger than 2 mm is 35% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	22	43	22	10	25	5.7	4.4	2.2	.14
Sub	20	33	26	11	30	5.5	4.7	0.6	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	1.5	0.6	0.3	0.1	2.5	6.4	39	0.1	4
Sub	1.3	0.7	0.2	0.1	2.3	5.0	46	0.0	1

QWABISE series 503 Qb — Greyish at surface, orange to yellow in subsoil and rotten rock: normally mid slopes: area 29,000 acres.

Q (Lowveld) or QL set — Solonetz with morphology deceptively similar to that of Hlunya: Two-Deck with slightly alkaline top of light texture sharply separated from highly alkaline and sodic (brack) olive-drab sandy clay with columnar structure: low in humus: poorly drained: area about 1,000 acres: tiny occurences in Western Lowveld mapped with H set at 1:125,000 scale.

QUALM series 406 Qu — Top yellowish grey and often high in fine sand: Ecca sediments contribute much sodium and magnesium to colloidal complex: area 1,000 acres.

R set — Brown Soil (in all respects save organic matter, which is higher than the 1.0% carbon limit of SPI) or Fersialitic Soil: dark reddish: heavy texture: horizons merge: compound nutty structure and moderate permeability (except Rasheni): from basic p.m. on mid slopes: in

Eastern Lowveld medium to large sized blocks common, progressively getting small westwards: chief Western Lowveld localities are between Usutu and Ingwavuma: area 143,000 acres, including NL set q.v. (Lower Middleveld 4,000 acres: Western Lowveld 33,000 acres: Eastern Lowveld 99,000 acres: Lubombo Range 7,000 acres): slopes over 14% make up 2% of R set.

RONDSPRING series 529 Ro – Brown Soil intergrade Fersialitic Soil: clay loam or occasionally clay: firm consistence: normally 50 to 100 cm deep to weathering p.m. and the same depth again until consolidated rock is reached: iron concretions absent or rare: area 67,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	26	16	29	18	37	6.3	5.0	1.6	.12
Sub	20	21	23	16	40	6.5	5.2	0.9	.08

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	8.5	4.3	0.5	0.4	13.7	20.8	66	0.9	2
Sub	10.3	4.9	0.2	0.4	15.8	21.6	73	0.4	1

RATHBONE series 536 Rt – Brown Soil intergrade Fersialitic Soil: clay with modal depth to saprolite about 180 cm: infrequently has traces of free lime below 90 cm: compact blocky and faintly mottled layer at or near base of solum may slightly impede drainage if copiously wetted: nutty structure throughout rest of profile: area 45,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	17	14	27	20	39	6.4	5.2	1.9	.12
Sub	13	15	22	17	46	6.3	5.3	1.2	.10

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	6.7	2.1	0.5	0.2	9.5	13.6	70	0.5	2
Sub	6.0	2.8	0.3	0.3	9.4	12.6	75	0.6	1

RHEBOK series 528 Rk – Fersialitic soil: clay loam to clay with iron concretions or soft iron pan below 60 to 100 cm and weathering rock often before 140 cm depth: commonest in Umbeluzi basin, Eastern Lowveld, where associated with Tambankulu: area 15,000 acres: median quantity of particles larger than 2 mm is 22% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	14	8	19	17	56	6.2	5.0	1.6	.13
Sub	10	15	23	15	47	6.5	4.9	0.7	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	7.0	5.2	0.3	0.3	12.8	20.0	64	0.2	1
Sub	8.8	10.4	0.3	0.2	19.7	28.0	70	0.2	1

RASHENI series 534 Rs – Brown Soil intergrade to Lithomorphic Vertisol: top 60 to 90 cm of heavy texture and blocky structure is underlain by dark orange friable calcareous clay: imperfectly drained: commonest around Big Bend: area 7,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	6	10	16	20	54	7.0	6.3	1.9	.16
Sub	5	12	16	29	43	8.5	7.1	0.5	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	22.0	6.9	0.3	0.5	29.7	30.4	98	0.3	2
Sub	28.0	9.7	0.4	1.1	39.2	39.2	100	1.8	7

REIDBULT series 535 Re – Brown Soil intergrade Eutrophic Brown Soil: clay with modal depth about 110 cm to weathering rock: subsoil contains lime specks and occasionally nodules: area 2,000 acres.

S (Highveld) or SH set – Ferrisol: rather shallow, usually less than 120 cm to rock: dark-coloured humic top and strong structure, blocky breaking to nutty: medium or heavy texture: good to moderate drainage: weatherable minerals quite high: from basic crystalline rocks of upper slopes in Middleveld as well as Highveld: scattered, usually small, patches which sometimes mirror stockworks of e.g. epidiorite dykes: area 84,000 acres (Highveld 45,000 acres: Upper Middleveld 20,000 acres: Lower Middleveld 19,000 acres: Western Lowveld specks mapped on Dumezulu (M7) hill): slopes over 14% make up 63% of SH set.

SANGWENI series 531 Sa – Intergrade Eutrophic Brown Soil: dark brown clay loam: mean depth to weathering p.m. is about 100 cm: area 65,000 acres: median quantity of particles larger than 2 mm is 20% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	30	33	22	16	29	5.8	4.8	2.1	.17
Sub	24	28	23	14	35	5.9	5.0	0.6	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	2.6	1.9	0.3	0.2	5.0	8.4	60	0.3	2
Sub	2.3	2.0	0.4	0.2	4.9	7.8	63	0.2	1

SIVULO series 524 Sv – Clay loam with orange or yellowish brown horizon between humic top and altered rock: mean depth about 70 cm: area 19,000 acres.

S (Lowveld) or SL set – Lithosol derived from basic crystalline rock: soil less acid than O set: very shallow, rarely 40 cm to weathering p.m. and approximately the same thickness again to virtually unaltered rock: dark in colour: medium to heavy texture, usually with appreciable gravel and stone: moderately well supplied with humus: weak horizonation: good drainage: rich in weatherable minerals: on upper slopes, steep at relatively high altitudes but often medium to gentle in Eastern Lowveld: in that subregion large expanses of SL form matrix in which other sets lie – also true of Lower Middleveld fringe from St Mary (V7) southwards: elsewhere many small to medium single areas: area 295,000 acres or 7% of Swaziland (Lower Middleveld 29,000 acres: Western Lowveld 72,000 acres: Eastern Lowveld 163,000 acres: Lubombo Range 31,000 acres): slopes over 14% make up 6% of SL set.

SOMERLING series 208 So – Perhaps intergrade to Rendzina: usually dark brown loam, slightly calcareous: invariably p.m. is reached by 35 cm depth: commonest in Eastern Lowveld: area 213,000 acres: only Top analyses required: median quantity of particles larger than 2 mm is 16% there.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	21	24	29	17	30	6.4	5.0	2.0	.16

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	8.3	6.4	0.5	0.4	15.6	21.4	73	0.4	5

SIKHUTWANE series 212 Sk – Intergrade to Brown Soil: dark red and not always calcareous: invariably p.m. is reached by 35 cm depth: thought of as Rondspring series truncated profile: area 30,000 acres.

STEGI series 209 St – Intergrade to Fersialitic Soil: dark brown loam to clay loam about 40 cm to altered rock, somewhat deeper than average for set: free lime absent: mainly Lubombo plateau: area 29,000 acres.

SHEBANI series 211 Sh – Intergrade to Lithomorphic Vertisol: usually black loam to clay loam: entirely calcareous and rests on hard lime pan, perforated or fissured enough not to impede drainage: area 14,000 acres.

SPEKBOOM series 210 Sp – Intergrade to Lithomorphic Vertisol: black loam to clay loam, more acid than Somerling at surface, but calcareous by 30 cm depth: though listed for convenience as SL this soil, unlike others of set, is commoner in Middleveld and drier Highveld: Baillie (1968) has in fact mapped it with SH set: area 9,000 acres.

T (Highveld) or TH set – Ferralitic Soil intergrade to Regosol: shallow loamy sand to sandy loam on very soft rock, predominantly acid and weathered to great depth, often Jamestown schist but also gneiss or granite: medium humus content: there may be thin quartz stoneline, but normally horizons merge: very freely permeable: mostly upper slopes: medium and some large blocks in northern and central Highveld: also many small pieces throughout western mountainland, frequently abutting on U set: area 117,000 acres (Highveld 102,000 acres: Upper Middleveld 14,000 acres: Lower Middleveld 1,000 acres): slopes over 14% make up 85% of TH set.

TATENI series 507 Tx – Grey with reddish or pinkish tint: saprolite by 50 to 80 cm depth of various hues, chiefly white of kaolinite but sometimes streaked or suffused by mauve of disintegrating mafic minerals: area 105,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	25	39	32	14	15	4.8	4.2	1.9	.12
Sub	19	17	43	22	18	4.7	4.3	0.2	.03

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	0.6	0.5	0.1	0.1	1.3	6.9	18	0.1	2
Sub	0.5	0.5	0.1	0.1	1.2	6.3	19	0.0	1

TORGYLE series 506 To – Yellowish grey top over white, yellow and orange rotten rock: some mid as well as upper slopes: area 12,000 acres.

T (Lowveld) or TL set – Dark grey or dark brown soils of medium to heavy texture: moderately high in organic matter: clear horizonation: not calcareous at surface: from basic p.m. on lower slopes: most extensive in Umbeluzi basin, Eastern Lowveld: area 22,000 acres (Western Lowveld 2,000 acres: Eastern Lowveld 20,000 acres): no slopes over 14% mapped for TL set.

TAMBANKULU series 540 Tm – Lithomorphic Vertisol intergrade Fersialitic Soil: blocky clay over layer of unpolished iron concretions and soft iron pan between 70 and 150 cm depth, then weathering basalt: without free lime: imperfectly drained: area 16,000 acres: median quantity of particles larger than 2 mm is 41% in Sub analyses.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	10	14	29	20	37	6.1	4.9	2.0	.16
Sub	9	10	13	17	60	6.8	5.5	0.4	.07

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	10.7	8.5	0.3	0.5	20.0	31.9	63	0.4	1
Sub	14.9	16.2	0.3	0.6	32.0	40.5	79	0.5	1

TSHANENI series 539 Ts – Lithomorphic Vertisol intergrade Mineral Hydromorphic Soil: as

Tambankulu but in addition there are stiff olive-drab and grey mottled bands and lenses of very heavy texture within and/or below sesquioxidic layer: subsoil often calcareous: poorly drained: intimately mixed with Tambankulu: area 4,000 acres.

THORBURN series 526 Th — Fersialitic Soil intergrade Mineral Hydromorphic Soil: clay loam, moderately to very deep: mottled orange, red and yellow below 60 cm: free lime absent: imperfectly drained: pockets in Lower Middleveld as well as Lowveld: area 2,000 acres (perhaps undermapped).

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	7	33	33	10	24	6.0	5.0	1.2	.10
Sub	7	37	19	12	33	6.2	5.0	0.4	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.4	2.5	0.4	0.2	6.5	11.0	59	0.3	4
Sub	2.9	2.5	0.3	0.3	6.0	9.5	63	0.3	2

U set — Bare rock and talus: commonest Swaziland set, in which more than 15% of the land surface — and often more than 40% — has outcrops or is boulder-strewn (other sets usually have less than 6% of rocky ground): soil cover discontinuous: occasionally buried soil may be sandwiched between stone mantle and consolidated rock: ubiquitous except in flattest parts of Lowveld: appears as background to 1:125,000 Soil Map, setting in which soils proper are mounted: area 1,278,000 acres or 30% of the country (Highveld 541,000 acres: Upper Middleveld 134,000 acres: Lower Middleveld 206,000 acres: Western Lowveld 92,000 acres: Eastern Lowveld 98,000 acres: Lubombo Range 207,000 acres): slopes over 14% make up 87% of U and it is steepest set in each subregion.

UNGABOLIMA series 103 Un — Living rock is at the surface, often hard slabs or dwalas, though sometimes tors or castle kopjes: also includes skirts of mesas, escarpment free faces etc. (see Table 4): small pockets of soil are generally sedentary: mostly acid and intermediate rocks: area 817,000 acres.

UPCOUNTRY series 102 Uc — Unconsolidated debris, or jointed rock weathering in situ, with fairly large volume of interstitial soil to considerable depth: dolerite "bombs" make ideal p.m. but exfoliating granite, particularly A5 plutons, also gives rise to bouldery slopes, the boulders being resistant cores within or from a preweathered matrix normally: area 395,000 acres.

UMBELUZI series 101 Ub — Small pockets of soil are drift of colluvial-alluvial origin: mostly valley floor rock bars near waterfalls and cascades: rounded cobbles and pebbles, singly or in beds, are common and wear potholes in country rock when churned by floods: area 65,000 acres.

V set — Topomorphic Vertisol: deep, usually more than 150 cm: dark-coloured prismatic cracking clay with olive-drab lower layers, some of which may be less strongly structured: not very highly humic: weak horizonation: sometimes visible depositional stratification but generally soil too mobile vertically for this to be preserved: poor drainage: formed in bottoms from gully wash with solely basic p.m. as catchment, mainly in Lowveld: elongated strips usually 200 or 300 yards across, and several miles long: area 30,000 acres (Highveld 1,000 acres: Upper Middleveld 1,000 acres: Lower Middleveld 1,000 acres: Western Lowveld 2,000 acres: Eastern Lowveld 25,000 acres): no slopes over 14% mapped for V set.

VALUMGWACO series 318 Va — Black, with free lime from surface down: often greatest enrichment in olive-drab horizon, where median $CaCO_3$ content 9% for Sub samples: often Eastern Lowveld: area 15,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	8	18	25	13	44	7.7	6.8	2.2	.16
Sub	5	19	13	27	41	8.5	7.2	0.8	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	37.8	5.2	0.3	1.2	44.5	44.5	100	0.6	9
Sub	32.4	19.0	0.2	1.6	53.2	53.2	100	1.8	2

VIMY series 317 Vm – Intergrade to Saline-Alkali soil: coarse prisms may be dispersed in places by sodic accumulations: dark brown top then often reddish tinge in subsoil below 60 to 80 cm: free lime throughout: only in Lowveld: area 11,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	17	9	21	20	50	7.8	6.8	1.4	.12
Sub	12	12	13	18	57	7.9	7.0	0.5	.06

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	29.0	8.5	0.7	5.3	43.5	43.5	100	2.6	9
Sub	26.3	7.7	0.4	9.8	44.2	44.2	100	11.0	7

VUSO series 319 Vu – Black, top 50 or 60 cm leached of lime, remainder of profile calcareous: sporadically at higher altitudes than rest of set, largest patches between Vilekazi (W3) and St Anthony (Y4): area 4,000 acres.

W set – Upper terrace Late Quaternary alluvium along major rivers: deep, more than 200 cm: orange or brown or occasionally red: medium to rather light texture: low in humus: weak horizonation: weatherable minerals fairly high: currently never flooded: often Lowveld: elongated discontinuous strips, sometimes facing each other across B and X set lower, younger valley floor drifts: area 24,000 acres (Highveld 2,000 acres: Upper Middleveld 2,000 acres: Lower Middleveld 2,000 acres: Western Lowveld 10,000 acres: Eastern Lowveld 8,000 acres): gradients smoother and hummocky microrelief less common than in B set, consequently no slopes over 14% mapped for W set.

WINN series 308 Wn – Juvenile Soil closest to achieving independent status, in this case as Fersialitic Soil: orange, mode loam: free of cobbles or pebbles and noncalcareous: good drainage: area 17,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	23	16	57	9	18	6.6	5.5	1.0	.09
Sub	14	13	58	7	22	6.6	5.7	0.3	.04

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.7	1.8	0.2	0.3	6.0	7.1	84	0.2	3
Sub	3.9	1.8	0.2	0.3	6.2	7.3	85	0.3	2

WASPAGENI series 302 Wa – Probably intergrade to Fersialitic Soil: orange, mode sandy loam or loam at surface but by 40 to 100 cm depth cobble or pebble beds begin: good drainage: area 3,000 acres.

WISSELRODE series 310 Ws – Intergrade to Topomorphic Vertisol, with signs of halomorphism too: brown loam to clay loam, sometimes heavier at depth: calcareous: imperfect drainage: in troughs behind riverain levees: may pass to Vimy: only in Lowveld: area 2,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	5	12	40	18	30	8.2	6.9	1.0	.06
Sub	3	10	37	18	35	8.6	7.2	0.4	.03

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	24.0	6.3	0.5	6.4	37.2	37.6	99	2.8	3
Sub	9.0	5.7	0.4	10.2	25.3	25.3	100	4.0	8

WHITEROCK series 307 Wh — Intergrade to Brown Soil: orange, mode loam at surface but by 100 cm contains white to pale grey lime zone or lime pan: moderate drainage: only in Lowveld: area 2,000 acres.

X set — Actively accumulating coarse textured stratified alluvium of flood plains and stream channels: bare or recently colonized by reeds: so frequently disturbed and redistributed that pedogenesis is impossible: small bands normally too thin to map at 1:125,000 scale: area 7,000 acres (Highveld 1,000 acres: Upper Middleveld 1,000 acres: Lower Middleveld 2,000 acres: Western Lowveld 2,000 acres: Eastern Lowveld 1,000 acres): no slopes over 14% mapped for X set.

XULWANE series 301 Xu — Polychrome gravels: when dry, white or pale brown overall impression from a distance: area 7,000 acres.

Y set — Saline or Saline-Alkali Soil: clay, calcareous as well as sodic (brack): usually more than 120 cm deep: permeability almost nil: flat depressional sites in Lowveld: one dozen patches, minute except that at Balekazulu (D8): area 2,000 acres (Western Lowveld 1,000 acres: Eastern Lowveld 1,000 acres): these are 1967 figures: at maximum extent, around 1963, covered just under 5,000 acres: comments on reclamation are at page 221: no slopes over 14% mapped for Y set.

YOUNGSVLEI series 316 Yo — Dark brown with grey to white saline patches in top 60 cm: produced from K or V or ZL profiles after few years over-irrigation, either on the spot or upslope: area 1,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	12	4	25	11	60	7.9	7.1	1.3	.13
Sub	9	7	24	11	58	8.3	7.1	1.0	.09

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	24.5	9.8	0.6	9.3	44.2	44.2	100	4.7	3
Sub	26.8	10.5	0.4	12.9	50.6	50.6	100	13.0	2

YAKENI series 315 Ya — Dark grey and mottled; in lacustrine alluvium: encroaches on adjacent Ivy series where latter is bench-strip irrigated at Balekazulu: acid top, only calcareous below 90 cm usually: area 1,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	4	23	20	7	50	5.4	4.2	1.4	.13
Sub	3	16	13	4	67	6.8	5.8	0.5	.07

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	7.2	3.0	0.4	0.6	11.2	22.8	49	4.7	5
Sub	4.9	4.0	0.3	2.7	11.9	15.3	77	18.0	1

Z (Highveld) or ZH set — Lithic Kaolisol, presumably Ferralitic: red and orange: medium texture: no marked humus staining in surface horizon: apedal, friable and permeable: from intermediate (sometimes acid) p.m. on upper slopes of Middleveld as well as Highveld, often bordering or amid U set: either erosion proceeds at much the same pace as soil formation or, towards the tops of pediments and apices of fans, M set profiles have been truncated to produce ZH: scattered small patches: area 24,000 acres (Highveld 15,000 acres: Upper Middleveld 8,000 acres: Lower Middleveld 1,000 acres): slopes over 14% make up 79% of ZH set.

ZOMBODE series 521 Zo — Red loam to clay loam: weathering rock by 90 cm depth: most often occurs as enclaves within U set and may grade to Madevu series: area 17,000 acres.

ZAYIFU series 522 Za — Orange loam to clay loam, otherwise as Zombode: clearly less organic matter than Sivulo: might be confined to Highveld: area 7,000 acres.

Z (Lowveld) or ZL set — Solodized Solonetz: Two-Deck profile: thin top of light to medium texture lies abruptly on compact prismatic dark grey sandy clay, over olive-drab lime-rich zone with silty clay fine earth: not high in humus: faintly to appreciably saline: poor drainage: subdued relief, long connecting slopes and, in the case of Zikane and Zebra series, bottoms: intermediate p.m. — especially Ecca sandstone and shale plus subordinate dyke dolerite, colluvially mixed over hundreds of yards or even a few miles: large expanses making the Western Lowveld matrix: little elsewhere: area 187,000 acres or 4½% of Swaziland (Lower Middleveld 3,000 acres: Western Lowveld 160,000 acres: Eastern Lowveld 24,000 acres): no slopes over 14% mapped for ZL set.

ZWIDE series 420 Zd — Surface layer grey or dark grey sandy loam about 30 cm thick: sandy clay bottom deck cracks and swells, stretching and snapping and squeezing roots: damage to them more noticeable even than in Vertisols of K and V sets: principal calcareous horizon, modal depth 110 to 150 cm, has lime puppets up to 8 cm wide: fairly far-travelled and old (possibly Early Quaternary) pedisediment: elevated platforms in Western Lowveld: retains perched watertable for several months in toto annually: area 123,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	31	43	29	10	18	6.2	5.0	1.1	.08
Sub	28	26	24	11	39	7.7	6.2	0.7	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	4.0	3.0	0.5	0.4	7.9	13.2	60	0.7	3
Sub	6.8	5.2	0.3	1.4	13.7	14.0	98	3.0	2

ZWAKELA series 419 Zl — Intergrade from Lithosol: usually only 60 to 80 cm deep, always with less than 20 cm light top: not highly calcareous: often near-sedentary on p.m. of hard shale occasionally shot through by basic dykelets: underdrainage to rock more effective than in other set members: area 35,000 acres.

ZIKANE series 312 Zn — Intergrade from or to Saline-Alkali Soil: light top sometimes absent: deeper than average of set, often 300 cm: in gully wash material of bottomlands and younger than Zwide: same deleterious effects on rooting observed: seasonally waterlogged: area 25,000 acres.

	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	9	29	20	14	37	6.8	5.5	1.4	.12
Sub	7	26	20	11	43	7.8	6.6	0.5	.05

	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	4.8	3.2	0.6	0.5	9.1	13.0	70	0.8	4
Sub	8.2	5.1	0.3	1.4	15.0	15.0	100	2.5	1

ZEBRA series 414 Ze – Pale brown fine sandy loam top is wash of B set material: otherwise internally much as Zwide, but occurs lower in landscape, adjacent to alluvial ribbons: area 4,000 acres.

The writer is indebted to I.C. Baillie for having provided data on his discoveries of the past three years, which resulted in the addition of Gudzeni, Hersov, Mbeli, Sivulo, Zayifu and Zombode series to the above list, and in improved definitions of several more soils. The instigator (1958-1960) of Ebede, Jolobela, Lutzi, Peebles and Thorburn series was J.P. Andriesse, to whom thanks are also due.

Nine additional series names, operative in the past but currently disused, are Bennett Bt (now in Betusile), Cibelomvubu Cb (now in Vimy), Kingsley Ky (now in Vuso), Libetsa Lb (now in Thorburn), Lupondo Lp (now in Orrin), Murphy Mr (redesignated Cimurphy), Newhaven Ne (now in Nduma), Obovane Ob (redesignated Jovane) and Siphoco Sc (now in Sivulo).

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TABLE 17

Routine Analyses

Top	No	CS	FS	Si	Cl	pHW	pHK	OC	TN	Ca	Mg	K	Na	Sme	Tme	V	EC	D
Al	15	18	33	17	32	5.2	4.4	2.7	.20	1.9	0.8	0.2	0.1	3.0	8.6	35	0.1	3
Bu	22	14	66	7	11	6.7	5.6	0.9	.07	5.0	2.3	0.2	0.3	7.8	8.4	92	0.5	4
Be	10	36	34	10	20	6.5	5.4	1.2	.08	5.5	2.4	0.3	0.2	8.4	10.5	80	0.3	9
Co	7	18	16	9	57	6.2	4.8	2.6	.17	5.0	1.9	0.6	0.1	7.6	11.8	64	0.2	2
Cm	11	22	18	13	47	5.0	5.0	2.6	.17	5.3	2.8	0.4	0.2	8.7	16.0	55	0.2	1
Ca	23	13	26	19	42	6.7	5.2	1.8	.12	13.4	5.5	0.8	0.6	20.3	22.4	91	0.8	4
De	5	15	30	15	40	6.7	5.2	2.0	.15	6.0	4.2	0.5	0.7	11.4	16.3	70	0.5	8
Ek	18	62	30	4	4	5.7	4.8	0.5	.04	1.0	0.6	0.1	0.1	1.8	3.9	46	0.1	3
Em	5	61	28	5	6	5.9	4.8	0.7	.05	1.2	0.6	0.1	0.1	2.0	3.4	59	0.1	3
Fe	8	28	30	19	23	6.4	5.0	1.3	.09	5.7	2.8	0.6	0.2	9.3	11.0	84	0.9	3
Fu	12	35	37	12	16	5.5	4.8	1.9	.13	2.5	1.6	0.4	0.1	4.6	8.7	53	0.1	2
Gc	17	55	23	7	15	5.8	4.9	0.8	.05	2.6	1.7	0.2	0.2	4.7	7.8	61	0.5	3
Gb	6	57	32	5	6	5.3	4.4	0.5	.04	1.1	0.3	0.1	0.1	1.6	5.7	28	0.1	9
Ha	26	49	33	6	12	6.0	4.8	0.9	.07	2.5	1.3	0.2	0.2	4.2	6.3	67	0.4	3
Hl	12	39	42	10	9	6.0	4.5	0.9	.07	2.6	1.4	0.2	0.2	4.4	7.6	58	0.4	3
Id	7	50	26	14	10	5.3	4.2	1.4	.09	1.2	0.9	0.2	0.1	2.4	6.5	38	0.0	5
In	9	33	27	20	20	5.5	4.9	1.8	.13	1.7	1.0	0.2	0.1	3.0	6.7	45	0.0	1
Jw	10	39	22	11	28	5.5	4.4	1.7	.12	3.3	1.5	0.4	0.1	3.8	5.5	69	0.1	4
Jb	9	38	29	17	26	5.3	4.2	1.6	.09	1.5	0.8	0.1	0.0	2.4	9.6	25	0.0	4
Jv	5	63	24	6	7	6.2	5.0	0.8	.07	2.5	1.0	0.2	0.1	3.8	5.5	69	0.1	4
Kz	18	9	26	17	48	7.5	5.6	1.9	.12	23.7	9.0	0.6	1.3	34.6	35.8	97	0.8	6

TABLE 17 – Continued

Top	No	CS	FS	Si	Cl	pHW	pHK	OC	TN	Ca	Mg	K	Na	Sme	Tme	V	EC	D
Le	59	36	28	11	25	6.0	5.0	1.4	.09	3.3	1.7	0.4	0.2	5.6	9.7	58	0.4	2
Lo	35	10	28	27	35	6.1	5.0	2.9	.20	5.0	3.8	0.6	0.2	9.6	15.4	62	0.2	3
Ld	17	42	38	9	11	6.4	5.2	1.1	.08	3.2	1.4	0.3	0.1	5.0	8.0	63	0.5	3
Ma	88	33	20	15	32	5.5	4.6	2.0	.14	2.2	1.3	0.2	0.1	3.8	7.6	50	0.2	2
Mt	34	48	13	15	24	4.9	4.5	1.6	.10	1.0	0.7	0.2	0.1	2.0	6.8	29	0.1	3
Mo	20	39	30	11	20	5.5	4.4	1.9	.10	2.7	0.8	0.2	0.1	3.8	10.2	37	0.1	4
Md	34	43	17	14	26	5.4	4.5	1.8	.13	1.6	1.0	0.2	0.1	2.9	7.5	38	0.1	2
Nd	46	28	28	15	29	5.0	4.3	2.7	.18	1.0	0.6	0.2	0.1	1.9	8.7	22	0.1	2
Ot	30	46	38	7	9	6.0	4.8	0.7	.06	1.9	1.0	0.2	0.1	3.2	5.8	56	0.2	4
Or	50	50	27	9	14	5.8	4.8	1.3	.08	1.9	1.0	0.2	0.1	3.2	6.0	54	0.5	3
Ol	8	49	32	9	10	5.7	4.4	2.2	.15	1.0	0.8	0.2	0.0	2.0	4.7	43	0.0	2
Ok	5	27	44	16	13	5.5	4.7	1.8	.13	1.9	2.6	0.1	0.1	4.7	9.0	52	0.1	3
Po	29	52	28	9	11	5.7	4.6	1.0	.06	1.8	0.7	0.1	0.1	2.7	5.6	48	0.4	3
Pt	10	54	30	7	9	6.0	4.9	1.2	.09	3.0	1.2	0.4	0.1	4.7	7.2	65	0.3	2
Qo	22	43	22	10	25	5.7	4.4	2.2	.14	1.5	0.6	0.3	0.1	2.5	6.4	39	0.1	4
Ro	26	16	29	18	37	6.3	5.0	1.6	.12	8.5	4.3	0.5	0.4	13.7	20.8	66	0.9	2
Rt	17	14	27	20	39	6.4	5.2	1.9	.12	6.7	2.1	0.5	0.2	9.5	13.6	70	0.5	2
Rk	14	8	19	17	56	6.2	5.0	1.6	.13	7.0	5.2	0.3	0.3	12.8	20.0	64	0.2	1
Rs	6	10	16	20	54	7.0	6.3	1.9	.16	22.0	6.9	0.3	0.5	29.7	30.4	98	0.3	2
Sa	30	33	22	16	29	5.8	4.8	2.1	.17	2.6	1.9	0.3	0.2	5.0	8.4	60	0.3	2
So	21	24	29	17	30	6.4	5.0	2.0	.16	8.3	6.4	0.5	0.4	15.6	21.4	73	0.4	5
Tx	25	39	32	14	15	4.8	4.2	1.9	.12	0.6	0.5	0.1	0.1	1.3	6.9	18	0.1	2

TABLE 17 – Continued

Top	No	CS	FS	Si	Cl	pHW	pHK	OC	TN	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Tm	10	14	29	20	37	6.1	4.9	2.0	.16	10.7	8.5	0.3	0.5	20.0	31.9	63	0.4	1
Th	7	33	33	10	24	6.0	5.0	1.2	.10	3.4	2.5	0.4	0.2	6.5	11.0	59	0.3	4
Va	8	18	25	13	44	7.7	6.8	2.2	.16	37.8	5.2	0.3	1.2	44.5	44.5	100	0.6	9
Vm	17	9	21	20	50	7.8	6.8	1.4	.12	29.0	8.5	0.7	5.3	43.5	43.5	100	2.6	9
Wn	23	16	57	9	18	6.6	5.5	1.0	.09	3.7	1.8	0.2	0.3	6.0	7.1	84	0.2	3
Ws	5	12	40	18	30	8.2	6.9	1.0	.06	24.0	6.3	0.5	6.4	37.2	37.6	99	2.8	3
Yo	12	4	25	11	60	7.9	7.1	1.3	.13	24.5	9.8	0.6	9.3	44.2	44.2	100	4.7	3
Ya	4	23	20	7	50	5.4	4.2	1.4	.13	7.2	3.0	0.4	0.6	11.2	22.8	49	4.7	5
Zd	31	43	29	10	18	6.2	5.0	1.1	.08	4.0	3.0	0.5	0.4	7.9	13.2	60	0.7	3
Zn	9	29	20	14	17	6.8	5.5	1.4	.12	4.8	3.2	0.6	0.5	9.1	13.0	70	0.8	4
Sub	**No**	**CS**	**FS**	**Si**	**Cl**	**pHW**	**pHK**	**OC**	**TN**	**Ca**	**Mg**	**K**	**Na**	**Sme**	**Tme**	**V**	**EC**	**P**
Al	14	13	42	15	30	5.2	4.4	0.6	.05	0.7	0.5	0.2	0.1	1.5	6.3	24	0.0	1
Be	5	17	59	8	16	6.7	5.8	0.3	.04	4.2	3.1	0.1	0.3	7.7	8.6	90	0.4	3
Co	7	16	12	9	63	5.7	4.8	1.3	.09	4.7	1.2	0.3	0.2	6.4	11.2	58	0.1	2
Cm	10	19	13	12	56	5.8	5.2	0.9	.06	3.8	2.9	0.2	0.2	7.1	12.3	58	0.2	1
Ca	11	24	20	17	39	7.4	6.0	1.2	.09	18.0	4.7	0.5	0.6	23.8	23.8	100	0.6	1
De	4	13	26	19	42	6.7	5.5	0.8	.07	3.9	2.6	0.4	0.4	7.3	9.8	75	0.2	3
Ek	12	64	25	7	4	5.6	4.3	0.1	.02	0.8	0.4	0.1	0.3	1.6	2.8	57	0.6	2
Em	5	72	18	4	6	6.0	4.8	0.2	.02	0.7	0.3	0.1	0.1	1.2	2.5	48	0.1	2
Fe	7	15	27	18	40	5.9	4.9	0.6	.05	2.0	3.7	0.4	0.4	6.5	9.8	67	2.0	1
Fu	10	30	26	15	29	5.4	4.7	0.6	.05	3.3	2.4	0.3	0.2	6.2	10.7	58	0.3	1

TABLE 17 – Continued

Sub	No	CS	FS	Si	Cl	pHW	pHK	OC	TN	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Gc	15	36	25	10	29	6.3	5.1	0.4	.04	2.3	1.9	0.2	0.5	4.9	8.6	57	0.5	2
Gb	4	58	31	6	5	5.9	5.3	0.2	.02	1.6	0.8	0.1	0.2	2.7	5.5	49	0.1	5
Ha	25	34	22	9	35	6.7	5.1	0.3	.04	4.6	4.8	0.2	0.9	10.5	12.0	88	0.5	1
Hl	10	30	25	8	37	6.0	4.1	0.3	.05	3.4	3.9	0.2	0.7	8.2	13.7	60	1.0	4
Id	3	40	18	10	32	5.6	4.4	0.5	.03	1.8	1.7	0.0	0.2	3.7	6.9	54	0.0	2
In	6	28	20	15	37	6.0	5.1	0.7	.04	2.2	1.5	0.2	0.2	4.1	6.0	68	0.1	2
Jw	9	22	16	15	47	5.3	4.8	0.8	.06	2.7	3.0	0.4	0.1	6.2	10.9	57	0.1	1
Jv	4	58	22	7	13	5.8	4.6	0.2	.03	2.1	0.9	0.2	0.1	3.3	6.6	50	0.1	2
Kz	9	17	16	18	49	8.3	7.0	1.0	.08	29.3	12.8	0.4	5.5	48.0	48.0	100	0.8	3
Le	43	30	20	12	38	6.2	5.1	0.5	.04	2.9	1.8	0.2	0.2	5.1	8.4	60	0.5	1
Lo	27	8	23	23	46	5.9	4.9	1.0	.07	3.3	2.9	0.4	0.2	6.8	12.9	53	0.2	1
Ld	12	30	26	10	34	6.2	4.9	0.5	.05	3.6	2.7	0.2	0.2	6.7	11.5	58	0.4	2
Ma	66	26	13	15	46	5.5	4.7	0.6	.05	1.6	1.0	0.2	0.1	2.9	5.4	53	0.1	1
Mt	20	26	13	15	46	5.2	4.7	0.5	.05	0.8	0.6	0.2	0.1	1.7	4.9	36	0.1	1
Mo	15	38	16	12	34	5.2	4.3	0.7	.06	1.9	1.0	0.2	0.1	3.2	9.5	34	0.1	2
Md	24	32	15	16	37	5.4	4.6	0.5	.04	1.2	0.6	0.2	0.1	2.1	4.8	45	0.1	1
Nd	33	24	22	16	38	5.2	4.4	0.6	.04	0.9	0.5	0.1	0.1	1.6	9.0	18	0.0	1
Or	42	48	23	9	20	5.7	4.7	0.5	.04	1.8	0.9	0.3	0.1	3.1	5.4	58	0.2	1
Po	13	44	20	11	25	5.3	4.8	0.4	.03	2.5	1.6	0.2	0.2	4.5	7.4	61	0.4	2
Pt	10	35	22	8	35	6.7	5.1	0.5	.07	2.8	2.3	0.2	0.2	5.5	6.9	80	0.4	2
Qo	20	33	26	11	30	5.5	4.7	0.6	.05	1.3	0.7	0.2	0.1	2.3	5.0	46	0.0	1

TABLE 17 – Continued

Sub	No	CS	FS	Si	Cl	pHW	pHK	OC	TN	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Ro	20	21	23	16	40	6.5	5.2	0.9	.08	10.3	4.9	0.2	0.4	15.8	21.6	73	0.4	1
Rt	13	15	22	17	46	6.3	5.3	1.2	.10	6.0	2.8	0.3	0.3	9.4	12.6	75	0.6	1
Rk	10	15	23	15	47	6.5	4.9	0.7	.05	8.8	10.4	0.3	0.2	19.7	28.0	70	0.2	1
Rs	5	12	16	29	43	8.5	7.1	0.5	.05	28.0	9.7	0.4	1.1	39.2	39.2	100	1.8	7
Sa	24	28	23	14	35	5.9	5.0	0.6	.06	2.3	2.0	0.4	0.2	4.9	7.8	63	0.2	1
Tx	19	17	43	22	18	4.7	4.3	0.2	.03	0.5	0.5	0.1	0.1	1.2	6.3	19	0.0	1
Tm	9	10	13	17	60	6.8	5.5	0.4	.07	14.9	16.2	0.3	0.6	32.0	40.5	79	0.5	1
Th	7	37	19	12	33	6.2	5.0	0.4	.04	2.9	2.5	0.3	0.3	6.0	9.5	63	0.3	2
Va	5	19	13	27	41	8.5	7.2	0.8	.05	32.4	19.0	0.2	1.6	53.2	53.2	100	1.8	2
Vm	12	12	13	18	57	7.9	7.0	0.5	.06	26.3	7.7	0.4	9.8	44.2	44.2	100	11.0	7
Wn	14	13	58	7	22	6.6	5.7	0.3	.04	3.9	1.8	0.2	0.3	6.2	7.3	85	0.3	2
Ws	3	10	37	18	35	8.6	7.2	0.4	.03	9.0	5.7	0.4	10.2	25.3	25.3	100	4.0	8
Yo	9	7	24	11	58	8.3	7.1	1.0	.09	26.8	10.5	0.4	12.9	50.6	50.6	100	13.0	2
Ya	3	16	13	4	67	6.8	5.8	0.5	.07	4.9	4.0	0.3	2.7	11.9	15.3	77	18.0	1
Zd	28	26	24	11	39	7.7	6.2	0.7	.05	6.8	5.2	0.3	1.4	13.7	14.0	98	3.0	2
Zn	7	26	20	11	43	7.8	6.6	0.5	.05	8.2	5.1	0.3	1.4	15.0	15.0	100	2.5	1

For each property 53 Topsoil medians are followed by 47 Subsoil medians.
Abbreviations of soil series and of properties tested appear on pages 103 to 126.

TABLE 18

Additional Analyses

Top			TRACE ELEMENTS						CLAY MINERALS				SAND MINERALS		
	Gr	L	Al	Fe	Zn	Mo	B	Cu	M	I	K	G	Q	Fe	W
Al	–	–	1.6	–	–	–	–	–	0	6	74	20	–	–	–
Bu	–	–	0.5	–	1.8	0.1	2.2	0.3	42	50	8	0	40	13	47
Ca	–	–		0.4	–	–	–	–	86	4	10	0	67	10	23
Ek	–	–	0.2	0.1	–	–	–	–	–	–	–	–	91	2	7
Fu	–	–	–	–	–	–	–	–	–	–	–	–	79	16	5
Gc	–	–	0.2	0.3	–	–	–	–	0	50	50	0	66	25	9
Ha	–	–	0.2	0.2	–	–	–	–	20	40	40	0	86	3	11
Hl	–	–	–	–	–	–	–	–	0	69	31	0	87	9	4
Id	–	–	0.2	–	–	–	–	–	0	11	85	4	–	–	–
Jb	40	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jv	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–
Kz	–	–	3.5	0.1	–	–	–	–	90	6	4	0	80	3	17
Le	–	–	–	–	–	–	–	–	11	32	57	0	70	9	21
Lo	–	–	0.5	–	2.2	0.3	2.4	0.1	0	26	74	0	–	–	–
Ma	–	–	3.2	–	–	–	–	–	0	3	82	15	–	–	–
Mt	–	–	4.6	–	0.7	0.1	0.7	0.5	0	4	76	20	–	–	–
Mo	–	–	–	–	1.3	0.2	0.7	0.3	0	8	77	15	–	–	–
Md	–	–	–	–	1.8	0.1	0.7	0.6	0	9	80	11	–	–	–
Nd	–	–	4.9	–	1.0	0.1	0.3	0.4	0	3	71	26	–	–	–
Ot	15	–	0.5	0.2	1.8	0.1	0.4	0.2	–	–	–	–	88	5	7
Or	–	–	0.8	0.3	–	–	–	–	18	9	73	0	40	7	53
Po	–	–	0.5	–	0.9	0.1	0.4	0.2	–	–	–	–	–	–	–

TABLE 18 — Continued

Top	TRACE ELEMENTS								CLAY MINERALS				SAND MINERALS		
	Gr	L	Al	Fe	Zn	Mo	B	Cu	M	I	K	G	Q	Fe	W
Ro	–	–	1.0	0.6	1.4	0.1	1.2	0.7	7	41	52	0	50	16	34
Rk	–	–	0.3	0.8	–	–	–	–	8	33	55	4	–	–	–
Rs	–	–	0.4	0.5	–	–	–	–	47	33	20	0	27	18	55
So	16	2	1.2	0.3	–	–	–	–	83	10	7	0	63	10	27
Tx	–	–	–	–	–	–	–	–	0	3	92	5	–	–	–
Tm	–	–	0.3	–	–	–	–	–	13	40	40	7	–	–	–
Vm	–	–	0.7	0.2	1.6	0.1	2.5	0.3	90	6	4	0	55	3	42
Wn	–	–	0.3	0.2	–	–	–	–	34	19	47	0	46	8	46
Yo	–	–	–	–	–	–	–	–	86	7	7	0	–	–	–
Ya	–	–	–	–	–	–	–	–	80	10	10	0	–	–	–
Zd	–	–	0.3	0.1	–	–	–	–	63	17	20	0	79	5	16
Sub	Gr	L	Al	Fe	Zn	Mo	B	Cu	M	I	K	G	Q	Fe	W
Ca	–	1	2.5	0.4	–	–	–	–	–	–	–	–	–	–	–
De	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fe	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fu	25	–	–	–	–	–	–	–	–	–	–	–	73	22	5
Gc	47	–	0.3	0.5	–	–	–	–	0	24	76	0	57	38	5
Gb	39	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ha	10	–	0.4	0.3	–	–	–	–	20	30	50	0	76	3	22
Hl	–	–	–	–	–	–	–	–	0	50	50	0	87	9	4
Id	–	–	0.7	–	–	–	–	–	0	9	82	9	–	–	–
Kz	–	2	1.9	0.3	–	–	–	–	76	20	4	0	71	4	25
Le	–	–	–	–	–	–	–	–	14	30	56	0	80	5	15

TABLE 18 – Continued

Top					TRACE ELEMENTS				CLAY MINERALS				SAND MINERALS		
	Gr	L	Al	Fe	Zn	Mo	B	Cu	M	I	K	G	Q	Fe	W
Lo	–	–	0.5	–	0.5	0.4	2.6	0.1	0	26	74	0	–	–	–
Ma	–	–	1.8	–	–	–	–	–	0	9	77	14	–	–	–
Mt	–	–	2.5	–	0.4	0.1	0.5	0.9	0	4	76	20	–	–	–
Mo	–	–	–	–	0.9	0.2	0.8	0.4	0	8	79	13	–	–	–
Md	–	–	–	–	0.9	0.1	0.6	0.5	0	0	87	13	–	–	–
Nd	–	–	1.0	–	1.5	0.1	0.3	0.4	0	0	66	34	–	–	–
Or	26	–	1.7	0.4	–	–	–	–	16	10	74	0	55	6	39
Po	29	–	0.5	–	2.0	0.1	0.4	0.3	–	–	–	–	–	–	–
Pt	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ro	–	–	0.5	0.3	0.7	0.1	0.9	0.6	40	22	38	0	76	9	15
Rk	22	–	0.6	0.7	–	–	–	–	12	33	55	0	–	–	–
Rs	–	3	1.5	0.2	–	–	–	–	60	40	0	0	8	13	79
Sa	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tm	41	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Va	–	9	0.8	–	–	–	–	–	90	5	5	0	–	–	–
Vm	–	4	0.5	0.1	0.4	0.2	5.1	0.3	97	3	0	0	51	3	46
Wn	–	–	0.5	0.2	–	–	–	–	–	–	–	–	42	8	50
Yo	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Ya	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Zd	–	2	0.3	0.1	–	–	–	–	63	22	15	0	69	8	23
Zn	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 18 – Continued

KEY TO COLUMNS –

Gr Gravel and stone, particles over 2 mm, by volume per cent: medians of 9 or less are excluded

L Free lime in diagnostic horizon, as $CaCO_3$ per cent: medians of less than 0.5 are excluded

MANY OF THE FOLLOWING DATA ARE FOR SINGLE PROFILES PER SERIES

Al Exchangeable aluminium, me per 100 g fine earth

Fe Exchangeable iron, me per 100 g fine earth

Zn Mo B Cu Parts per million "available" zinc, molybdenum, boron and copper

M I K G Montmorillonite, illite, kaolinite and gibbsite in clay fractions, adjusted to total 100: other minerals of this size found include goethite, quartz and rarely halloysite, hematite, limonite, smectite, vivianite

Q Fe W Quartz-garnet-zircon, iron ore and weatherable minerals in sands, adjusted to total 100

KEY TO LINES –

Abbreviations of soil series, as on pages 105 to 126

Top and Sub are explained on page 103

– Signifies excluded analyses (under Gr and L) or no data (under other headings)

LABORATORY RESULTS:

Except for a few analyses of waterholding capacity, reported in Murdoch and Andriesse (1964), the writer has performed no indoor tests on soil samples. Laboratory results are nonetheless essential to complement narrative soil descriptions, and the following soil scientists have worked on some among the 3,900 samples for which determinations have been made. Their contribution to pedology in Swaziland is greatly appreciated.

(a) At Malkerns Research Station — P. Jackson and L.A. Whelan.

(b) At African Explosives and Chemical Industries, Johannesburg — B.C. Beuthin and P. Van Steenderen and colleagues.

(c) At the Soil Research Institute, Pretoria — H. Weber (on clay minerals).

(d) At the University of Natal, Pietermaritzburg — L.P. Van Reeuwijk and I.C. Baillie (on clay minerals).

(e) At Mount Edgecombe Research Station, Natal — B.E. Beater and R. Maud and T. Sexton.

(f) At Government laboratories in Salisbury, Rhodesia — R.N. Thomas and colleagues.

(g) At Rothamsted Experiment Station, Harpenden, England — C.L.. Bascomb and G. Brown.

(h) At the Royal Tropical Institute, Amsterdam, Holland — H. Kiel and K. Muller.

The results are gathered together at Table 17 of routine analyses quoted in the foregoing index. Laboratory studies undertaken less commonly on the same series are summarized, again using median values, at Table 18. For the majority of samples the routine analytical procedures have been those of Bouyoucos — mechanical analysis, Walkley and Black — organic carbon, Kjeldahl — nitrogen, Schollenburg — exchangeable cations, and Bray — phosphorus (with some findings according to methods of Truog, Olsen, Morgan etc. converted by P. Jackson to approximate Bray readings). The other research has been done by means of differential thermal analysis and X ray diffraction (clay minerals), microscopic examination of the 30 to 500 microns fractions (sand minerals) and Rothamsted techniques for quantifying trace elements.

The writer is conscious that Tables 17 and 18 infringe the tenets of Orchard (1965)

TABLE 19

National Medians and Means of Analyses

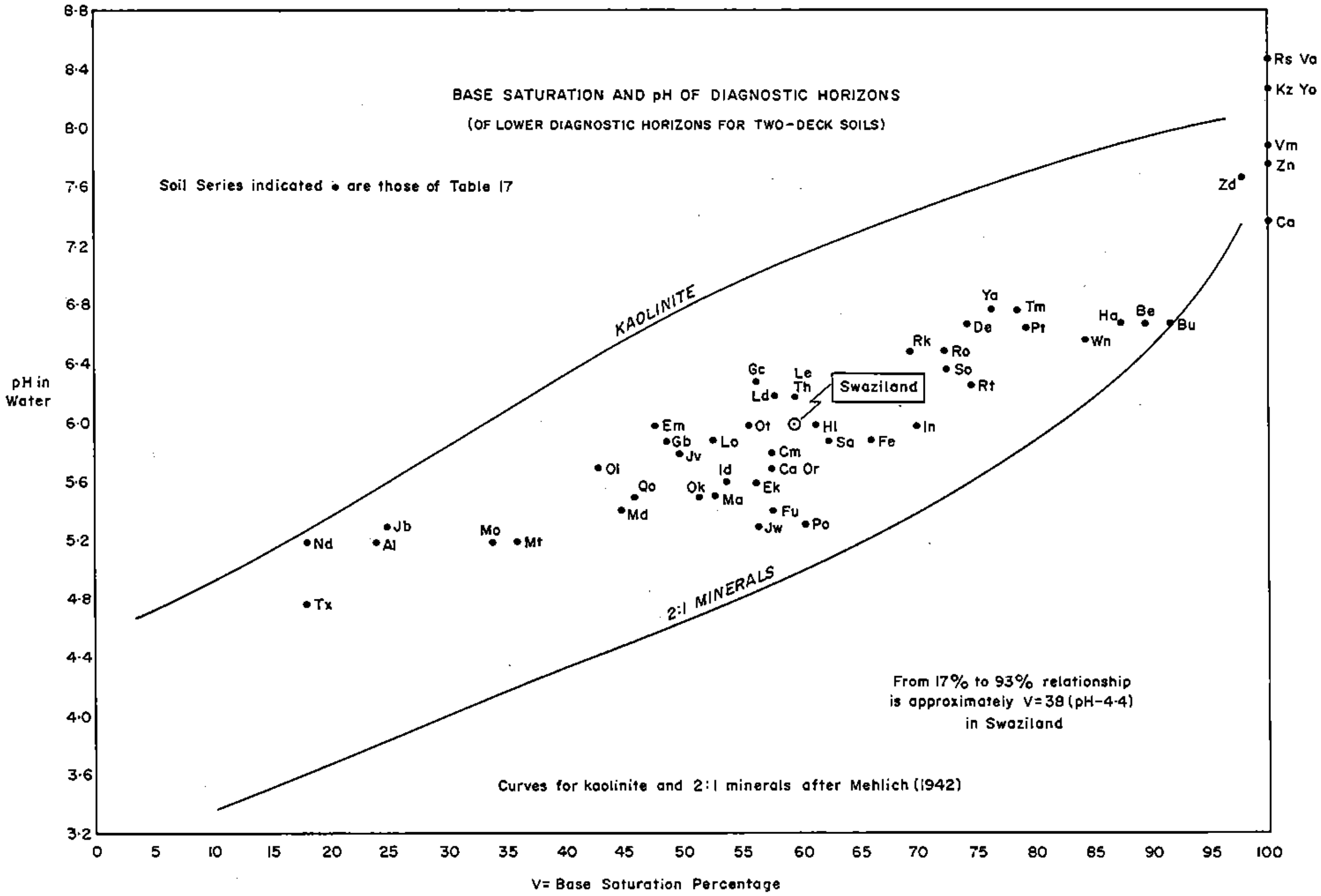
	No	CS	FS	Si	Cl	pHW	pHK	OC	TN
Top	1007	34	28	11	27	6.0	4.9	1.7	.12
Sub	683	26	24	11	38	6.2	5.1	0.6	.05
	Ca	Mg	K	Na	Sme	Tme	V	EC	P
Top	3.2	1.8	0.3	0.2	5.5	9.4	58	0.3	3
Sub	3.4	2.5	0.2	0.3	6.4	9.8	66	0.4	2

ABOVE — Medians for topsoils of the 53 series and subsoils of the 47 series listed in Table 17: abbreviations on page

BELOW — Gravel and lime medians are for all the Table 17 series: Al and trace element medians are from Table 18 as are clay mineral means (for series with both Top and Sub results): sand mineral means are not of value nationally as soils without weatherable minerals were deliberately left unsampled, but the data must be close to "average" for the Lowveld: abbreviations are in Table 18.

	Gr	L	Al		Fe	Zn	Mo	B	Cu
Top	3	0	0.5		0.2	1.6	0.1	0.7	0.3
Sub	6	0	0.5		0.2	0.8	0.1	0.7	0.4
	M	I	K	G		Q	Fe	W	
Top	18	22	54	6		66	9	25	
Sub	20	19	54	7		60	11	29	

FIGURE 13


BASE SATURATION AND pH OF DIAGNOSTIC HORIZONS
(OF LOWER DIAGNOSTIC HORIZONS FOR TWO-DECK SOILS)
Soil Series indicated • are those of Table 17
KAOLINITE
2:1 MINERALS
Swaziland
From 17% to 93% relationship is approximately V=38 (pH-4·4) in Swaziland
Curves for kaolinite and 2:1 minerals after Mehlich (1942)
pH in Water
V= Base Saturation Percentage
8·8
8·4
8·0
7·6
7·2
6·8
6·4
6·0
5·6
5·2
4·8
4·4
4·0
3·6
3·2
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Rs Va
Kz Yo
Vm
Zn
Zd
Ca
Ya
Tm
De
Pt
Ha
Be
Bu
Wn
Rk
Ro
So
Rt
Gc
Le
Th
Ld
Em
Ot
Hl
In
Gb
Lo
Sa
Fe
Jv
Cm
Oi
Id
Ca Or
Qo
Ok
Ek
Ma
Md
Fu
Jw
Po
Jb
Mo
Nd
Al
Mt
Tx

who, speaking about fertilizer advisory services, stressed that analytical data obtained by empirical methods can be used successfully only if those methods are "adjusted for variations in the pedological nature of the soil". Errors due to routine analysis having sometimes been employed on non-routine soil (strongly acid, highly calcareous, alkaline etc.) may even be compounded by the collection of data from several sources. However it is heartening that, despite occasionally inappropriate laboratory techniques, pooled results for series are in line with those elsewhere, as regards their statistical variability – see page 146.

The number of samples to which Table 17 refers is 1,690. The remaining 2,210 analysed to date comprise either (a) third, fourth etc. samples of the same series or (b) different, less commonly examined series or (c) soils, except Y set, that are too far from their virgin state to be included – particularly those from fields known to have had heavy fertilizer dressings. The most-sampled series, with more than one profile per 1,000 acres on average throughout the country, are Alicedale, Betusile, Cimurphy, Delcor, Lesibovu, Lomahasheni, Ludomba, Malkerns, Mdutshane, Thorburn, Vimy, Winn, Wisselrode, Yakeni and Youngsvlei. For Africa this is a very high density of soil testing: and in addition to these 15, another 30 series have a topsoil analysis for every 1,000 to 5,000 acres.

From all the determinations one can in turn build up an account of the hypothetical "average" Swaziland soil series. This is done in Table 19. Of course no such pedons exist, unless by a fluke, and as the medians relate to 53 series, not to all, they will be imprecise. As a rough guide to where particular series stand, in national perspective, Table 19 has merit, however.

In general the analytical results provide no surprises and are consistent with profile morphological traits. The main exception is CEC and base saturation of Ferralitic Soils, which rather frequently contravene the SPI injunctions (namely T value less than 20 me per 100 g clay and V 40% or less). This is most blatant in Highveld sets – A and CH and NH – where the T on subsoil clay is 18 to 24 me, median value. A and NH exhibit suitably low S values on clay but Coseni series has 10 me and Cimurphy series 13 me, in both cases 58% saturation. The classification Ferralitic has nonetheless been allowed to stand for all these sets – and for QH, which is marginal – because firstly there is no gainsaying the profile features, secondly incomplete dispersion prior to mechanical analysis of such sesquioxide-rich soils, causing underestimates of clay, is notoriously difficult to avoid, and thirdly it may be that extraction of more Ca Mg K Na H than the readily exchangeable amounts took place at times, i.e. answers were obtained lying much closer to the "maximum positive" charge of Mehlich (1960) than to his "permanent" charge. The clay mineralogy of Alicedale and Nduma series corroborates their Ferralitic status: no clay mineral counts for CH set are available.

A useful linear correlation exists between V percentages and pH in water – see Figure 13 – and further derived data which are of interest pedologically include silt/clay ratios, differences between pH in water and pH in KCl, C/N ratios, variations of clay content and pH from topsoil to subsoil etc. All can be had by perusal of Table 17.

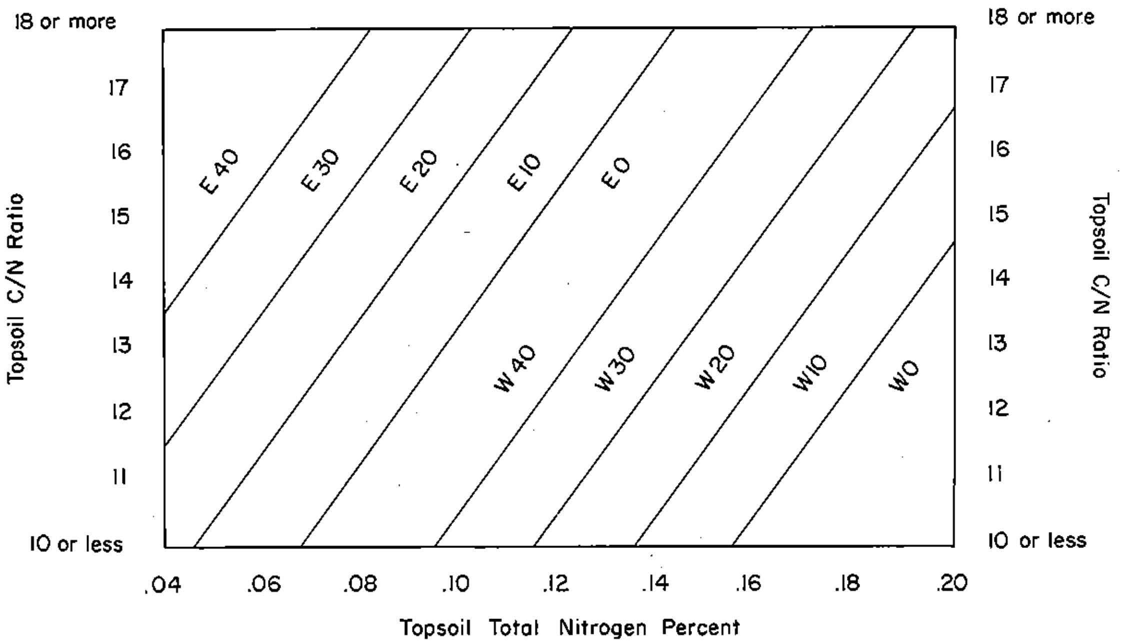
FERTILIZER NEEDS:

The requirement of raingrown maize, yielding 1.0 to 1.5 tons per acre grain, for the three major nutrients has been studied by D.B. Latham and the writer. The following rough relationships have been found, based on field trials of the past decade, initiated by A.C. Venn. Results from early years are reported in Jones and Murdoch (1965).

(a) Nitrogen is much less limiting in the Eastern Lowveld and on the Lubombo than in other regions, presumably because of the more rapid mineralization that takes place at

FIGURE 14

Nitrogen Need



Strip labelled E40 indicates 40 pounds per acre N need for raingrown maize, E30 indicates 30 pounds per acre... W10 indicates 10 pounds per acre, W0 indicates no N required.

E stands for Eastern soil sets viz. B CL DL H JL K L NL QL R SL TL V W Y ZL, part of F O
W stands for Western soil sets viz. A CH DH E G I JH M NH P QH SH TH ZH, part of F O
E includes Fe Fr Ot Ou Om and Os series, while W includes Fu Or Ol and Ok series.

the first rains in the east, during the warm late winter and hot early summer. Moreover close links between N need and C/N ratio are evident, the former increasing as the latter does. The nomogram of Figure 14 reflects both these factors.

(b) Phosphorus is necessary in approximately these quantities: nil if topsoil Bray values are 8 ppm or more of elemental P: 10 pounds per acre — again elemental P — if 5 or 6 or 7 ppm are recorded: 20 pounds per acre equivalent to 3 or 4 ppm: and 30 pounds per acre equivalent to 1 or 2 ppm. Sandy soils are seen from Table 17 to have the highest available P contents, relative to other nutrient elements.

(c) Potassium is not chronically deficient. To most soils with 0.2 me exchangeable K or more none should be applied: with 0.1 me K only about 10 pounds per acre of the element. However, sandy texture may indicate a need for occasional extra potash, and with intensive cropping "maintenance" dressings are advisable.

The NPK recommendations which result from these arithmetical exercises deriving from soil analysis are compared in Table 20 with current Ministry of Agriculture advice, and good agreement is revealed, especially as regards N and P. It should be stressed, however, that the information in Table 20 indicates no more than likely NPK deficiences which maize will experience on new fields or on recultivated old fallow. The exact requirement of a particular field will depend on cropping history, past doses of artificials and/or dung, stage of erosion or exhaustion etc. Amounts of NPK, on a national scale, that these findings imply should be given to maize are discussed on page 269. The best compounds to use are, generally, calcium ammonium nitrate for N in the west, ammonium sulphate in the east, triple superphosphate and muriate of potash. Both straights and mixtures are used. On this subject Mapham (1965) gives much more detailed recommendations, for maize and other crops.

On the way to arriving at Table 20 the writer and colleagues contrived to present crop nutrient lack by the order of importance of missing elements. The sequence of elements in each panel of Table 21 suggests their priority as nutrients, and farmers with limited funds available are encouraged to apply all of the first element, then all the second and so on, rather than pro rata reductions of every element, to obtain the best possible yields. CaMg amounts are one fifth of the dressing actually applied if dolomitic lime is broadcast once every 5 seasons, though in certain forms even these elements can be given annually. The very small amounts of lime to use, compared with spreadings of several tons per acre on temperate climate acid soils, reflect the need in Swaziland for calcium as plant food but not as an ameliorant of texture or catalyst of bacterial activity. The lime requirement table of Gardner (1950) for cropland on kaolinitic-illitic English soils would, if employed in Swaziland, give maximum apparent needs of 4 tons per acre (by Nduma and Mtilane series) but, as Jackson, Venn and I'Ons (1965) state, experiments on major crops have shown no significant responses, even on the Highveld, to rates above one ton per acre $CaCO_3$ equivalent every few years.

In several soils besides those shown as requiring dolomite at Table 21 the Ca/Mg ratio is suboptimal, and such imbalances may prove difficult to correct where pH is already high. Series with subsoil ratios of unity or less include Felwako, Habelo, Hlunya, Juweel, Rhebok, Tateni and Tambankulu. Ongeluk topsoil is also highly magnesian.

Jackson, Venn and I'Ons (1965) refer to the many trace element responses that are reproducible in the Upper Middleveld and Highveld. Farmers commonly put on zinc sulphate and treatment of maize seed with sodium molybdate has increased markedly of late. Jones and Murdoch (1965) note that iron and manganese are least abundant in Regosols, Vertisols and Solodized Solonetz, and that sulphur deficiencies have not shown up in the field, although demonstrable in glasshouse pot trials when S is withheld.

TABLE 20

N P K Requirement

Series	RESEARCH ADVICE 1967-1968			THEORETICAL CALCULATIONS			AGREEMENT BETWEEN PRACTICE and THEORY			
	N	P	K	N	P	K	N	P	K	All %
Ca	0	30	0	0	20	0	1	0	1	67
Ha	20	20	10	20	20	10	1	1	0	67
Le	30	30	10	20	30	10	0	1	1	67
Lo	0	20	0	0	20	0	1	1	1	100
Ma Mt	30	30	40(a)	40	30	0	0	1	0	33
Nd	20	30	30(a)	20	30	0	1	1	0	67
Ot	20	20	10	20	20	10	1	1	0	67
Or	40	20	10	40	20	10	1	1	1	100
Po Pt	40	20	10	40	20	20	1	1	0	67
Qo	40	30	20	40	20	10	1	0	0	33
Ro Rt	0	30	0	0	30	0	1	1	1	100
Sa	10	30	0	10	30	0	1	1	1	100
So	0	30	0	0	10	0	1	0	1	67
Tx	40	30	20	40	30	20	1	1	1	100
Mean	21	27	10	21	24	6	86%	79%	57%	74%

First six columns of numbers are pounds per acre of elements (not oxides) for raingrown maize: in next three columns 1 means yes and 0 means no.

BASIS FOR THEORETICAL CALCULATIONS: N = Graph in Figure 14. P = Formula 39 – 5B where B is Bray phosphorus ppm in topsoil: positive answers rounded to nearest 10: for negative answers 0 is recorded. K = Formula 20 – 100M ÷ C where M is me potassium in topsoil, per 100 g fine earth, and C is 10 if topsoil clay 26% or less, 0 otherwise: answers treated as for P.

(a) Assuming dolomitic lime spread same year: reducible to 20 or 10 if there have been previous K applications, or if newly ploughed from uneroded rough pasture, or more than one season after liming.

TABLE 21

Plant Food Priorities

Region or Sub-region	High-veld	Upper Middle-veld	Lower Middle-veld	Western Lowveld	Eastern Lowveld	Lubombo Range
RED SOILS	NH	M	L	L R	R	L
	Ca 60	Ca 80	P 30	P 30	P 30	P 20
	Mg 40	Mg 60	Zn 10	Zn 10		
	P 30	Zn 10	N 30	N 30		
	Zn 10	K 40	K 20			
	K 30	P 30	Ca 20			
	N 20	N 30				
GREY SOILS	TH QH	O P	O P	O H	Rare	O
	P 30	P 30	P 20	P 20		P 10
	Zn 10	Zn 10	Zn 10	Zn 10		N 20
	K 20	N 40	N 40	N 40		K 10
	N 40	K 20	K 10	K 10		
	Ca 30	Ca 20				
DARK SOILS	SH	SH	Rare	SL	CL SL	Rare
	P 30	P 30		P 30	P 30	
	Zn 10	Zn 10		N 20		
	Ca 20	N 20				

Examples of typical soil sets are given. Numbers are pounds of element to apply per acre per maize crop, raised from molybdenum-treated seed.

Although chiefly for raingrown fields, these recommendations are made on the assumption that moisture is not a limiting factor, so the Lowveld entries are superfluous, unless irrigation can be resorted to.

TABLE 22

Soil Series of Texas, Puerto Rico and Swaziland Compared

Series and Country (a)	Top or Sub	No. (b)	Clay Percent		pH in Water		Organic Matter (c)		Calcium me	
			Med	SIQR	Med.	SIQR	Med.	SIQR	Med.	SIQR
Ruston	Top	17	5	2	5.6	0.3	0.9	0.4	0.9	0.3
(USA)	Sub	17	22	6	5.1	0.3	0.2	0.1	0.8	0.5
Mdutshane	Top	22	25	8	5.4	0.3	2.6	0.7	1.0	0.3
(Swaziland)	Sub	13	38	7	5.5	0.4	0.7	0.2	0.6	0.4
Jacana	Top	9	48	11	6.4	0.5	4.0	0.5	22	5
(Puerto Rico)	Sub	9	22	5	7.1	0.6	0.3	0.1	20	4
Rondspring	Top	20	37	6	6.3	0.4	2.8	0.5	8	4
(Swaziland	Sub	11	44	7	6.5	0.2	1.6	0.4	9	3
Wilson	Top	13	----------------		5.7	0.4	1.5	0.3	----------------	
(USA)	Sub	13	----------------		7.2	0.6	0.8	0.3	----------------	
Zwide	Top	20	----------------		6.5	0.5	1.8	0.4	----------------	
(Swaziland)	Sub	16	----------------		7.9	0.4	0.7	0.3	----------------	
Austin	Top	13	----------------		8.0	0.2	2.4	0.5	----------------	
(USA)	Sub	13	----------------		8.0	0.2	2.0	0.6	----------------	
Kwezi	Top	18	----------------		7.4	0.6	3.1	0.7	----------------	
(Swaziland)	Sub	9	----------------		8.3	0.4	1.7	0.5	----------------	

TABLE 22 – Continued

Series and Country (a)	Top or Sub	No. (b)	Clay Percent Med.	Clay Percent SIQR	pH in Water Med.	pH in Water SIQR	Organic Matter (c) Med.	Organic Matter (c) SIQR	Calcium me Med.	Calcium me SIQR
Houston	Top	12	66	8	8.0	0.1	2.3	0.5	34	9
(USA)	Sub	12	53	7	8.0	0.2	1.1	0.2	30	10
Vimy	Top	15	50	10	7.9	0.3	2.4	0.6	28	9
(Swaziland)	Sub	10	53	12	8.2	0.4	0.5	0.4	28	9
Mean (d)	Top	13	40	7	6.8	0.3	2.1	0.4	19	5
(Transatlantic)	Sub	13	32	7	7.1	0.4	0.9	0.3	17	5
Mean (d)	Top	19	37	8	6.7	0.4	2.5	0.6	12	4
(Swaziland)	Sub	12	40	9	7.3	0.4	1.0	0.4	13	4

NOTES:
(a) Texas references Kunze et al (1959), Godfrey et al (1963): Puerto Rico references Roberts (1942) and Carter (1965): also Soil Conservation Service archives in Fort Worth and San Juan. For Zwide and Kwezi only items with Texas counterparts are included.
(b) Number of samples.
(c) Percentages: Swaziland figures are 1.7 times organic carbon.
(d) Unweighted averages.

Sodium salt excess is only a problem in Y set and in the series which can most readily be pushed over the borderline to Youngsvlei or Yakeni, namely those of K or V or ZL sets, plus Wisselrode and Ivy. Lea, Murdoch and Dicks (1963) suggest that a topsoil conductance of 4 mmhos be regarded as the threshold of salt tolerance for NCo310 sugarcane. Both Y set series have nearer 5 mmhos as their median and no other soil exceeds 3 mmhos.

Although the inherent fertility of many Swaziland soil sets, particularly in the west of the country, is low or very low and multiple nutrient deficiencies occur, the impressive agricultural research programme since 1955 – largely organized by A.C. Venn – has indicated that insurmountable technical barriers to raising productivity are rare. Almost every soil series* which can be regarded as "arable" on other grounds – depth, texture, structure, drainage etc. – is also fertile already or could be made so economically. Because of this, soil fertility is not a factor which needs to be evaluated separately when land capability is being assessed – see further on page 197.

SERIES VARIABILITY:

In 1966 the writer was able to compare Swaziland soils with some series in Texas and Puerto Rico, by courtesy of L.J. Bartelli and L.H. Rivera and their colleagues. Using analytical data then available, medians and semi-interquartile ranges for pairs of series were obtained, each pair being reasonably analoguous morphologically and chemically – see Table 22 for examples. From the unweighted averages of SIQR and also from the Illinois study by Liu and Thornburn (1965) it seems that Transatlantic soils are slightly more homogeneous: but mainly typifying pedons were chosen for analysis in the USA and Puerto Rico while the Swaziland soils express the range of characteristics within each series, so there is no cause for alarm at the greater variability here.

A more refined statistical appraisal by R. Webster of laboratory data relating to 470 soil profiles in 22 Swaziland series has yielded results set out in Table 23. He states that all intraclass correlations are significant at the 0.1% level, and also that similar rather high coefficients of variability apply to batches of English soil series he has investigated – Webster (1965). The writer is most grateful for these valued comments.

FURTHER DIAGNOSTIC FEATURES OF SERIES:

Three highly significant horizons in the warmer parts of the United States – most nearly comparable physiographically with Southeast Africa – are oxic, calcic and natric. Which Swaziland series have these kinds of horizon? Taking oxic first, Table 24 shows that only Malkerns and Mtilane, out of the nine listed, unequivocably qualify on clay amount and type, with Mdutshane a possibility. Because it also possesses an argillic horizon Malkerns would not, however, be permitted in the Oxisol order: Mtilane undoubtedly could be placed there.

No series with calcic horizons – more than 15% free lime, as required by Smith et al (1960) – appear in Table 18, but individual Kwamtusse and Whiterock calcareous pan analyses reach that amount. Natric horizons, with sodium more than 15% of all exchangeable bases, include subsoils of Vimy, Wisselrode, Youngsvlei and Yakeni series. The alternative desideratum, a ratio in milliequivalents of subsoil Na+Mg/Ca+H exceeding unity, is also approached by Habelo and Zwide, each with 0.9 Qualm series has not been tested.

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*Ongeluk and Ngazi may be unimportant exceptions.

TABLE 23

Series Variability

	m	s	v	r
Clay % Topsoil	24	6.7	28%	0.77
Clay % Subsoil	35	11.4	32%	0.49
pH in Water: Topsoil	5.9	0.54	35%	0.69
pH in Water: Subsoil	6.2	0.50	30%	0.77
Organic C % Topsoil	1.5	0.52	34%	0.58
Organic C % Subsoil	0.6	0.34	61%	0.33

m = Mean of all readings: 470 profiles in 22 series

s = Standard deviation, in this case equivalent to square root of pooled variance

v = Coefficient of variation

r = Intraclass correlation

TABLE 24

Oxic Horizons

	Clay %	T Value (a)	Permanent Charge			Qualifications out of 3
American Specifications (b)	Over 15	Under 16	Under 10			3
Swaziland Candidates (c)			S +	Al =	P (d)	
Alicedale	30	20	5	4?	9?	Probably 2
Coseni	63	18	10	3?	13?	1
Cimurphy	56	22	13	5?	18?	1
Malkerns	46	12	6	4	10	3
Mtilane	46	11	4	5	9	3
Mooihoek	34	27	9	3?	12?	Probably 1
Mdutshane	37	12	6	4?	10?	Either 2 or 3
Nduma	38	24	4	3	7	2
Qolweni	30	17	8	2?	10?	Either 1 or 2

NOTES:
(a) Cation exchange capacity (Ca Mg K Na H) me per 100 g clay.
(b) Selection from pages 28 to 33 of Kellogg (1967).
(c) All analytical data are for subsoils, as in Tables 17 and 18.
(d) Permanent charge P = Ca Mg K Na Al me per 100 g clay: only 3 of the 9 series have subsoil exchangeable Al determinations and numbers followed by ? are estimates.

TABLE 25

Textural Grouping

SWAZILAND NAME	DEFINITION (a)	53	SWAZILAND SERIES (b)
Very Fine	50% or more clay	6	Co Cm Tm Vm Yo Ya
Fine	35% to 49% clay	24	Ca De Fe Ha Hl In Jw Kz Le Lo Ma Mt Md Nd Pt Ro Rt Rk Rs Sa Va Ws Zd Zn
Medium	18% to 34% clay	13	Al Fu Gc Id Jb Ld Mo Or Po Qo So Th Wn
Coarse	10% to 17% clay	6	Bu Be Jv Ol Ok Tx
Very Coarse	9% or less clay	4	Ek Em Gb Ot

NOTES: (a) Clay under 2 microns: only diagnostic horizons (or lower diagnostic horizons) considered.

(b) For full names of series see pages 105 to 126, clay percentages are those of subsoils except Bu Jb Ot Ol Ok So Tx.

The grouping of series into textural divisions, as if for classification in the style of American families, may be done as in Table 25, omitting the adjective Skeletal, which could be applied where particles larger than 2 mm make up more than 35% of the soil by volume — see Table 18 for some of the Swaziland series concerned. Because silt is low in Swaziland, only 11% on average, the maximum series median being 29% for Rasheni subsoil, approximately equivalent American terms (in brackets) to the proposed five local names would be Very Fine (Very Fine), Fine (Fine), Medium (Fine-Loamy), Coarse (Coarse-Loamy), and Very Coarse (Sandy).

Another attribute of the family, already referred to on page 26, is soil temperature, for which Kellogg (1967) has introduced prescribed boundaries. Swaziland's pedoclimatic isotherm of 72°F — critical to the American scheme — probably passes through the Lower Middleveld but not enough is known as yet about its course to decide whether it separates unlike soils satisfactorily. In that subregion pairs such as L and M sets, SL and SH sets, R or CL and CH sets, Zikane and Ingoje series and (less clearcut) Otandweni and Orrin series are all divided, but at elevations descending from about 1,750 feet to 1,400 feet in the order of the dichotomies cited. Some of these partings may run the length of a good limiting isotherm. However, this could be a fit enforced at the expense of Lubombo Range soils: such series as Lomahasheni and Stegi transgress to 2,600 feet altitude, so could not join a hyperthermic family. Both Swaziland and the Republic of South Africa might find thermic categories useful in distinguishing "true Highveld" from lower Pseudopodzolics — e.g. pockets of H set at Cibide (Y4) are certainly not hyperthermic, whereas the main bodies of H soils far to the east are. In the Lower Rio Grande valley, the part of the USA most akin to Swaziland latitudinally and climatically, soil isotherms are playing havoc with mapped areas of some long-established series which must now be split, although they are of value in differentiating others. Smith et al (1960) are satisfied that a given soil isotherm is meaningful in all kinds of profiles pedologically, but one wonders if this will necessarily be so as regards crop root environment. From that viewpoint, varying moisture regimes and ranges of texture and structure might mean that a certain temperature signifies different things in different soils.

COLOUR AIR PHOTOGRAPHY FOR SOIL MAPPING:

Favourable reports by Colwell (1960), Simakova (1964) and others on the use of colour aerial photographs to delineate soil boundaries led the writer and I.C. Baillie to test their applicability in Swaziland. The experiment was a success and it is strongly recommended that in all future soil-photographic flying true colour or infrared colour film be used. Fees have gone down recently and are now little more than for black-and-white. Savings in ground checking time must soon offset the small additional cost.

In the experiment the only type of terrain which could in certain circumstances be observed better on black-and-white than on colour photos was rocky land (U set) which the former often render uniformly pale grey to white, whereas in colour the rock hues, especially of melanocratic basic crystalline formations, may be confused with those of adjacent Lithosols. With that proviso, the complete superiority of colour was evident. Details of the study follow, and Table 26 summarizes results using the Munsell (1954) notation.

The site chosen was Sipofaneni (Q7) and an arc of 8 miles on the north bank of the Usutu around that village. The locality has a great variety of geology, from very acid to ultrabasic rocks — Scogings and Lenz (1953) — and there was known to be an even greater complexity of soils, which the 1:125,000 Soil Map manages to hint at, though it is naturally a generalization in this area as elsewhere. At the end of the 1965 winter when vegetation was least

TABLE 26

Soil Colour in the Field and on Air Photos

Soil	Airdry Topsoil in Situ	Areas with Sparse Natural Vegetation (a)	Recently Ploughed Fields (b)
B	10 YR 5/4	10 YR 8/3	10 YR 5/1
CL	5 YR 2/2	7.5 YR 6/4 (c)	?
E	10 YR 6/1	N 9/0	10 YR 8/1
H	10 YR 4/2	10 YR 8/1	10 YR 6/1 (c)
K	10 YR 2/1	N 5/0	N 3/0
L	5 YR 3/4	2.5 YR 7/4	10 YR 3/6
O	10 YR 5/2	5 YR 8/1 (c)	7.5 YR 6/2 (c)
R	5 YR 3/3	10 YR 5/3 (c)	10 YR 3/4
SL	7.5 YR 3/2	5 YR 7/2 (c)	5 YR 4/1 (c)
U	rocky	5 YR 8/2 (c)	nil
W	5 YR 4/5	5 YR 8/4	2.5 YR 6/6
X	pebbly	7.5 YR 8/1	nil
ZL	10 YR 3/1	10 YR 7/2 (c)	10 YR 4/2

NOTES: (a) On vertical photographs: including abandoned croplands as well as virgin savanna, but excluding severely gullied patches.

(b) On vertical photographs: rains permitting cultivation had been succeeded by several dry weeks during which wetting fronts receded into subsoil and rock, so moisture differences did not hamper soil identification.

(c) Indicates most variable contact print images.

luxuriant, Map Studio Productions of Johannesburg flew the required segment, using a Zeiss camera to produce contact stereo-pair prints 8 inches square at about 1:20,000 scale. Early in 1966 the ground survey of 13,000 acres was done, with rapid plotting of soil series and soil set limits. As Table 26 shows, not only were the sets satisfactorily separable on the photos, but their span of hues, over 5 Munsell pages from 10 R to 10 YR, was wider than the range of modal airdry topsoil colours in situ – the 3 Munsell pages 5 YR to 10 YR – so further facilitating correct identification.

SERIES COMPARED INTERNATIONALLY:

Swaziland soils must be duplicated in the Republic of South Africa and Mozambique, at least along common frontiers, and joint field trips with pedologists from those countries have permitted fairly precise correlations at series level to be made. Nevertheless South African series have not settled down yet to uniform interpretation throughout all four provinces by every organization engaged in soil survey. This is mainly because one province, Natal, pioneered series nomenclature. The latest catalogue of 213 series issued by Aircraft Operating Company Technical Services (1967) omits at least 55 series names previously published in works by M'Vicar, Loxton and Van Der Eyk (1965), Beater (1957-1962), De Villiers (1962), Loxton (1962), M'Vicar (1963), Thorrington-Smith (1960) and Van Der Eyk (1965). All these sources have been tapped and some named profiles of Van Der Merwe (1940), which seem to differ from anything described later, have been added in order to arrive at the 69 South African soils chosen for comparisons made below. An interestingly different array is assembled by Baillie (1968). It is emphasized that both this selection and his give, for the most part, roughly equivalent units to local series cited, not the absolute analogues which are known in many cases to exist, as South African modal profiles and optimum limits will not always coincide along the continuum with modes of and breaks between Swaziland series.

As well as 300 or so South African series and named pedological sites, approximately the same number of series etc. in six other African countries were glossed and 104 of these are incorporated into the comparative lists. The Mozambique representatives are series of Barradas (1962) or group members which can fairly easily be related to series, using placenames accorded them by Gouveia and Azevedo (1955). The Lesotho sets of Carrell and Bascomb (1967) have been studied. For Rhodesia Thompson (1965) is quoted – his letter-digit suffixes are readily distinguishable – as well as earlier series descriptions by Thompson (1957), Du Toit (1957), Young et al (1952) and Ellis (1951). In Tanzania the vernacular soil vocabularies of Milne (1947) and Malcolm (1953) were referred to, along with series of Anderson (1957). Kenyan series are reported by Jones (1948) and Thorp et al (1960), while the compendium of more than 130 Ugandan series, complexes and catena members collected by Chenery (1960) as a result of his researches and those of J.F. Harrop, C.D. Ollier, S. Radwanski and J.G. Wilson has yielded apparently comparable profiles. But even for these areas the soils examined in the literature and in the field (visits have been paid to parts of each country) are not exhaustive, and there may well be series of which the writer is unaware that are more directly comparable to some in Swaziland. Juxtapositions below must be regarded as subjectively selective. To make them more comprehensive will involve much travel – including journeys to e.g. Malawi and Angola – and this remains a longterm objective.

Three inventories follow – (a) 82 Swaziland series associated with the 69 soils from (S) South Africa and 27 from (R) Rhodesia, 25 from (U) Uganda, 23 from (T) Tanzania, 18 from (M) Mozambique, 7 from (K) Kenya, 4 from (L) Lesotho: (b) these 173 other soils with abbreviations for associated Swaziland series: and (c) Swazi language soil and landform names with the series which most centrally represent them – not perhaps so rich and definitive a range as the soil terminology over much of East Africa, but an indication that consciousness of soil differences by the Swazi is fairly advanced. In the cross-references (a) and (b) the sign x indicates units other than series, viz. catena or group members, sets, complexes, profiles or indigenous words: revision and augmentation in the future will be well worthwhile.

(a)	Alicedale	Normandien (S)
	Amuke	Oatsdale (S)
	Atondozi	Ruston (S): Sinoia AI (R)
	Bushbaby	Maputo (M): Mooiriver (S): Paraá(U)
	Betusile	Mwilago (T)
	Bona	Balul (M): Fernwood (S): Uswa (R)
	Coseni	Chipinga EI (R): Gurue x(M)
	Cimurphy	Bushenyi (U): Kikuyu x(K): Sprinz (S)
	Canterbury	Moamba (M): Sharpeville (S)
	Darketown	Nomanci (S)
	Dziva	Ivanhoe (S)
	Delcor	Bezuidenhout (S)
	Daputi	Dingue (R): Leksand (S)
	Enkulunyo	Mopai (M): Nyamindlovu KI (R)
	Empahli	Kinele x(T): Nangoi (T)
	Felwako	Darwindale XI (R): Kikungu x(T)
	Funebizo	Dokolo (U): Loskop (S)
	Gocuka	Hamman (S): Mitumbati (T): Wasbank (S): Yumbe x(U)
	Gongola	Chiumbati (T): Klipfontein (S): Mashishiwe x(T)
	Gege	Nzia (U)
	Gubane	Luseni x(T): Tabora (T): Vaalsand (S)
	Habelo	Avoca (S): Kihue (T): Naipingo (T): Norton (R): Rossboom (S): Slangkop (S)
	Hlunya	Chirundu x(R): Cornelia (S): Ibambasi x(T): Portohenrique (M): Sephula x(L)
	Homestead	Misgund (S): Welgegund (S)
	Hersov	Rockland (S)
	Idukathole	Dell (S): Lydiate (R)
	Ingoje	Bukora (U): Pakelli x(U): Sinkwazi (S): Varzea (M): Waterhole (T)
	Ivy	Incomati (M): Patel (K)
	Juweel	Doveton (S)
	Jovane	Humberdale (S)
	Jekhi	Portsmouth (S): Rutenga GI (R)
	Kwezi	Arcadia (S): Chisumbanje BI (R): Juja (K): Moamba (M): Phechela x(L)
	King	Selous XI (R)
	Kwamtusse	Sunduine (M)
	Lesibovu	Bududa (U): Kalapata (U): Lokitanyale (U): Makatini (S): Nachingwea (T): Nduha x(T)

Lomahasheni	Glendale (S): Mona (S): Namaacha (M): Panyangara (U)
Lutzi	Triangle (R)
Ludomba	Karoi GI (R)
Malkerns	Doveton (S): Kiamara (U): Vlakdam (S): Weston (S)
Mtilane	Farningham (S)
Mooihoek	Melsetter MI (R): Vlakdam (S)
Mdutshane	Msinga (S)
Mbeli	Bikita GI (R)
Nduma	Griffin (S): Kranzkop (S): Zeu x(U)
Ngazi	Cleveland (S)
Otandweni	Dombo (R): Isanga x(T): Umshandige GO (R)
Orrin	Humani x(R): Kusasa (S)
Oldreef	Okollo x(U)
Outspan	Metu (U): Trelawny (R)
Omhlandlu	Pogela (S): Sao Jeronimo (M)
Osaguleni	Messina x(S)
Pofane	Kaboko x(U): Tayside (S)
Petronella	Williamson (S)
Qolweni	Bontberg (S)
Qwabise	Glenrosa (S)
Qualm	Maseru x(L): Uitvlug (S)
Rondspring	Bubandi (U): Mabenga (M): Sabuk (K)
Rathbone	Glendale (S): Salisbury (R)
Rhebok	Bellevue (S)
Rasheni	Bloukranz (S): Tugela (S)
Reidbult	Sunvalley (S)
Sangweni	Stroomdrif (S)
Somerling	Satara x(S): Tombo (S)
Sikhutwane	Gemvale (S): Matopos EO (R): Tete x(M)
Stegi	Effingham (S): Libombos (M)
Tateni	Chester (S): Joubertina (S)
Tambankulu	Rama (K): Winterton (S)
Tshaneni	Rydalvale (S): Volo (K)
Upcountry	Katikekile (U): Nandeti (T)
Umbeluzi	Aswa (U)
Valumgwaco	Kibegori (K): Kidepo (U): Mbuga x(T): Rensburg (S): Sebei (U): Serui (R)
Vimy	Nyati (T): Ora (U): Siabuwa S2 (R)
Winn	Shorrock (S)
Waspageni	Rwangu (U): Zwartfontein (S)
Whiterock	Pinacabral (M)
Xulwane	Conglomerado (M): Misengwa x(T)
Youngsvlei	Yabubuni Mbuga x(T)
Yakeni	Sabi U4 (R): Semliki (U): Xangane (M)
Zayifu	Southwold (S)

Zwide	Estcourt (s): Guija x(M): Itogoro x(T): Ladysmith (S): Thurleston (S): Zindi (R):
Zikane	Alcock (S): Lubiri (T): Mbuga x(T): Retief (S): Thulo x(L): Weiga x(U)
Zebra	Enkeldoorn (R)

(b)

Alcock (S) Zn	Ibambai x(T) Hl	Moamba (M) Ca Kz
Arcadia (S) Kz	Incomati (M) Iv	Mona (S) Lo
Aswa (U) Ub	Isanga x(T) Ot	Mooiriver (S) Bu
Avoca (S) Ha	Itogoro x(T) Zd	Mopai (M) Ek
Balul (M) Bo	Ivanhoe (S) Dz	Msinga (S) Md
Bellevue (S) Rk	Joubertina (S) Tx	Mwilago (T) Be
Bezuidenhout (S) De	Juja (K) Kz	Nachingwea (T) Le
Bikita Gl (R) Mb	Kalapata (U) Le	Naipingo (T) Ha
Bloukranz (S) Rs	Karoi Gl (R) Ld	Namaacha (M) Lo
Bontberg (S) Qo	Katikekile (U) Uc	Nandeti (T) Uc
Bubandi (U) Ro	Kiamara (U) Ma	Nangoi (T) Em
Bududa (U) Le	Kibegori (K) Va	Nduha x(T) Le
Bukora (U) In	Kidepo (U) Va	Nomanci (S) Dk
Bushenyi (U) Cm	Kihue (T) Ha	Normandien (S) Al
Chester (S) Tx	Kikungu x(T) Fe	Norton (R) Ha
Chipinga El (R) Co	Kikuyu x(K) Cm	Nyamindlovu Kl (R) Ek
Chirundu x(R) Hl	Kinele x(T) Em	Nyati (T) Vm
Chisumbanje Bl (R) Kz	Klipfontein (S) Gn	Nzia (U) Ge
Chiumbati (T) Gn	Koboko x(U) Po	Oatsdale (S) Am
Cleveland (S) Nz	Kranzkop (S) Nd	Okollo x(U) Ol
Conglomerado (M) Xu	Kusasa (S) Or	Ora (U) Vm
Cornelia (S) Hl	Ladysmith (S) Zd	Pakelli x(U) In
Darwindale Xl (R) Fe	Leksand (S) Dt	Panyangara (U) Lo
Dell (S) Id	Libombos (M) St	Paraa (U) Bu
Dingue (R) Dt	Lokitanyale (U) Le	Patel (K) Iv
Dokolo (U) Fu	Loskop (S) Fu	Phechela x(L) Kz
Dombo (R) Ot	Lubiri (T) Zn	Pinacabral (M) Wh
Doveton (S) Jw Ma	Luseni x(T) Gb	Pogela (S) Om
Effingham (S) St	Lydiate (R) Id	Portohenrique (M) Hl
Enkeldoorn (R) Ze	Magenga (M) Ro	Portsmouth (S) Jk
Estcourt (S) Zd	Makatini (S) Le	Rama (K) Tm
Farningham (S) Mt	Maputo (M) Bu	Rensburg (S) Va
Fernwood (S) Bo	Maseru x(L) Qu	Retief (S) Zn
Gemvale (S) Sk	Mashishiwe x(T) Gn	Rockland (S) He
Glendale (S) Lo Rt	Matopos EO (R) Sk	Rossboom (S) Ha
Glenrosa (S) Qb	Mbuga x(T) Va Zn	Ruston (S) At
Griffin (S) Nd	Melsetter Ml (R) Mo	Rutenga Gl (R) Jk
Guija x(M) Zd	Messina x(S) Os	Rwangu (U) Wa
Gurue x(M) Co	Metu (U) Ou	Rydalvale (S) Ts
Hamman (S) Gc	Misengwa x(T) Xu	Sabi U4 (R) Ya
Humani x(K) Or	Misgund (S) Ho	Sabuk (K) Ro
Humberdale (S) Jv	Mitumbati (T) Gc	Salisbury (R) Rt

Sao Jeronimo (M) Om
Satara x(S) So
Sebei (U) Va
Selous XI (R) Kn
Semliki (U) Ya
Sephula x(L) Hl
Serui (R) Va
Sharpeville (S) Ca
Shorrock (S) Wn
Siabuwa S2
Sinkwazi (S) Ln
Sinoi Al (R) At
Slangkop (S) Ha
Southwold (S) Za
Sprinz (S) Cm
Stroomdrif (S) Sa
Sunduine (M) Kt
Sunvalley (S) Re
Tabora (T) Gb
Tayside (S) Po
Tete x(M) Sk
Thulo x(L) Zn
Thurleston (S) Zd
Tombo (S) So
Trelawny (R) Ou
Trinagle (R) Lz
Tugela (S) Rs
Uitvlug (S) Qu
Umshandige GO (R) Ot
Uswa (R) Bo
Vaalsand (S) Gb
Varzea (M) In
Vlakdam (S) Ma Mo
Volo (K) Ts
Wasbank (S) Gc
Waterhole (T) In
Weiga x(U) Zn
Welgegund (S) Ho
Weston (S) Ma
Williamson (S) Pt
Winterton (S) Tm
Xangane (M) Ya
Yabubuni x(T) Yo
Yumbe x(U) Gc
Zeu c(U) Nd
Zindi (R) Zd
Zwartfontein (S) Wa

(c)

Dwala	Rock outcrops in Ungabolima series
Libovu	Red clay of Rathbone and allied series
Libumba	Subsoil potclay of Habelo and allied series
Lubishi	Moist lowlying land of e.g. Petronella series
Matshe	Stony ground, often Upcountry series
Sibovu	Red loam of Lesibovu and Malkerns and allied series
Sidzaka	Black clay of Kwezi and Zikane and allied series
Simhlope	Pale grey sand in Enkulunyo series
Tihlambo	Backwater alluvium, above most floods, often Betusile series
Tihobudla	Coarse sand and gravel in stream beds, Xulwane series
Umgubane	Subsoil iron concretions of Gocuka and allied series
Xapoti	Swampy bottomland, Idukathole or Ingoje series

Outside Southern and East Africa there are undoubtedly many, probably hundreds, of series that could also profitably be likened to Swaziland's. Some soils in Ghana and Sudan are referred to by Murdoch and Andriesse (1964) and the series established in Senegal and Togo and Nigeria, among other states, include counterparts. In tropical and subtropical zones of other continents the writer's firsthand experience of low-level soil taxonomy is confined to places where the American Seventh Approximation is the pedological lingua franca. Positions which some Swaziland series would have in subgroups, defined by Kellogg (1967), have been worked out, partly in collaboration with G.S. M'Kee and J. De Ment in Texas, whose assistance it is a pleasure to record. The series include –

Bushbaby	Typic Xerofluvent: high-altitude pedons would be Ustifluvent
Enkulunyo	Grossarenic Paleustult
Felwako	Ultic Haplustalf
Gocuka	Argillic Plinthustalf
Hlunya	Arenic Paleustalf, if sandy top thicker than 50 cm
Kwezi	Typic Pellustert
Lesibovu	Typic Rhodustalf: textural family different from Rondspring

Malkerns	Rhodudult subgroup: would be Umbriorthox but for argillic horizon
Mooihoek	Perhaps most leached pedons belong to an Acrustox subgroup
Nduma	Perhaps most leached pedons belong to a Haplohumox subgroup
Otandweni	Lithic Quartzipsamment
Rondspring	Typic Rhodustalf or, with mollic epipedon, Typic Argiustoll
Stegi	Lithic Haplustoll
Shebani	Lithic Calciustoll
Valumgwaco	Vertic Ustifluvent
Vimy	Where not alluvial Natric Chromustert
Winn	Typic Ustochrept, provided cambic horizon is present
Youngsvlei	Salorthid subgroup possibly
Zwide	Vertic Natraqualf: if cracks not wide enough Mollic

Only a minority of the above are perfect correlations, the rest being "best fits" to subgroups or groups in the light of present knowledge. The main unknowns, which have had to be guessed at, include length of time profiles are dry annually, exactly what colours (to 0.5 unit value or chroma) some topsoils should be considered as having, and how "aquic" claypans are. Many other Swaziland series simply cannot be accommodated satisfactorily in the Seventh Approximation as now constituted: it has already been mentioned on page 80 that nobody insists that they ought to be*.

AREAS AND PATTERNS OF SOIL SETS:

The ensuing tables give the areas of soils (sets except in Table 36, where series are treated) broken down according to regions and subregions and parent materials in Table 27, SPI mapping units in Table 28, slope categories in Table 29 and major catchments in Table 30. Proportions of sets by types of land tenure and by economic zonation, Cores versus Periphery, are indicated in Tables 31 and 32 respectively. Sets are ranked according to acreage in Table 33, according to altitude in Table 34, and according to steepness by regions in Table 35. Series are arranged in order of acreage at Table 36. The NSR mapped areas are compared with previous forecasts of the extent of sets in Table 37, which shows how near to the eventual answers that early guesswork was – in a few cases, and how far from them in many cases.

Soil set area measurements were done on the 1:125,000 map with the aid of a square-lattice dot grid whose points were at quarter-inch intervals vertically and horizontally, so that each dot represented 153 acres or 0.24 square mile. The desired 157 to 163 acres spacing – which could have been referred to as 0.25 square mile – was not achieved as the dots were found to total 28,030 or about 4% too many, taking the total area of Swaziland as 6,700 to 6,720 square miles. The counts were made on each of 31 transparent draft soil map sheets, the lengths of whose sides were not whole-number multiples of 0.25 inch. Because of this, and because of map projection distortions, the over-enumeration occurred.

Acreages given for the Highveld and Lower Middleveld neglect their exclaves which are marked on Map 2 in respectively the Upper Middleveld and Lowveld. The exclaves were measured as integral parts of the lower subregions. Throughout Tables 27 to 35 regions and subregions are abbreviated as in Table 2.

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*World Soil Map units of Dudal (1968) were published too late for comment here.

TABLE 27

Acreages of Soil Sets by Regions and Parent Materials

Sets (a)	Swaziland	HV	MV	LV	LR	PM (b)
A	40,000	35,000	5,000	0	0	I
B	50,000	3,000	12,000	31,000	4,000	I
CH	24,000	15,000	9,000	0	0	B
CL	97,000	0	2,000	91,000	4,000	B
DH	12,000	12,000	0	0	0	A
DL	7,000	0	0	6,000	1,000	I
E	50,000	2,000	21,000	27,000	0	A
F	32,000	5,000	14,000	8,000	5,000	I
G	72,000	25,000	25,000	17,000	5,000	I
H	217,000	0	19,000	197,000	1,000	A
I	88,000	37,000	47,000	1,000	3,000	I
JH	92,000	70,000	22,000	0	0	I
JL	45,000	0	12,000	33,000	0	A
K	70,000	1,000	4,000	63,000	2,000	B
L	99,000	0	28,000	44,000	27,000	I
M	198,000	74,000	124,000	0	0	I
NH	102,000	92,000	10,000	0	0	I
O	569,000	100,000	235,000	182,000	52,000	A
P	77,000	10,000	49,000	17,000	1,000	A
QH	146,000	92,000	54,000	0	0	A
R	143,000	0	4,000	132,000	7,000	B
SH	84,000	45,000	39,000	0	0	B
SL	295,000	0	29,000	235,000	31,000	B
TH	117,000	102,000	15,000	0	0	A
TL	22,000	0	0	22,000	0	B
U	1,278,000	541,000	340,000	190,000	207,000	A(c)

TABLE 27 – Continued

Sets (a)	Swaziland	HV	MV	LV	LR	PM (b)
V	30,000	1,000	2,000	27,000	0	B
W	24,000	2,000	4,000	18,000	0	I
X	7,000	1,000	3,000	3,000	0	A
Y	2,000	0	0	2,000	0	B
ZH	24,000	15,000	9,000	0	0	I
ZL	187,000	0	3,000	184,000	0	I
32	4,300,000	1,280,000	1,140,000	1,530,000	350,000	A (d)

Sets (e)	UM	LM	WL	EL
A	5,000	0	0	0
B	6,000	6,000	17,000	14,000
CH	6,000	3,000	0	0
CL	0	2,000	23,000	68,000
DH	0	0	0	0
DL	0	0	1,000	5,000
E	3,000	18,000	25,000	2,000
F	10,000	4,000	5,000	3,000
G	14,000	11,000	14,000	3,000
H	0	19,000	183,000	14,000
I	35,000	12,000	1,000	0
JH	19,000	3,000	0	0
JL	0	12,000	33,000	0
K	1,000	3,000	13,000	50,000
L	0	28,000	42,000	2,000
M	112,000	12,000	0	0
NH	10,000	0	0	0

TABLE 27 – Continued

Sets (e)	Um	LM	WL	EL
O	77,000	158,000	173,000	9,000
P	11,000	38,000	38,000	1,000
QH	41,000	13,000	0	0
R	0	4,000	33,000	99,000
SH	20,000	19,000	0	0
SL	0	29,000	72,000	163,000
TH	14,000	1,000	0	0
TL	0	0	2,000	20,000
U	134,000	206,000	92,000	98,000
V	1,000	1,000	2,000	25,000
W	2,000	2,000	10,000	8,000
X	1,000	2,000	2,000	1,000
Y	0	0	1,000	1,000
ZH	8,000	1,000	0	0
ZL	0	3,000	160,000	24,000
32	530,000	610,000	920,000	610,000

NOTES:
(a) By regions, excluding NL (mapped with R) and QL (with H).
(b) Parent Materials: A mainly acid, I mainly intermediate and B mainly basic: see also Table 2.
(c) Total made up of about 930,000 acres acid rocks and 208,000 acres intermediate and 140,000 basic.
(d) Total made up of about 2,170,000 acres with mainly acid p.m. and 1,230,000 acres mainly intermediate and 900,000 acres mainly basic.
(e) By subregions of the Middleveld and Lowveld.

TABLE 28

Acreages of SPI Mapping Units by Regions

Units (a)	Swaziland	HV	MV	LV	LR	% (b)
A	1,278,000	541,000	340,000	190,000	207,000	30
B	1,144,000	143,000	378,000	530,000	93,000	27
D	219,000	2,000	8,000	203,000	6,000	5
F	217,000	0	19,000	197,000	1,000	5
G	143,000	0	4,000	132,000	7,000	3
J	249,000	29,000	96,000	91,000	33,000	6
K	150,000	70,000	80,000	0	0	3½
L	611,000	446,000	165,000	0	0	14
M	189,000	0	3,000	186,000	0	4
Rest	100,000	49,000	47,000	1,000	3,000	2½
10	4,300,000	1,280,000	1,140,000	1,530,000	350,000	100

Units (c)	UM	LM	WL	EL
A	134,000	206,000	92,000	98,000
B	114,000	264,000	329,000	201,000
D	2,000	6,000	40,000	163,000
F	0	19,000	183,000	14,000
G	0	4,000	33,000	99,000
J	48,000	48,000	81,000	10,000
K	57,000	23,000	0	0
L	140,000	25,000	0	0
M	0	3,000	161,000	25,000
Rest	35,000	12,000	1,000	0
10	530,000	610,000	920,000	610,000

TABLE 28 – Continued

NOTES: (a) By regions, from 1:125,000 Soil Map –

A Raw Minerals Soils of U set
B Weakly Developed Soils of B E G O P SL W X sets
D Vertisols of CL K TL V sets
F Pseudopodzolic Soils of H set
G Brown Soils of R set
J Fersialitic Soils of DL F JL L sets and one third of M set
K Ferrisols of SH set and one third of M set
L Ferralitic Soils of A CH JH NH QH TH ZH sets and one third of M set
M Halomorphic Soils of Y ZL sets
Rest Hydromorphic and Organic Soils of DH I sets

(b) National percentages differ somewhat from those in Figure 9, the latter being more accurate as acreages of series not sets were added to obtain them.

(c) By subregions: remarks on units under (a) apply.

TABLE 29

Acreages of Soil Sets by Slope Categories

Sets	Gradient 14% or less	Gradient over 14%	Sets	Gradient 14% or less	Gradient over 14%
A	31,000	9,000	O	397,000	172,000
B	49,000	1,000	P	66,000	11,000
CH	14,000	10,000	QH	62,000	84,000
CL	97,000	0	R	140,000	3,000
DH	4,000	8,000	SH	31,000	53,000
DL	7,000	0	SL	276,000	19,000
E	49,000	1,000	TH	17,000	100,000
F	29,000	3,000	TL	22,000	0
G	66,000	6,000	U	169,000	1,109,000
H	215,000	2,000	V	30,000	0
I	75,000	13,000	W	24,000	0
JH	52,000	40,000	X	7,000	0
JL	45,000	0	Y	2,000	0
K	69,000	1,000	ZH	5,000	19,000
L	96,000	3,000	ZL	187,000	0
M	128,000	70,000			
NH	39,000	63,000	32	1,500,000	1,800,000

TABLE 31

Soil Sets by Order of Predominance in CNL

Set	%(a)	Set	%(a)	Set	%(a)	Set	%(a)
JL	86	V	62	G	57	SL	46
K	73	P	61	O	57	A	35
L	68	X	60	I	56	NH	34
E	67	CH	59	QH	54	TH	31
F	65	W	59	ZH	53	DH	24
B	64	M	58	U	51	DL	22
H	64	SL	58	JH	50	TL	22
CL	62	ZL	58	R	47	Y	0

(a) Percentages of the acreage of each set on Communal and National Land: remainders are on Individual Tenure Holdings: national mean 54% in CNL.

TABLE 32

Soil Sets by Order of Predominance in Cores

Set	%(a)	Set	%(a)	Set	%(a)	Set	%(a)
Y	97	I	28	ZH	18	F	11
TL	54	X	27	CL	17	P	11
DL	50	V	26	G	17	E	10
TH	41	B	25	K	17	H	10
NH	36	R	25	ZL	17	DH	8
M	35	JH	20	SH	16	O	8
W	35	QH	20	SL	15	JL	6
A	28	CH	18	U	12	L	5

(a) Percentages of the acreage of each set in Cores, as on Map 10: remainders are in the Periphery: national mean 16% in Cores.

TABLE 33

Soil Sets Ranked According to Acreage

Set	%(a)	Set	%(a)	Set	%(a)	Set	%(a)
U	29.8	TH	2.7	G	1.7	CH	0.6
O	13.2	NH	2.4	K	1.6	W	0.6
SL	6.9	L	2.3	B	1.2	ZH	0.6
H	5.1	CL	2.2	E	1.2	TL	0.5
M	4.6	JH	2.1	JL	1.0	DH	0.3
ZL	4.4	I	2.0	A	0.9	DL	0.2
QH	3.4	SH	1.9	F	0.7	X	0.2
R	3.3	P	1.8	V	0.7	Y	0.1

(a) Percentages of Swaziland: mean 3.1 but 1.8 is median.

TABLE 34

Soil Sets Ranked According to Elevation

Set	% (a)	Set	% (a)	Set	% (a)	Set	% (a)
DH	100 HV	SH	54 HV	L	45 LV	K	90 LV
NH	90 "	U	43 "	X	47 "	V	90 "
A	88 "	I	42 "	B	53 "	H	91 "
TH	86 "	G	35 "	E	55 "	R	92 "
JH	75 "	M	55 UM	JL	72 "	CL	94 "
QH	62 "	F	34 "	W	76 "	TL	97 "
CH	61 "	P	49 LM	SL	79 "	ZL	99 "
ZH	58 "	O	33 LV	DL	86 "	Y	100 "

(a) Percentages of the acreage of each set in its dominant altitudinal belt, out of four — Highveld, Upper Middleveld, Lower Middleveld and Lowveld (Western and Eastern Lowveld are at about the same heights and Lubombo Range is never dominant): sequence is approximately descending order of mean elevation.

TABLE 36

Soil Series Ranked According to Acreage (a)

		% (b)
Ungabolima	817,000	19.0
Upcountry	396,000	9.2
Otandweni	220,000	5.1
Somerling	213,000	4.9
Orrin	173,000	4.0
Zwide	123,000	2.7
Qolweni	117,000	2.6
Habelo	112,000	2.5
Tateni	105,000	2.4
Malkerns	80,000	1.9
Nduma	74,000	1.7
Canterbury	73,000	1.7
12 above	2,503,000	57.6

Hlunya	68,000	Jovane	25,000	Atondozi	11,000
Rondspring	67,000	Zikane	25,000	Gege	11,000
Sangweni	65,000	Cuba	24,000	Vimy	11,000
Umbeluzi	65,000	Petronella	23,000	Betusile	10,000
Kwezi	60,000	Homestead	22,000	Ludomba	10,000
Juweel	55,000	Jekhi	20,000	Madevu	10,000
Lesibovu	49,000	Mdutshane	19,000	Cimurphy	9,000
Oldreef	48,000	Osaguleni	19,000	Johannesloop	9,000
Idukathole	45,000	Sivulo	19,000	Spekboom	9,000
Rathbone	45,000	Winn	17,000	Darketown	8,000
Mtilane	43,000	Zombode	17,000	Gubane	8,000
Outspan	41,000	Alicedale	16,000	Mzawo	7,000
Pofane	40,000	Coseni	15,000	Rashweni	7,000
Ingoje	39,000	Empahli	15,000	Xulwane	7,000
Ongeluk	36,000	Rhebok	15,000	Zayifu	7,000
Zwakela	35,000	Tambankulu	15,000	Bona	6,000
Bushbaby	34,000	Valumgwaco	15,000	Frazer	6,000
Gocuka	32,000	Gongola	14,000	King	6,000
Omhlandlu	32,000	Hersov	14,000	Nhloya	6,000
Enkulunyo	31,000	Lutzi	14,000	Delcor	5,000
Sikhutwane	30,000	Peebles	14,000	Gudzeni	5,000
Qwabise	29,000	Shebani	14,000	Dziva	4,000
Stegi	29,000	Amuke	13,000	Ebede	4,000
Jolobela	28,000	Felwako	13,000	Kwamtusse	4,000
Ngazi	28,000	Funebizo	13,000	Tshaneni	4,000
Lomahasheni	26,000	Mbeli	12,000	Vuso	4,000
Mooihoek	26,000	Torgyle	12,000	Zebra	4,000

TABLE 36 — Continued

Imbojane	3,000
Waspageni	3,000
Daputi	2,000
Groening	2,000
Reidbult	2,000
Thorburn	2,000
Whiterock	2,000
Wisselrode	2,000
Ivy	1,000
Munali	1,000
Nsoko	1,000
Qualm	1,000
Yakeni	1,000
Youngsvlei	1,000

NOTES:
(a) These are probable rankings, from the estimated acreages on pages 105 to 126: mean 40,000 but median is only 15,000 acres.
(b) Percentage of national area.

TABLE 37

Area of Soil Sets in Square Miles 1960-1964

Sets	Partial Forecast 1960	Full (a) Forecast 1964	Mapped in NSR 1968
A	–	170	60
B	200	200	80
CH	–	60	40
CL	–	100	150
DH	–	20	20
DL	–	30	10
E	250 (b)	120	80
F	–	150	50
G	350	330	110
H	450	420	340
I	300	300	140
JH	–	80	140
JL	–	100	70
K	–	170	110
L	–	190	160
M	600	450	310
NH	400	380	160
NL	–	40	(c)
O	700	740	890
P	–	200	120
QH	–	100	220
R	400	300	210
SH	–	80	130
SL	300	250	460
TH	–	100	180
TL	–	60	30
U	800	970	2,000
V	–	130	50
W	–	100	40
X	–	60	10
Y	–	10	(d)
ZH	–	50	40
ZL	250	260	290
All	5,000	6,720	6,720

NOTES:
(a) After Lea and Murdoch (1964)
(b) Including what is now JL set
(c) Mapped with R set
(d) Less than 5 square miles

The objects of having so many "statistical quarries" are firstly to make the most of the area calculations, secondly to present relationships between sets which are either not visible at a glance on the Soil Map or not deducible at all from it (because e.g. watersheds, cadastral boundaries, socio-economic zones are not shown) and thirdly to provide maximal basic data on to which meaningful land capability assessments can later be grafted — see pages 197 to 260.

To end this Chapter salient features of the regional distribution of soil sets, indicated in cyphers at Tables 27 to 35, are reviewed briefly. The Highveld is mostly either rocky or mantled by Ferralitic Soils — U set occupies 42% of it and SPI mapping units La to Ls another 35%. Lithosols take up less area than elsewhere — only 11% — because of the prevalent pre-weathered crustal condition. The four sets next in frequency after U each cover 7% or 8% of the region viz. NH O QH TH. In the far north (Lomati and Komati basins) and far south (Ingwavuma and Pongola basins) M set is also prominent, but JH tends to displace it in the centre, especially along the Ngwempisi valley.

Kaolisols are commoner than Raw Mineral Soils in the Upper Middleveld — about 37% as against 25% — and the Ferrisolic element of Kaolisols is more pronounced than in any other part of the country, especially just to the north of the Great Usutu where M set covers 33% of that river's catchment, chiefly on gentle to moderate colluvial slopes: M set comes to 21% of the whole subregion. Lithosols are fairly common, also 21% of the total, and mainly from acid rocks. After U and M and O the next sets, with 7% to 8% of the area, are QH and I: the latter, a Mineral Hydromorphic Soil, is not so well expressed elsewhere.

The Lower Middleveld has 34% rocky terrain, concentrated in the steepland south of the Usutu River, and an even larger area of Lithosols, again mostly from acid rocks, including 26% O set. For the Umbeluzi basin a rise to 40% O set reflects the embayment there in the Middleveld's east-facing scarps. About half of P set — Lithic with some Mineral Hydromorphic influence — is found in this subregion, but no other soil reaches its mode here. On the other hand all SPI units of Table 28 are represented, which cannot be said for any other subregion. These points underline the area's transitional character pedologically. Of well-developed profiles Fersialitic Soils are commonest, with 8% of the area: L set accounts for 10% of the Lomati-Komati basins.

The Western Lowveld is dominated by Lithosols 36% and Sol Lessivé 20% (entirely H set) and Solodized Solonetz 18% (virtually all ZL set). Of Lithic sets the acid O with 19% is much more frequent than the basic SL with 8%. Raw Mineral Soils are only 10% of the total area, but more than 17% in the far south (Ingwavuma and Pongola catchments). Nearly 5% of this subregion, as of the Lower Middleveld, comprises L set.

Lithosols continue into the Eastern Lowveld, forming 33% of it — but mainly from basic crystalline rock, SL set having 27%. The main development of both Vertisols and Brown Soils is here. They amount to respectively 27% and 16% — the latter entirely R set. U set also has 16%, increasing to 24% in the far south due to the hard dolerite dyke swarms there. Among Vertisols CL set occupies 11% and K set 8%: the Umbeluzi basin contains nearly all of TL set.

The Lubombo Range is the rockiest region, 59% being mapped as U set. Lithosols at 27% and Fersialitic Soils at almost 10% are locally important, the counts of soils that follow U set being 15% O then 9% SL then 7% L set.

Chapter 3

LAND CAPABILITY

With Particular Reference to Yield-Soil Correlations

DEFINITION AND SCOPE:

The suitability of soils, slopes and areas in Swaziland for agriculture and forestry is discussed in this chapter. To accompany it the 1:125,000 Land Capability Map, in two sheets, has been compiled. A ranking into Land Classes is involved and the system devised by the United States Department of the Interior (1953) for studying the agricultural potential of the American West, with a gamut of 8 classes, was the model for early work done along the same lines in Swaziland. Modifications made to suit local conditions are, however, fairly numerous: some of them stem from the recommendations of Greene (1957) but most changes have been introduced by the writer in consultation with Swaziland colleagues.

Soil sets or, in more detail, soil series provide an adequate basis, when mapped, for assessing land capability as their differentiae are directly or indirectly major influences on the farming activities of an area. Direct effects include those due to soil depth, texture, structure, consistency and other profile characteristics, while the indirect or derived attributes most important to crops are permeability – through each soil horizon and through the substratum – and productivity, the latter being a function of (i) natural fertility, (ii) the volume of soil penetrated by healthy roots and (iii) the pedoclimate, which in turn is influenced mainly by permeability and by atmospheric climate and weather.

In most soil sets, and even within many series, the chief variable affecting agriculture is land slope rather than any internal soil feature. The discussion on this topic at pages 135 to 137 of Murdoch and Andriesse (1964) applies to irrigability in the Lowveld. It is even more apt for irrigation schemes in the hillier Middleveld and Highveld, and the relevance of land slope to dry-land farming, though somewhat less vital and exacting than to irrigated crops, is nonetheless obvious. Separate mapping of slope categories is therefore undertaken with each land capability survey and the combination cartographically of soil set or series crop rating and slope category gives the Land Capability Class (abbreviated usually to Land Class) of any particular parcel of ground.

Some of the first clinography – slope mapping – carried out in Swaziland, following the publication of the 1:50,000 topographic maps with 50 feet contours, was done by Daniel (1958) and Zwane (1963). The latter worked under the author's direction. Their contributions are duly acknowledged and prints of their originals, photographically reduced to 1:125,000 in 1967, have greatly facilitated the drawing of the Land Capability Map.

Future extensions of the land capability framework about to be described are practicable and will be advisable, to include new agroforestal developments and to unify the various possible approaches to the suitability of soils, slopes and areas for surface communications, urban and industrial purposes and amenities such as recreational facilities and nature conservancy. None of these are proper subjects for this memoir: they are again referred to only in the conclusion, see page 290. Several have already been investigated, including road and railway and airfield soils (both foundations and construction materials), soils suitable for factory siting and for effluent disposal, and soils of game sanctuaries. In each case ascribing ratings to the series and sets found has proved a useful, concise way of conveying capability information to the land users concerned.

INTERVENTION BY THE FARMER:

Man can modify the capability of land by farming practices, the changes often being highly beneficial (application of manure and fertilizer, artificial drainage, terracing) but sometimes quite disastrous (soil exhaustion, preventable erosion, severe salinity).

Because management varies so much it is not incorporated in land capability assessments. Instead only inherent, permanent* characteristics of the soil and landsurface are evaluated or measured as guides for the rural community. Commercial farms and forests managed to a "reasonable standard" (preferably defined, but often has to be deduced) have been benchmarks for checking Land Class allocations. It follows that a much-better-than-average farmer will apparently make nonsense of the Land Class scale by obtaining from "poor" soil yields of crops equal to or greater than those harvested by neighbours from "better" fields. There is no way round this anomaly. Ranking the farmers as well as the soils in an area would be not only irksome but dangerous on account of libel suits that would be filed or even more violent demonstrations of hostility that might occur. In any case ownership and expertise will alter with time on an individual farm or plot no less than over larger areas.

Crop yields are moreover only one factor in judging the success of commercial farming and a sounder indication – which could also serve as the briefest definition of "capability" as used in this thesis – is how easily a piece of land can be coaxed into providing longterm profits to those who farm it, without soil deterioration. As well as output, input must therefore be considered and some, at least, of the speculators and marginal farmers, who by choice or force of circumstances develop poor-quality land, must expend so much time and money in the effort that the enhanced gross earnings are swallowed up and the true value of the area remains low.

LAND CLASSIFICATION METHODS AND CODES:

Until 1965 a single letter or number was used in Swaziland to designate Land Classes – I to VII for irrigability surveys, A to F for raingrown crops, as described by Murdoch (1961). Now, however, it is deemed more informative to adopt a two-letter tag for each Class – see Table 38.

The first letter of the pair, between A and M, indicates the soil rating in respect of series and sets, for specified farming systems, of which the most important, now or in the foreseeable future, include the following :–

IRRIGATED ROTATION (Annuals: Food Crops and Cotton)
IRRIGATED SUGARCANE
IRRIGATED RICE (Bench Strip Method, not Hillside Flooding)
IRRIGATED CITRUS
IRRIGATED PASTURE
DRYLAND ROTATION (Annuals: Maize and Beans mainly)
DRYLAND ROTATION (Annuals: Cotton and Sorghum mainly)
DRYLAND PINEAPPLE
DRYLAND AVOCADO
DRYLAND PASTURE (Improved Strains)
CONIFEROUS FOREST (especially Pinus patula)

Tying the soil ratings to farming systems that are actually in operation has the merit of obviat-

*On the human time scale of a few generations, not in geomorphological terms.

TABLE 38

Components of Land Classes

SOIL RATING (a)		SLOPE CATEGORY Code	Z	Y	X	W	V	U
		Mnemonic	Zero gradient	Yes: arable	Xtra care needed	Water runs off fast	Very steep	Unploughable (b)
Code	Mnemonic	Percent (c)	0	0-3	3-7	7-14	14-22	22+
A	Admirable — economically realizable potential high		AZ	AY	AX	AW	AV	AU
B	Better than most land though not first class		BZ	BY	BX	BW	BV	BU
C	Cropping prospect but productivity limited		CZ	CY	CX	CW	CV	CU
D	Desperately poor — avoid tillage if possible		DZ	DY	DX	DW	DV	DU
E	Eliminated, except as unimproved pasture		EZ	EY	EX	EW	EV	EU
F	Futile even to attempt extensive grazing		FZ	FY	FX	FW	FV	FU

NOTES: (a) Each two-letter combination from AZ to FU describes a Land Class. Mnemonics under SOIL RATING are in respect of a suitable SLOPE CATEGORY and vice versa.

(b) Unless step-terraced.

(c) Lines of equal percentage gradient are referred to as isoclines in the text. The geological term isocline has quite another meaning.

ing unrealistic or ill-motivated or perfunctory soil surveys, whereof the frequency in the tropics and subtropics perturbs De Wilde (1967). Any relevant farming system qualifies for soil ratings, therefore the addition of say eucalyptus forest, tea and sisal to the list, when warranted, will involve no more than a thorough study of those crops' soil requirements and familiarization with their present and past performance on different series, or perhaps on analogous soils outside Swaziland.

The second letter of the code, between M and Z, denotes the slope category. The sequences A B C D E F and W V U reflect descending order of suitability (i.e. of longterm profits to the farmer or forester), but the gentler slopes Z Y X W are categories of almost equal value for certain pursuits, e.g. the growing of most dryland crops and of timber, though hierarchic in a variable manner for others, e.g. surface irrigation, which is easy on Y slopes, impossible on Z, inadvisable on W.

Areas in each of the six slope categories over the whole country are presented diagrammatically at Figure 15. For the NSR the 14% isocline was mapped but the others, because of boundary intricacies, had to be omitted. As the Figure shows, there is a marked "break of slope" near 14% – a sudden decrease (proceeding from gentler to steeper grades) in the amount of land between equally spaced isoclines. From field and topo map observations it would appear that while this national characteristic applies to much of the Middleveld, the break comes at about 8% in the Lowveld and perhaps 20% in the Highveld. Generalizations about the arability of slope categories are summarized in Table 39. Some soils will not require drainage even on dead flat terrain and some have a greater need for conservation against erosion than others, hence the imprecision of the assessments.

While U to Z are mappable directly from contoured maps or plans, A to F need interpreting from soil maps, with the aid of the soil rating guide at Table 40. The sole criterion for this sixfold division, A to F, continues to be judgment based on theory, experience and results of research. The latter play an ever-increasing part in the apportionment of the commoner arable series to soil ratings as the findings of experiment stations multiply and the study of yields from commercial farmland progresses: see also pages 195 to 197. It is not the policy to place series into assemblages with equal numbers or equal areas per soil rating, but as Table 41 shows a good spread of series across the range of ratings has been achieved.

In all previous Swaziland Soil Survey reports ratings have been described as "tentative" or "provisional". These terms can now be superseded by a more refined qualifying phrase with a time limit suggested. Thus 1968-1970 is added to the title of Table 40, signifying that through the next few crop seasons the ratings stipulated are expected to remain in force. Thereafter a revision in the light of new research on crop behaviour, new crop varieties, improved farming techniques or fresh economic considerations may well result in some of the ratings being altered. Reappraisals every two or three years will serve to keep the ratings realistic and abreast of advances in agriculture.

Every series is rated for every farming system, save conifers, in Table 40. This will prove to be rather more than is strictly necessary, as the climatic environments of some soils render them unsuitable for certain crops, e.g. on Highveld soils neither sugarcane nor cotton could be grown commercially on a field scale. The major climatic and altitudinal constraints imposed upon each farming system are dealt with later – see pages 201 to 257. The onus is on the user of a soil series map of a small area to eliminate initially farming systems which he thinks are unacceptable, whether climatically or from some other point of view, such as unmarketability of produce or insufficiency of irrigation water supplies.

Extra Land Classes, less precise than those in Table 38 (the AZ to FU block), are

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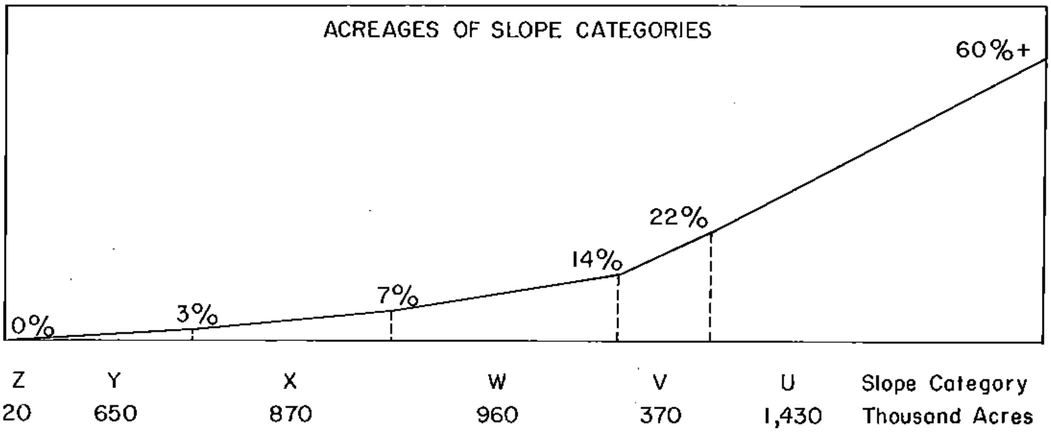
TABLE 39

Slope Categories: General Statement of Potential

FIGURE 15



Note that potential may be modified according to farming system and soil rating

SLOPE CATEGORY	IRRIGATED CROPS OVERHEAD	IRRIGATED CROPS SURFACE	RAINGROWN CROPS
Z	Good if drained	Unfit	Good if drained
Y	Good if drained	Good if drained	Good if drained
X	Good if conserved	Fair if conserved	Good if conserved
W	Fair if conserved	Unfit	Good if conserved
V	Unfit	Unfit	Fair if conserved
U	Unfit	Unfit	Unfit

TABLE 40

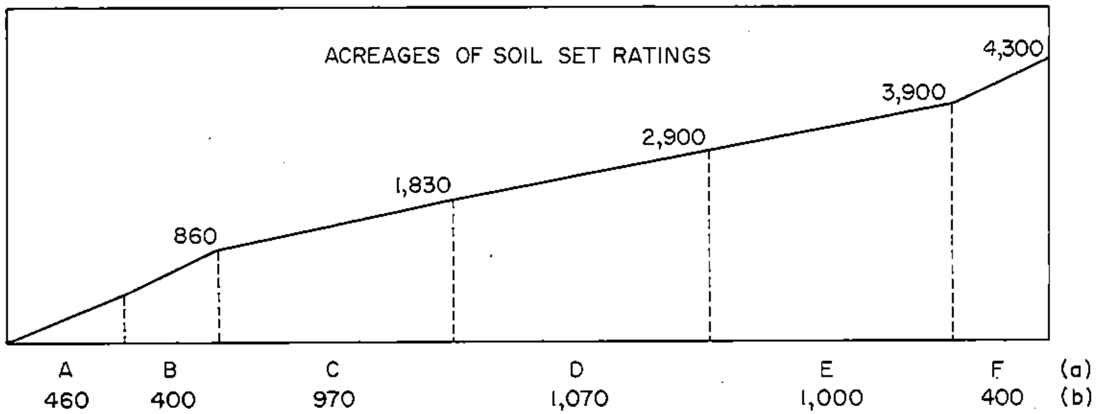
Soil Ratings for Eleven Farming Systems 1968-1970

Soil Series		I Mixed	I Sugarcane	I Rice	I Citrus	I Pasture	R Maize	R Cotton	R Avocado	R Pineapple	R Pasture	R Conifers
Alicedale	Al	B	B	B	B	B	A	B	C	A	B	B
Amuke	Am	B	B	C	B	B	A	B	B	A	B	B
Atondozi	At	C	C	A	C	B	D	D	D	C	C	C
Bushbaby	Bu	C	C	E	A	B	C	C	A	B	C	C
Betusile	Be	A	B	D	A	A	B	A	A	A	A	B
Bona	Bo	E	E	E	C	D	E	E	C	C	E	D
Coseni	Co	B	A	B	C	A	A	A	C	B	A	A
Cimurphy	Cm	B	A	B	C	A	A	A	C	B	A	A
Canterbury	Ca	C	B	A	D	A	B	A	D	D	A	N
Cuba	Cu	C	B	A	D	A	B	A	D	D	A	N
Darketown	Dk	E	E	E	E	E	E	E	E	E	E	E
Dziva	Dz	E	E	C	E	D	E	E	E	E	D	E
Delcor	De	B	B	A	B	A	A	A	C	B	A	N
Daputi	Dt	A	A	B	A	A	B	A	A	A	A	N
Enkulunyo	Ek	D	E	E	C	D	D	D	D	D	C	D
Empahli	Em	E	E	B	E	D	E	E	E	E	D	E
Ebede	Eb	E	E	E	E	D	E	E	E	E	D	D
Felwako	Fe	B	B	C	C	A	B	B	C	B	A	B
Funebizo	Fu	A	B	C	B	A	A	A	B	B	A	B
Frazer	Fr	C	B	C	C	A	C	C	D	B	B	C
Gocuka	Gc	D	D	B	D	B	C	C	E	D	C	D
Gongola	Gn	E	E	E	E	E	E	E	E	E	E	E
Gege	Ge	D	D	B	D	C	C	C	E	D	C	D
Gubane	Gb	D	D	E	D	D	D	D	E	D	C	D
Gudzeni	Gz	C	C	C	D	B	C	C	D	C	B	C
Groening	Gr	D	D	C	D	B	D	C	E	D	C	D
Habelo	Ha	D	D	A	E	C	D	C	E	E	C	N
Hlunya	Hl	D	D	A	E	C	D	C	E	E	C	N
Homestead	Ho	C	B	A	D	B	C	C	E	D	B	N
Hersov	He	D	D	A	E	C	D	C	E	E	C	N
Idukathole	Id	E	E	B	E	E	E	E	E	E	D	E
Ingoje	In	E	E	A	E	E	E	E	E	E	D	E
Imbojane	Im	E	E	C	E	E	E	E	E	E	E	E
Ivy	Iv	E	E	C	E	E	E	E	E	E	D	E
Juweel	Jw	C	C	C	C	B	C	B	C	B	B	D
Jolobela	Jb	C	C	D	C	B	D	C	C	B	B	D
Johannesloop	Jh	C	C	C	C	B	C	B	C	B	B	C
Jovane	Jv	C	D	E	B	C	D	C	B	B	C	N
Jekhi	Jk	C	D	E	B	C	D	C	B	B	C	N

TABLE 40 – Continued

Soil Series		I Mixed	I Sugarcane	I Rice	I Citrus	I Pasture	R Maize	R Cotton	R Avocado	R Pineapple	R Pasture	R Conifers
Kwezi	Kz	D	D	A	E	B	B	B	E	E	A	N
King	Kn	D	D	A	E	B	B	B	E	E	B	N
Kwamtusse	Kt	D	D	A	E	B	B	B	E	E	B	N
Lesibovu	Le	A	A	D	A	A	A	A	A	A	A	N
Lomahasheni	Lo	A	A	D	A	A	A	A	A	A	A	N
Lutzi	Lz	B	A	E	A	A	C	C	B	A	A	N
Ludomba	Ld	B	A	D	A	A	B	B	A	A	A	N
Malkerns	Ma	A	A	D	A	A	A	A	A	A	A	A
Mtilane	Mt	B	B	D	B	A	B	B	B	B	A	A
Mooihoek	Mo	A	A	E	A	A	A	B	A	A	A	A
Mdutshane	Md	A	A	E	A	A	A	A	A	A	A	A
Mbeli	Mb	A	A	D	B	A	A	A	B	B	A	A
Madevu	Mv	E	E	E	E	E	D	D	E	D	C	C
Mzawo	Mz	B	B	D	A	A	B	B	B	A	A	A
Munali	Mu	B	B	B	D	B	B	B	D	B	A	B
Nduma	Nd	B	B	D	B	B	A	B	B	B	B	B
Ngazi	Nz	C	D	D	D	B	C	D	C	C	C	B
Nhloya	Nh	A	B	D	B	A	A	A	B	B	A	N
Nsoko	Ns	A	A	D	B	A	A	A	B	B	A	N
Otandweni	Ot	D	D	E	D	D	D	D	D	D	D	D
Orrin	Or	C	C	D	C	B	C	B	C	B	C	C
Oldreef	Ol	D	D	E	D	D	D	D	D	D	D	D
Outspan	Ou	D	D	E	D	B	C	C	D	C	B	C
Ongeluk	Ok	D	D	E	D	D	D	D	D	D	D	D
Omhlandlu	Om	D	D	E	D	C	D	D	D	C	D	C
Osaguleni	Os	D	D	E	D	C	D	D	D	D	D	C
Pofane	Po	C	C	A	D	C	C	C	E	D	C	D
Petronella	Pt	D	D	B	D	C	C	D	E	E	C	D
Peebles	Pb	D	D	B	D	C	D	D	E	E	C	D
Qolweni	Qo	D	C	E	C	C	D	C	C	C	C	C
Qwabise	Qb	D	C	E	C	C	D	C	C	C	C	C
Qualm	Qu	E	E	E	E	E	E	E	E	E	E	N
Rondspring	Ro	B	A	C	B	A	A	A	B	B	A	N
Rathbone	Rt	A	A	C	B	A	A	A	B	B	A	N
Rhebok	Rk	A	A	B	B	A	A	A	B	C	A	N
Rasheni	Rs	B	B	B	D	A	A	A	D	D	A	N
Reidbult	Re	B	B	B	C	A	A	A	C	C	A	N
Sangweni	Sa	B	B	B	C	A	B	B	D	C	A	B
Sivulo	Sv	C	C	C	D	A	C	B	D	C	B	B

FIGURE 16



NOTES: (a) Ratings defined in Table 42, as shown on 1:125,000 Land Capability Map, except that F is joined with E there: for division by slope categories, to give NSR Land Classes, see Table 51 on page 208.

(b) Thousand acres, rounded: cumulative totals are inside rectangle.

TABLE 41

Frequency of Each Soil Rating

Soil Rating	I Mixed	I Sugarcane	I Rice	I Citrus	I Pasture	R Maize	R Cotton	R Avocado	R Pineapple	R Pasture	R Conifers	Totals
A = Best	14	16	15	12	32	22	23	10	13	37	10	204
B	17	22	17	16	30	17	24	14	22	20	10	209
C	22	22	20	21	21	24	26	18	19	28	16	238
D	31	28	21	28	10	26	15	19	20	10	17	226
E = Unfit	23	19	34	30	14	18	19	46	33	12	12	258
Totals	107	107	107	107	107	107	107	107	107	107	65	1,135

Numbers are series which have the soil rating indicated. Key to farming systems is in Table 40.

possible using four more letters viz.

G = Gross area of agricultural land: A to C or A to D (specify which) for one or more relevant farming systems.

H = Hard or impossible to cultivate: D to F or E to F (specify which) for all farming systems considered.

S = Suitable slope for given farming system(s): under surface irrigation this will comprise Y plus X and with most raingrown crops Z to V.

T = Too steep for given farming system(s): ranges between W to U for surface irrigation and U alone for dryland farming.

Thus GW or CS could be used as cropland, whereas HY or AT should not be. For explanatory purposes where visual clarity is of paramount importance, as at large open-air gatherings, maps picking out Class GS only in a distinctive bright colour can be most effective. The NSR Land Capability Map at 1:125,000 portrays not the maximum 36 Land Classes but ten, combining S and T with A B C D E (F is included in the latter): for further details see pages 206 to 219.

On occasion it may be desirable to refer to slope category alone or to soil rating alone. For example on precipitous U gradients it is sometimes unnecessary to map separately AU, BU, FU and so on. An umbrella term, the 17th and last in the code, M for Miscellaneous, serves to direct attention towards one component. In the case instanced Class MU would be invoked. Similarly if all excellent soils, no matter what their slope category, must be selected for a certain purpose, the mapping of Class AM will achieve the object.

Since 1965 at the large scale of 1:25,000 the following simplified sixfold key, as a supplement to or bold overprint on soil series maps, has proved most convenient, within the framework of given farming systems — Class AS, Class BS, Class CS, Class DS, Class GT (defining G as soil ratings A to D) and Class HM (defining H as soil ratings E and F). In this manner, detailed surveys of present and possible Rural Development Areas — totalling about 140,000 acres throughout the four regions, see also page 242 — have been expounded to local authorities, extension personnel and interested farmers.

For irrigation planning on single holdings or small blocks of farms soil ratings in respect of series are now considered indispensible, and for raingrown cropping they are very useful. However on large areas — irrigation projects with many participating farmers, or river catchments, or other regional planning schemes — soil set maps are often the only ones available. The soil set reconnaissance is indeed a perfectly adequate indication of agricultural potential where the broad division into "arable" and "grazing" is the main thing required, e.g. during many preliminary investigations which it is known will be followed up by more detailed examinations of restricted areas, almost always within the "arable" category, that will repay series mapping.

In Table 42 therefore each soil set is accorded the rating of its commonest series for irrigated rotation farming (and as an alternative, except in the Highveld region, sugarcane growing). The 1:125,000 Land Capability Map shows the distribution of 1968-1970 soil ratings for sets. Though primarily aimed at giving a picture of the country's irrigation prospects, the map can also be considered as a blueprint for the eventual pattern of rainfed cropping, since the "good" soils — Classes AS, BS and some CS — will undoubtedly be those preferred for dryland crop production in areas unserved by irrigation, through inaccessibility or water shortage. Tables 51 to 57 convey the full statistics of soil set Land Classes but, to facilitate comparison with the countrywide slope category areas in Figure 15, the individual and cumulative acreages of set ratings are shown at Figure 16.

The dynamic nature of land capability studies in Swaziland is indicated by Tables 43 and 44, which feature old now-discarded ratings for, respectively, selected series and farming

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TABLE 42

Soil Ratings for Sets 1968-1970

SOIL SET	PRINCIPAL SERIES	RATING (a)	SOIL SET	PRINCIPAL SERIES	RATING (a)
A	Alicedale	B	OX(c)	Otandweni	D
B	Bushbaby	C	OY(c)	Orrin	C
CH	Coseni	B	P(d)	Pofane	C
CL(b)	Canterbury	B	QH	Qolweni	D
DH	Darketown	E	QL	Qualm	E
DL	Delcor	B	R(b)	Rondspring	A
E	Enkulunyo	D	SH	Sangweni	B
F	Felwako	B	SL(b)	Somerling	C
G	Gocuka	D	TH	Tateni	D
H	Habelo	D	TL(b)	Tambankulu	B
I	Idukathole	E	U(e)	Ungabolima	E
JH	Juweel	C	V(b)	Valumgwaco	D
JL	Jovane	C	W	Winn	A
K	Kwezi	D	X	Xulwane	E
L	Lesibovu	A	Y	Youngsvlei	E
M	Malkerns	A	ZH	Zombode	E
NH	Nduma	B	ZL(b)	Zwide	D
NL	Nhloya	A			

NOTES:

(a) Based on the best soil rating of the commonest series in respect of a surface-irrigated rotation of crops (and surface-irrigated sugarcane except on Highveld soils).

(b) Sugarcane soil ratings are given: rotation is one grade lower in each case.

(c) O set — the most extensive Swaziland soil, discounting rocky land — is subdivided according to region: the portion labelled OX occupies the Lowveld and is typified by Otandweni, shallower and sandier than other member series: OY denotes O set in the Highveld and Middleveld and on the Lubombo, with Orrin series dominant.

(d) The chief outstanding query in this table is — should P set, tantamount to Pofane series, be rated C or D? Its placing as C should certainly be reviewed closely a few years hence.

(e) As in Table 40 soil rating F is excluded: about 30% of U could be considered as belonging to it, but no other set.

TABLE 40 – Continued

Soil Series		I Mixed	I Sugarcane	I Rice	I Citrus	I Pasture	R Maize	R Cotton	R Avocado	R Pineapple	R Pasture	R Conifers
Somerling	So	D	C	D	D	C	C	C	E	D	C	N
Sikhutwane	Sk	D	C	D	D	C	C	C	E	D	C	N
Stegi	St	C	C	C	D	B	C	B	E	C	A	N
Shebani	Sh	D	C	D	D	C	C	C	E	E	C	N
Spekboom	Sp	D	C	D	D	C	C	C	E	E	C	N
Tateni	Tx	D	C	E	C	B	D	C	D	C	C	D
Torgyle	To	D	C	E	C	B	D	C	D	C	C	D
Tambankulu	Ta	C	B	B	D	B	B	B	E	D	A	N
Tshaneni	Ts	D	C	A	D	B	C	C	E	D	A	N
Thorburn	Th	B	B	A	C	A	A	A	C	C	A	N
Ungabolima	Un	E	E	E	E	E	E	E	E	E	E	E
Upcountry	Uc	E	E	E	E	E	E	E	E	E	E	C
Umbeluzi	Ub	E	E	E	E	E	E	E	E	E	E	E
Valumgwaco	Va	E	D	B	E	C	D	D	E	E	A	N
Vimy	Vm	E	D	D	E	C	D	E	E	E	C	N
Vuso	Vu	D	D	B	E	C	D	D	E	E	A	N
Winn	Wn	A	A	E	A	A	A	A	A	A	A	A
Waspageni	Wa	C	B	E	C	B	C	B	C	B	B	A
Wisselrode	Ws	D	D	C	E	B	C	B	E	E	B	E
Whiterock	Wh	C	B	C	C	A	B	A	C	C	A	C
Xulwane	Xu	E	E	E	E	E	E	E	E	E	E	E
Youngsvlei	Yo	E	E	E	E	E	E	E	E	E	E	N
Yakeni	Ya	E	E	E	E	E	E	E	E	E	E	N
Zombode	Zo	C	C	C	B	B	B	B	C	C	B	C
Zayifu	Za	C	C	C	C	B	B	B	D	C	B	C
Zwide	Zd	E	D	C	E	D	D	D	E	E	B	N
Zwakela	Zl	D	C	C	E	B	C	B	E	D	B	N
Zikane	Zn	E	D	D	E	C	E	E	E	E	C	N
Zebra	Ze	E	D	D	E	B	D	C	E	E	B	N

Key to farming systems: I = surface irrigated, R = raingrown, Mixed = mixed annual crops in rotation, Maize = maize and beans rotation, Cotton = cotton and sorghum rotation.

Key to entires: A to E = soil ratings, N = no pine trees are grown in these soil sets confined to low altitudes. Note that soil rating F is omitted as it applies only to unimproved pasture, which is not featured in the table. At a rough estimate half of Ungabolima series would deserve an F rating, but very little other land.

TABLE 43

Soil Ratings of Selected Series: Progressive Assessments 1960-1968

PURPOSE	Surface-Irrigated Rotation of Food Crops and Cotton					Raingrown Rotation Including Maize and Beans				
Year 19	60	62	64	66	68	60	62	64	66	68
Scale	1 to 5			A to E		1 to 4			A to E	
Al	1	1	1	B	B	1	2	2	B	A
Bu	3	3	3	C	C	3	3	3	D	C
Cm(a)	1	1	1	B	B	1	1	1	A	A
Ca	3	3	3	C	C	2	2	2	B	B
De	2	2	2	B	B	1	1	1	A	A
Ek	4	4	4	D	D	4	4	4	E	D
Fe(b)	0	2	2	B	B	0	2	2	B	B
Gc	4	4	4	D	D	3	3	3	D	C
Ge(b)	0	4	4	D	D	0	3	3	D	C
Ha	4	4	4	D	D	3	3	3	D	D
Jw	2	3	3	C	C	2	3	3	C	C
Jv(c)	4	4	4	D	C	3	3	3	D	D
Kz	4	4	4	D	D	2	2	2	B	B
Le	1	1	1	A	A	1	1	1	A	A
Lo	1	1	1	A	A	1	1	1	A	A
Lz	2	2	2	B	B	2	2	2	B	C
Ld	1	1	1	A	B	1	1	1	A	B
Ma	1	1	1	A	A	1	1	1	A	A
Mt	1	2	2	B	B	1	2	2	C	B
Mo	1	1	1	A	A	2	2	2	B	A
Md	1	1	1	A	A	1	2	2	B	A
Nd	2	2	2	B	B	2	2	2	B	A
Ot	4	4	4	D	D	3	3	3	D	D
Or	3	3	3	C	C	2	2	2	C	C
Po	4	4	4	D	C	3	3	3	D	C
Qo	3	4	4	D	D	2	3	3	D	D
Ro	2	2	2	B	B	1	1	1	A	A
Rt	1	1	1	A	A	1	1	1	A	A
Rk	1	2	2	B	A	1	1	1	A	A
Sa	3	3	3	B	B	2	2	2	B	B
So	4	4	4	D	D	3	3	3	C	C
Tx	2	4	4	D	D	2	3	3	D	D
Tm	3	3	3	C	C	2	2	2	B	B
Vm(d)	3	5	5	E	E	2	4	4	E	D
Vu(b)	0	5	5	E	D	0	4	3	D	D
Wn	1	1	1	A	A	1	1	1	A	A
Zd	5	5	5	E	E	3	3	3	D	D
Promoted		0	0	1	4		0	1	0	11
Relegated		6	0	2	1		5	0	15 (e)	2

TABLE 43 — Continued

PURPOSE	Surface-Irrigated Sugarcane				
Year 19	60	62	64	66	68
Scale	1 to 5			A to E	
Bu	3	3	3	C	C
Ca	2	2	2	B	B
De	1	1	1	B	B
Ek	4	4	4	D	E
Fe(b)	0	2	2	B	B
Gc	4	4	4	D	D
Ha	4	4	4	D	D
Jv(c)	4	4	4	D	D
Kz(f)	3	3	3	C	D
Le	1	1	1	A	A
Ld	1	1	1	A	A
Ma	1	1	1	A	A
Ot	4	4	4	D	D
Or	3	3	3	C	C
Pt	4	4	4	D	D
Ro	2	2	2	B	A
Rt	1	1	1	A	A
Rk	2	1	1	A	A
So(g)	4	4	4	C	C
Tm	3	2	2	B	B
Ts(b)	0	3	3	C	C
Va	5	4	4	D	D
Vm(d)	2	4	4	D	D
Wn	1	1	1	A	A
Zd	4	4	4	D	D
Zn	5	5	5	E	D
Promoted		3	0	1	2
Relegated		1	0	1	2

NOTES:
(a) Cimurphy was known as Murphy 1960-1962
(b) No recorded rating for 1960
(c) Jovane was known as Obovane 1960-1966
(d) Vimy was known as Cibelomvubu in 1960
(e) New scale in 1965 with an extra rating causes high number of apparent relegations 1964-1966
(f) Coulter (1968) suggested the downgrading to D
(g) Confirmation that the change to C was judicious is given by Coulter (1968).

TABLE 44

Soil Set Ratings: Progressive Assessments 1964-1968

SETS	1964	1966	1968	SETS	1964	1966	1968
A	A	B	B	QL	E	E	E
B	C	C	C	R	B	B	A
CH	B	B	B	SH	C	B	B
CL	B	B	B	SL	D	C	C
DH	E	E	E	TH	D	D	D
DL	A	B	B	TL	B	B	B
E	D	D	D	U	E	E	E
F(a)	A	B	B	V	D	D	D
G	D	D	D	W	A	A	A
H	D	D	D	X	E	E	E
I	E	E	E	Y	E	E	E
JH	C	C	C	ZH(b)	O	O	C
JL(b)	O	O	C	ZL	D	D	D
K	C	C	D				
L	A	A	A				
M	A	A	A				
NH	B	B	B				
NL	A	A	A				
OX(c)	D	D	D				
OY(c)	C	C	C				
P	D	C	C				
QH	D	D	D				

Ratings (d)	Number of Sets 1964	1966	1968
A	7	4	5
B	5	9	8
C	5	6	7
D	10	9	8
E	6	6	6
Total	33	33	35

NOTES:

(a) Funebizo not Felwako series was rated in 1964

(b) Set not established until 1966

(c) OX in Lowveld and OY elsewhere – see Table 42

(d) Defined in Table 42: numbers 1 to 5 were used in 1964, have been transcribed as A to E.

systems from 1960 to date, and all sets from 1964 to date. The coding prior to 1965 has been retained. Direct conversion to the A B C D E scale is feasible for irrigated farming systems but not for raingrown cropland, which was ranked at 4 not 5 levels originally. Quick reference to the 1:125,000 Soil Map ratings, by sets and parts thereof, is afforded below. Inclusion of NL set with R set presents no problem as both are rated A, but the tiny area of QL set has been sacrificed to H set, so increasing the domain, measured from the map, of D rating by 1,000 acres at the expense of E, an immaterial error.

A rating – L M R W sets
B rating – A CH CL DL F NH SH TL sets
C rating – B JH JL P SL ZH sets and O set outside the Lowveld
D rating – E G H K QH TH V ZL sets and the Lowveld fraction of O set
E rating – DH I U X Y sets: alternatively 70% of U set may be taken as E and 30% as F

SOIL CONSERVATION CLASSES:

The term Capability Class is used by Klingebiel and Montgomery (1962) in a much broader sense, on the whole, than here. The main emphasis on positive potentialities of a soil is placed by the American Soil Conservation Service (SCS) at the low level of Capability Unit, corresponding more or less to a slope subdivision of each soil series. An attempt has been made to determine which Classes of Klingebiel and Montgomery (1962) typify 35 selected Swaziland soil series, two from O set and one from each of the other sets, in six slope categories – see Table 45. A rough guide for fitting other Swaziland series with known soil ratings and slope categories into the Classes of the SCS is set out in Table 46. Dominant hazards or limitations of the 35 selected series on two commonly encountered slope angles are itemized in Table 47. Subclass symbols e and w and s have been advocated by Klingebiel and Montgomery (1962): e signifies erosion, w wetness and s other soil problems. The latter are split in Table 47, so as to be more informative, into sa shallowness, sb stoniness, sc excessive drainage and sd sodium toxicity. Magnitude of risk increases in general with Land Class number: for instance Class IVe is more troublesome than Class IIIe.

Tables 45 to 47 raise many questions – perhaps more than they answer. Examples are

(a) Should the repetition of Class IV for two adjacent soil ratings on each slope category between 3% and 22% be avoided? If so how best could this be done?

(b) Is it fair to push out of the arable group of Classes land with soil rating D on 7% to 14% slopes? Large areas of e.g. Qolweni and Tateni series are thus demoted to Class VI.

(c) Should slopes over 14% be occupied exclusively by non-arable Classes, as they are in USA? This means Class VI or worse, assuming V never exceeds 14% gradient. If so nearly half the series listed will need downgrading on land that is 14% to 22% gradient. As Murdoch (1961) and Baillie (1968) point out, slopes of 20% are in fact being farmed and their soil conserved in Swaziland – though soil abuse by bad husbandry is admittedly more likely on them than where topography is gentler. Outside the contiguous United States even SCS surveys are not always so stringent: in Puerto Rico Carter (1965) cites Mariana series sloping at 18% to 20% as Class IV.

(d) Would too many areas be mapped as Class VIII? Specifically, should any land be so marked on slopes less than 22% unless it comprises bare slabrock outcrop (part of Ungabolima series) or unvegetated marsh (very rare)?

(e) It was not always easy to pinpoint the preponderant reason for downgrading a series,

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TABLE 45

American Soil Conservation Service Land Classes for Selected Series (a)

SOIL SET AND SERIES		PERCENT GRADIENT AND SLOPE CATEGORY						SOIL RATING
		0	0-3	3-7	7-14	14-22	22+	(b)
		Z	Y	X	W	V	U	
A	Alicedale	I	I	II	III	IV	0	A
B	Bushbaby	III	III	IV	IV	VI	VII	C
CH	Coseni	I	I	II	III	IV	VI	A
CL	Canterbury	III	II	III	IV	IV	0	B
DH	Darketown	V	V	VIII	VIII	VIII	VIII	E
DL	Delcor	I	I	II	III	IV	0	A
E	Enkulunyo	IV	IV	IV	VI	VII	VII	D
F	Felwako	II	II	III	IV	IV	VII	B
G	Gocuka	IV	III	IV	IV	VI	VII	C
H	Habelo	V	IV	IV	VI	VII	0	D
I	Idukathole	V	V	V	VIII	VIII	VIII	E
JH	Juweel	III	III	IV	IV	VI	VII	C
JL	Jovane	IV	IV	IV	VI	VII	0	D
K	Kwezi	V	II	III	IV	IV	0	B
L	Lesibovu	I	I	II	III	IV	VI	A
M	Malkerns	I	I	II	III	IV	VI	A
NH	Nduma	I	I	II	III	IV	VI	A
NL	Nhloya	I	I	II	III	IV	0	A
O	Otandweni	IV	IV	IV	VI	VII	VII	D
O	Orrin	III	III	IV	IV	VI	VII	C
P	Pofane	IV	III	IV	IV	VI	VII	C
QH	Qolweni	IV	IV	IV	VI	VII	VII	D
QL	Qualm	V	V	V	VIII	0	0	E
R	Rondspring	I	I	II	III	IV	0	A

TABLE 45 – Continued

SOIL SET AND SERIES		PERCENT GRADIENT AND SLOPE CATEGORY						SOIL RATING
		0	0-3	3-7	7-14	14-22	22+	(b)
		Z	Y	X	W	V	U	
SH	Sangweni	II	II	III	IV	IV	VII	B
SL	Somerling	III	III	IV	IV	VI	0	C
TH	Tateni	IV	IV	IV	VI	VII	VII	D
TL	Tambankulu	III	II	III	IV	IV	0	B
U	Ungabolima	V	V	VIII	VIII	VIII	VIII	E
V	Valumgwaco	V	V	IV	VI	0	0	D
W	Winn	I	I	II	III	IV	VI	A
X	Xulwane	V	V	V	VIII	VIII	0	E
Y	Youngsvlei	V	V	V	VIII	0	0	E
ZH	Zombode	II	II	III	IV	IV	VII	B
ZL	Zwide	V	V	IV	VI	0	0	D

NOTES:

(a) Numbers I to VIII refer to SCS Classes and 0 = not found: Classes I to IV are arable: Class V is restricted to gentle slopes but not to wet land only, as in Rhodesia – Vincent et al (1957).

(b) For raingrown rotation of maize, beans and accompanying minor crops 1968-1970 on each series – see Table 40: therefore NOT the same as the set ratings in Table 42.

The 210 soil-slope combinations are distributed among Classes as follows:

Class I	18	Class IV	54	Class VII	18
Class II	18	Class V	22	Class VIII	15
Class III	27	Class VI	19	Not found	19

TABLE 46

Approximate Conversion from Swaziland to American Land Classes

SOIL RATING (a)	PERCENT GRADIENT AND SLOPE CATEGORY					
	0 Z	0-3 Y	3-7 X	7-14 W	14-22 V	22+ U
A	I	I	II	III	IV	VI
B	II	II	III	IV	IV	VII
C	III	III	IV	IV	VI	VII
D	IV	IV	IV	VI	VII	VII
E	V	V	VIII	VIII	VIII	VIII

(a) For raingrown rotation of crops

TABLE 47

Land Subclasses of Selected Series

SOIL SET AND SERIES		SLOPE CATEGORY 3 - 7% X	SLOPE CATEGORY 7 - 14% W
A	Alicedale	IIe	IIIe
B	Bushbaby	IVsc	IVsc
CH	Coseni	IIe	IIIe
CL	Canterbury	IIIsa	IVsa
DH	Darketown	VIIIsa	VIIIsa
DL	Delcor	IIe	IIIe
E	Enkulunyo	IVsc	VIsc
F	Felwako	IIIe	IVe
G	Gocuka	IVsa	IVe
H	Habelo	IVw	VIe
I	Idukathole	Vw	VIIIw
JH	Juweel	IVsb	IVsb
JL	Jovane	IVsc	VIe
K	Kwezi	IIIw	IVw
L	Lesibovu	IIIe	IIIe
M	Malkerns	IIe	IIIe
NH	Nduma	IIe	IIIe
NL	Nhloya	IIe	IIIe
O	Otandweni	IVsa	VIsa
O	Orrin	IVe	IVe
P	Pofane	IVw	IVe
QH	Qolweni	IVe	VIe
QL	Qualm	Vsd	VIIIsd
R	Rondspring	IIsa	IIIsa
SH	Sangweni	IIIsa	IVsa
SL	Somerling	IVsa	IVsa
TH	Tateni	IVsc	VIe
TL	Tambankulu	IIIw	IVsa
U	Ungabolima	VIIIsb	VIIIsb
V	Valumgwaco	IVw	VIw
W	Winn	IIsc	IIIsc
X	Xulwane	Vw	VIIIw
Y	Youngsvlei	Vsd	VIIIsd
ZH	Zombode	IIIsa	IVsa
ZL	Zwide	IVw	VIe

Suffixes suggest the chief risk or limitation to be combatted or endured by farmers, as follows: e erosion, w wetness, sa shallowness, sb stoniness, sc excessive drainage and sd sodium toxicity.

e.g. Pofane is rather erodible, slightly wet in summer and somewhat shallow. Patently multisuffix Subclasses would be clumsy.

On balance it does not appear that superimposing limitation Subclasses, important though they and their implications be, upon the suitability Classes in Table 38 will serve a useful purpose. Land in say Class CV or Class DX for a certain farming system has obviously had its poverty – or its vulnerability to adverse changes in the soil condition – noted and embodied in its assessment. The farmer is forewarned not to develop such unrewarding ground unless forced to. In the few cases where he must do so, the risks can be spelled out verbally, after recourse to the basic document i.e. the soil series map, as effectively as by subscript symbols on his land capability plan.

YIELD-SOIL CORRELATIONS:

At the beginning of the NSR in 1963 the question was posed – can crop yields and profits in Swaziland be related to soil mapping units? The writer's opinion is that quantitative studies, indicating how much harvest can be expected from X (crop) on Y and on Z (soil series or soil sets) under specified management conditions, should be the ultimate goal of applied pedology. It has been stated that crop yields alone are an inadequate measure of land capability. Monetary yields must be considered too, particularly where able individual farmers who reclaim near-wasteland are contrasted with bad farmers on fairly good soil. But if people of the latter type can be eliminated, by excluding them, and if management variations can be narrowed down satisfactorily within the "rather above average" bracket, the agronomically productive and the lucrative become factors with parallel trends. On ascertaining one, the other is deducible. This has been, at any rate, the underlying assumption in the work outlined below. Modest supporting cost-accounted calculations (see e.g. pages 239 and 245) lend credence to it.

Even in 1963 Swaziland was partway on the road to knowing yield-soil relationships, thanks to a good scatter of agricultural experiment plots – Murdoch (1965) – and to glasshouse subtractive fertilizer trials carried out by A.C. Venn. But on a nationwide scale, bringing commercial (and possibly subsistence) growers into the picture, how best could these quantitative studies be pursued? Three methods were soon rejected as not feasible at that time: they were

(a) Utilize existing demographic and official agricultural statistics. In Uganda M'Master (1962) had been able to employ a fine-mesh geographical breakdown – about 570 "parishes" with an average area of 120 square miles – to act as a template for plotting first taxpayers and then crop distributions. Only now, with the publication by Jones (1968) of the excellent population dot map – in rural areas 20 persons per dot – is a similar programme contemplated for Swaziland. But crop quantities are still, as in 1963, hard to come by for small areas of CNL, other than those which happen to have been sample survey choices. On ITH the better-run estates render exact returns of crop acreages and yields, but of course for Ministry of Agriculture statutory purposes these are global figures per holding without division according to the kind of soil.

(b) Follow up the 1960 sample survey by Holleman (1964) wherein 53 squares of about 2,000 acres each had been exhaustively scrutinized from many socio-economic angles. A plan to obtain estimates of major crop production per acre on each soil series within every square for two or more consecutive seasons had to be abandoned as administratively too cumbersome to tackle.

(c) Conduct "maximum yield" trials on each important series. This technique would have given upper limits of output – and also Baule units – as yardsticks against which to judge other results, including the prevailing farm harvests. At Samaru in Northern Nigeria the writer was shown by G.B. Jones and G.M. Higgins rainfed cotton plots of this nature. For the previous seven seasons, to 1963, they had given between 2,200 and 2,650 pounds per acre seed cotton from Karina series yellowish deep eolian fine sandy deposits on iron pan. Local yields without fertilizer and spraying were under 400 pounds per acre annually from Karina soil. Again the sheer organization of enough trials in Swaziland thwarted a territorial scheme. Moreover M.H. Carey has now undertaken sufficient field-scale demonstrations, often next to experiment blocks, for it to be clear that the differential which Venn (1963) already knew to exist between experiment panels and farmland can, economically, be bridged to a great extent. The relevant maize figures as early as 1964 were national average less than 500 pounds per acre: best rainfed research plot 3,400 pounds per acre: best irrigated field 6,000 pounds per acre (40 acres of Mdutshane series at Malkerns Research Station): best irrigated research plot 7,500 pounds per acre.

Remaining avenues, which were in fact followed, led to concentration not on predetermined soils or areas but on four important crops – sugarcane, maize, cotton and pine trees. By 1964 work on the first three had begun. Conifers were added in 1967 as a result of the forestry industry's interest in their effects on soil. Each of the four is reported in detail later, under the headings irrigability, the potential for raingrown crops and afforestation. The following paragraphs introduce the methodology of investigating them.

Irrigated sugarcane is grown on a quota system and since 1962 all new fields have had to be certified as inter alia possessing suitable soil. Except where subsequent malpractices have induced waterlogging or salinity or both – not a large area, and rectification of surplus water disposal is now reducing it – there are thus smaller differences between the best and worst canelands than might have appeared had indiscriminate planting been allowed.

But the range of "suitable" does span soil ratings A to D (though C and D are kept to a minimum) and much pre-1962 development was on low-rate soil, so for 8 estates with reasonably equivalent management standards it proved possible to find a wide enough spread of both ratings and sets – there were not soil series maps for some holdings. Particulars were taken of all fields entirely or predominantly occupied by one set, provided the complete cropping history from 1960 on was adequately diarized and available for inspection. In the event 235 surface-irrigated fields with the varieties NCo310 and NCo376 were studied. They contain 13 soil sets – see further on pages 198 to 206.

Raingrown maize, the staple food, has been the principal crop of demonstration fields run by farmers on CNL for several decades, with help from local agricultural extension personnel. These are primarily cash-income and not subsistence plots. From the 1957 harvest onwards virtually complete records of fertilizer applied and yields obtained on them are to hand.

How accurate are the records? Reaping and weighing was not standardized until 1964, some fields have been very small (less than 0.5 acre: the mean is 0.7 acre) and so have had marked edge effects, and senior extension staff express doubts about the value of the oldest records. Palpably wrong figures have been disregarded, but some errors must still lurk within the mass of data accumulated. It relates to 542 plot-years and 33 soil series, however, so there is hope that overstatements are counterbalanced by underestimates, at least in respect of the commoner series: 16 of them are represented by 10 to 83 plot-years each.

An equally worrying feature of the results already gathered in by 1964 was the low mean yield, by developed-nation not African standards, of about 1,500 pounds per acre annually. Would such a production level show up soil differences starkly enough for statistical treatment, and even if it did would the soils be in the same order, from highest to lowest yield, were the mean to be doubled or trebled?

Two encouraging findings that confirmed one should proceed despite these fears were (a) the FAO maize trials on fields of co-operator farmers in West and North Africa had since 1962 attained similar mean yields in fertilizer-treated panels and (b) the mean compared favourably with 1957-1964 harvests not only from all CNL (where 400 pounds per acre would have been an optimist's estimate) but also from private farms on ITH, judged from annual censuses to have been producing only 1,000 pounds per acre: this meant that above-average CNL growers were certainly participating in the demonstrations, thus helping to satisfy the condition that management be a constant or nearly so.

The soils of each plot were sampled by junior extension staff, directed by the author. Series identification was done at subdistrict headquarters usually. Findings are presented on pages 222 to 240. Subsistence maize would have to be omitted, it soon became clear, both because of the abysmally low and erratic yields and because of logistic and mechanical (e.g. weighing, field area measuring) difficulties.

Raingrown cotton has also been featured at many demonstration plots. It was investigated in exactly the same way as maize, for the same decade 1957-1966. In all 180 harvests from 25 soil series go towards providing the results on pages 242 to 250. As with maize, it was realized that yields were mediocre – only 600 pounds per acre annually of seed cotton by 1964 – but again they were more than 100 pounds per acre better than yearly ITH pickings over the same period. Moreover being inedible, baled and solely a cash crop, cotton was more trustworthily weighed than maize.

Pine trees (mainly Pinus patula) and their growth were thoroughly discussed with foresters on the three largest timber plantations, while they were being soil surveyed, before proceeding with an analysis of stem height measurements (and in some cases volume-under-bark estimates) for 734 subcompartments of forest, covering 11 soil series. As with sugarcane, only stands wholly or largely floored by a single soil series were selected. Full details are on pages 256 to 261.

There is no legal obligation on tree planters to confine themselves to "suitable" soils, but site quality surveys had been carried out just after World War II – Howick (1962) – to determine where the pines should go. Wise decisions were made, therefore the extreme lower range of edaphic conditions is poorly exposed. For example not only is wet land unplanted but, so as to match regulations by Ingwenyama Na Libandla (1953) – the King in Council – concerned with ploughing in neighbouring CNL, about 30 yards of footslope soils are also normally left treeless along marsh margins.

One ordinance has, however, resulted in a few poor – even abjectly poor – sites being included with the good: this was the rule that grid-pattern planting must go on across hillsides and mountains within a forest block, once chosen, the only permissible gaps being where outcropping rock precluded placement of a seedling. Thus pines, but no other crop, can be seen and measured struggling to grow on quite large parcels of Ungabolima series, which dominates about 6% of the subcompartments.

The yield-soil correlative research pertains to about 29% of all present canelands and 33% of pinewoods in Swaziland. And although the areas of maize and cotton demonstration plots are very small compared with total acreages of these crops, the coverage of producers (excluding the purely subsistence-sector maize growers) is better, exceeding 5% in each case. The four crops together in 1968 occupied nearly 570,000 acres – or omitting subsistence maize perhaps 340,000 acres – out of some 640,000 acres of fields, orchards and forests.

Coulter (1968) advises and is arranging for the statistical analysis at Rothamsted Experiment Station of the data collected. The first computations, for maize, have been received from P. Walker and J. Dunwoody. Some standard errors are incorporated in Figures 19 to 32 but it seems preferable to wait until all results are available, for the four crops, before commenting in extenso upon statistical significance.

IRRIGABILITY:

The general principles of irrigability classification, for crops other than rice, can be stated very simply – maximum depth of rooting zone: no extremes of texture (coarse sand or heavy clay) and of structure-consistency (apedal and loose or blocky to prismatic and stiff): optimally sandy loam to clay loam, without sudden textural changes: high or medium available water holding capacity: good or moderate permeability through all soil horizons and through underlying material: and the chief site criterion, gentle gradient without hummocks or wrinkles.

If all these factors are propitious, waterlogging and salinity and alkalinity – the bêtes noires of Swaziland irrigators – will not develop. And where there is danger that they might obtrude, anguish and ruin in the future can be avoided by observance of the golden rule: plan a scheme around its surplus water removal channels – earth ditches or grassed waterways or tile drains or moles – and construct them before beginning to irrigate.

Quantifying and analysing soil depth, texture and water relationships in ways meaningful to farmers presents alternatives, depending upon crops and their cycles, irrigation methods (especially whether surface or sprinkler) and acceptable or wishful output levels. Much has already been written about soil and slope desiderata by Swaziland workers – Baillie (1968), Lea and Murdoch (1964), Murdoch and Andriesse (1964) and with regard to specific crops Venn (1962) on maize, Lea et al (1965) on cotton, Dodson (1964) on citrus. In addition some Natal and Southern Mozambique publications are relevant for local irrigators – Thompson (1967) and Turck (1966) on sugarcane, Hensley and Sumner (1967), Thompson and Collings (1963), Barrados (1962) etc.

Limiting factors which are not separately evaluated in Swaziland when mapping Land Classes for either irrigated or rainfed farming systems, because they are transient or because other heads adequately cover them or because they are rare, include (a) soil fertility – see also page 146: (b) erosion and irregular microrelief: (c) rockiness and stoniness: (d) flooding: (e) intrinsic salinity and alkalinity – all these are thoroughly gone into by Murdoch and Andriesse (1964) and Baillie (1968).

The main purpose of the next few pages is not to add new material on the conceptual or the practical aspects of irrigability, but to present the geographical distribution of irrigable land in the country and the results of sugarcane irrigation researches. The sources of the brief descriptions relating to soil characteristics under the next six cross-headings are therefore Baillie (1968), whose statements on these topics are endorsed, and the timely, authoritative advice of Coulter (1968).

All comments unless otherwise noted refer to surface irrigation, either from gravity canals or from reservoirs to which water is pumped. Spray irrigation is treated separately as regards sugarcane on pages 202 and 206.

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TABLE 48

Sugarcane Yield-Soil Correlation

By 4 Land Classes containing 13 soil sets. Units, numbered in body of table, are 235 surface-irrigated fields of more than 7 acres each (mean about 50 acres) with 2 to 6 harvests (i.e. fields with less than one ratoon are excluded). Plantcane is usually cut at 17 months, whereafter the average interval between ratoon harvests is 15 months. Returns were pooled from 8 estates viz. Big Bend (S9), Hladeni (T9), Mhlume (F8), Sihoya (D7), Tambankulu (G9), Tshaneni (E8), Ubombo (R9) and Vuvulane (F9). Of these Sihoya is on CNL, the others ITH. Yields are mean lb/ac/mo (pounds per acre per month) green matter 1960-1967.

Sets	L	R	W	CL	DL	TL	B	SL	G	H	K	V	ZL	All
Classes		------- AS -------			-------- BS --------			--- CS ---			--------------- DS ---------------			All
Fields	4	54	23	22	5	5	5	11	3	24	23	16	40	235
lb/ac/mo		81			32			16			106			
10200		2												2
9600		1	1											2
9400		1												1
9300		1												1
9200		2												2
9100				2										2
9000								1				1		2
8700		1		1										2
8600		3												3
8500								1			1			2
8400		2				1				1				4
8300								1			1			2

TABLE 48 – Continued

Sets / Classes	L	R	W	CL	DL	TL	B	SL	G	H	K	V	ZL	All
	------ AS ------			-------- BS --------			--- CS ---		---------------- DS ----------------					All
8200		1	1	1		1		1						5
8100		1											1	2
8000		1											1	2
7900		1	1							1			1	4
7800		4												4
7700		3						1						4
7600		2	1	1	1								1	6
7500		1	1		1					1				4
7400		3			1	1							1	6
7300			2							1		1		4
7200			1				1							2
7100			1	1					1		1			4
7000		2	1	1						2			1	7
6900		3	1	1						1			2	8
6800		5	1						1	3			3	12 Mode
6700	1			1						1	1	1		5 Mean
6600			3		1						1		2	7
6500	1	3		2						2	1	1		10 Median
6400		3	2	1		1		1		1			1	11
6300			1							2				3
6200		2		2				1				1		6
6100	1	1	1				1			2			1	7
6000		3	2			1				1			1	8
5900	1	1		3				1				2	1	9
5800			1	2								2	2	7
5700		1	1	1	1					1			2	7
5600							1	1					2	4

TABLE 48 — Continued

Sets	L	R	W	CL	DL	TL	B	SL	G	H	K	V	ZL	All
Classes		------- AS -------			-------- BS --------		--- CS ---				---------------- DS ----------------			All
5500											1		1	2
5400											1		1	2
5300									1	1	3	1	2	8
5200										1	3		1	5
5100											1		2	3
5000								1				1	2	4
4900				1				1			2	1		5
4800				1							3			4
4700											1		1	2
4600										1		1	3	5
4500											2	1	1	4
4300							1							1
4200													1	1
4100												1		1
4000												1		1
3800													1	1
3700							1							1
3600										1			1	2
Medians:	63	76	68	65	74	74	56	64	64	65	52	58	57	65
Hundred lb/ac/mo		70			66		62				58			

Comparison is invited with data of Lea (1967) whose surface-irrigated research panels have had yields, for two or three harvests each during 1962-1966, which average 11500 lb/ac/mo on R set (14 plots): 8700 on W set (14 plots): 8000 on CL set (7 plots): 6900 on H set (7 plots).

IRRIGATED ROTATION OF ANNUAL CROPS:

Possible crops include the foods maize, wheat and vegetables and the fibre cotton. At present just under 20,000 acres of these are grown under irrigation, often not in a true rotation but monoculturally with brief intervals of other cropping or of fallow. Wheat (also oats) and vegetables can be produced during winter in the Lowveld and at some places higher up, so making useful fill-ins for maize and cotton fields and for ricelands if the soil profile dries out quickly enough at the period of the late summer rice harvest and just after. Large expansions in most of these crops, especially vegetables, would be faced with severe marketing problems currently, but they are agronomically feasible.

This farming system was chosen, along with sugarcane, out of the eleven rated (see Table 40), to portray on the 1:125,000 Land Capability Map both because the likelihood of its dissemination among progressive Swazi farmers is great and because it is highly demanding in its soil requirements, so giving a not too flattering visual cartographic impression of the prospects for intensive agriculture. One or other crop in the rotation will need relatively great soil depth and very good drainage. The shallow SL set soils whose rating for sugarcane was raised from D to C in 1966 remain therefore on D for rotated annuals meanwhile. Soils of heavy texture are downgraded compared with their rice and even their sugarcane ratings.

IRRIGATED SUGARCANE:

Soil ratings are similar to those for irrigated rotation, but shallow and heavy soils are upgraded. As may be seen from Table 42 the soil sets CL R SL TL V ZL benefit by one Class on the Land Capability Map from this easement. It seems fair that they should do so because, although the world market for sugar is at the moment rather depressed, the crop has an assured place in Swaziland agriculture (nearly 40,000 acres of cane are being grown) and its inclusion widens the significance of the map. Should opportunities occur in the next few years for further irrigation of either cane or other graminaceous crops – notably improved pasture – interspersed with annual cropping, the Land Capability Map sheets suggest where to encourage such mixed farming. It is practised now by the settlers at Vuvulane (see page 45), most of whom have 4 to 12 acres of sugarcane and 3 to 6 acres of vegetables and other crops.

Sugarcane yields on 13 soil sets well distributed over the four Land Classes AS to DS are presented in Table 48. Slope categories in the canefields are almost always Y or X, about 1% to 6% being normal land gradients. The difference between the best soil (R set) and the poorest (K set) is 2,400 pounds per acre per month or about 18 tons per acre per cut (57 versus 39 tons). Nett profits to planters are currently R 2 per ton of cane, before deducting transport costs and excluding interest on capital (so this is generous to K set which needs more drainage and dearer layout than R set). With road haulage charges 5c per ton-mile, it would thus be better to develop R set and similar excellent soils up to 12 motorable miles farther away from a mill than K set.

As the low K set yields suggest, the main sugarcane soil problem is waterlogging. It can be prevented on many soils, even some in K set, by initial deep cross-ripping and a fairly simple reticulation of infield drains (open or tile or mole) connected to main ditches spilling into natural streambeds, excavated or straightened where need be. But since 1966 on Kwezi and Viny series at Big Bend and on some Zwide series at Mhlume recourse has been had to the more drastic expedient of Nardi ploughing to depths as great as 4 feet (120 cm): the longterm effects of this will be observed with interest.

Table 48 refers to surface-irrigated blocks. Only 35 comparable fields with overhead

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TABLE 49

Sugarcane Yields by Surface and Overhead Irrigation

Soil Set	Number of Fields		Mean Yield lb/ac/mo		Benefit
	Surface	Overhead	Surface	Overhead	(a)
R	54	7	7600	8400	800
CL	22	5	6500	8200	1700
SL	11	4	6400	8000	1600
L	4	3	6300	7500	1200
K	23	6	5200	6700	1500
All	114	25	6400(b)	7800(b)	1400(b)

NOTES: (a) Advantage of sprinkling over gravity watering in pounds per acre per month.

(b) Unweighted means, to nearest hundred.

TABLE 50

Ubombo Sugarcane Growth Increments on Six Soil Sets

Increments as inches of stick per month for 3 years of measurement, from February 1962 to March 1965.

SOIL SETS (a)		SL	R	CL	K	V	W	All	All	
IRRIGATION METHODS (b)		All						All	Surface	Overhead
Number of Plants		385	183	187	90	72	83	1000	870	130
IN/MO	all year	8.5	8.9	8.9	8.0	6.7	8.7	8.3	8.2	9.2
	J-F	14.2	17.2	14.9	15.2	12.4	14.8	14.8	14.7	15.2
	M-A	11.0	12.3	11.6	10.0	10.8	11.6	11.2	11.3	10.3
	M-J	4.0	3.2	4.9	3.6	3.1	4.2	3.9	3.8	4.4
	J-A	3.0	2.1	2.7	2.4	1.5	2.4	2.4	2.2	3.6
	S-O	6.3	4.8	5.7	6.2	3.7	6.1	5.5	5.2	8.0
	N-D	12.5	13.9	13.5	10.8	9.0	12.7	12.0	11.8	13.5
INCHES/YEAR		102.0	107.0	106.5	96.5	81.5	104.0	99.5	98.0	110.0

NOTES: (a) From mean yields of cane in Figure 17 it appears that one inch of stick added is roughly equivalent to the following weights, pounds per acre, on each soil set: SL 710, R 790, CL 690, K 650, V 750 and W 830.

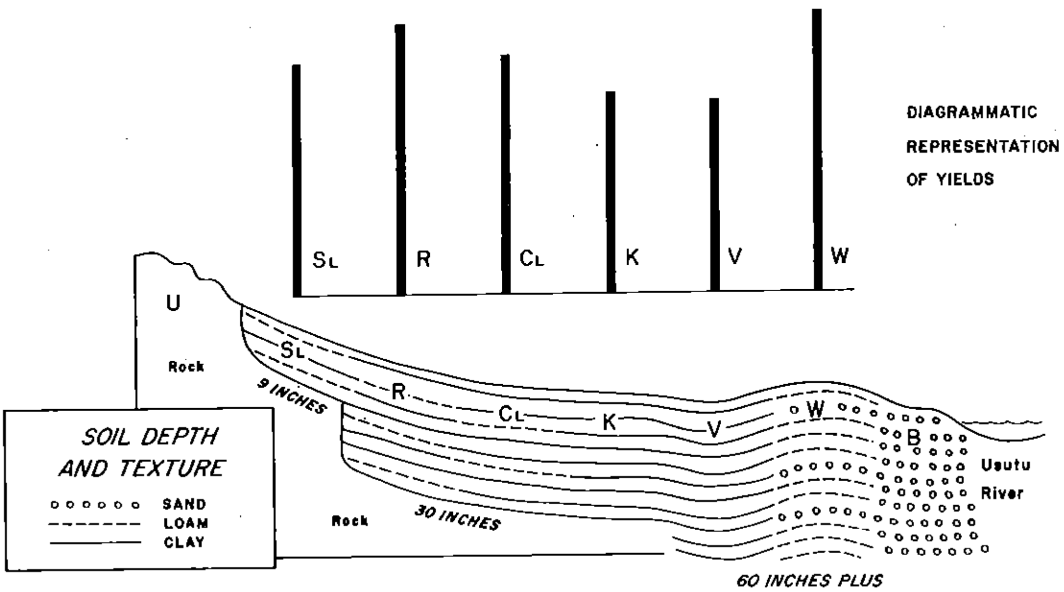
(b) No overhead irrigation yields are given in Figure 17 as the fields concerned had not reached their second ratoon at the date of the investigation.

FIGURE 17

Ubombo Sugarcane Yields on Six Soil Sets

Growth in pounds cane per acre per month over $4\frac{1}{2}$ years of harvests, from Sep. 1960 to Feb. 1965 : all surface-irrigated

SOIL SETS (a)	S_L	R	C_L	K	V	W	Avge
NUMBER OF FIELDS	4	10	10	7	7	5	7 (b)
LB/AC/MO	6,050	7,000	6,180	5,210	5,040	7,230	6,380



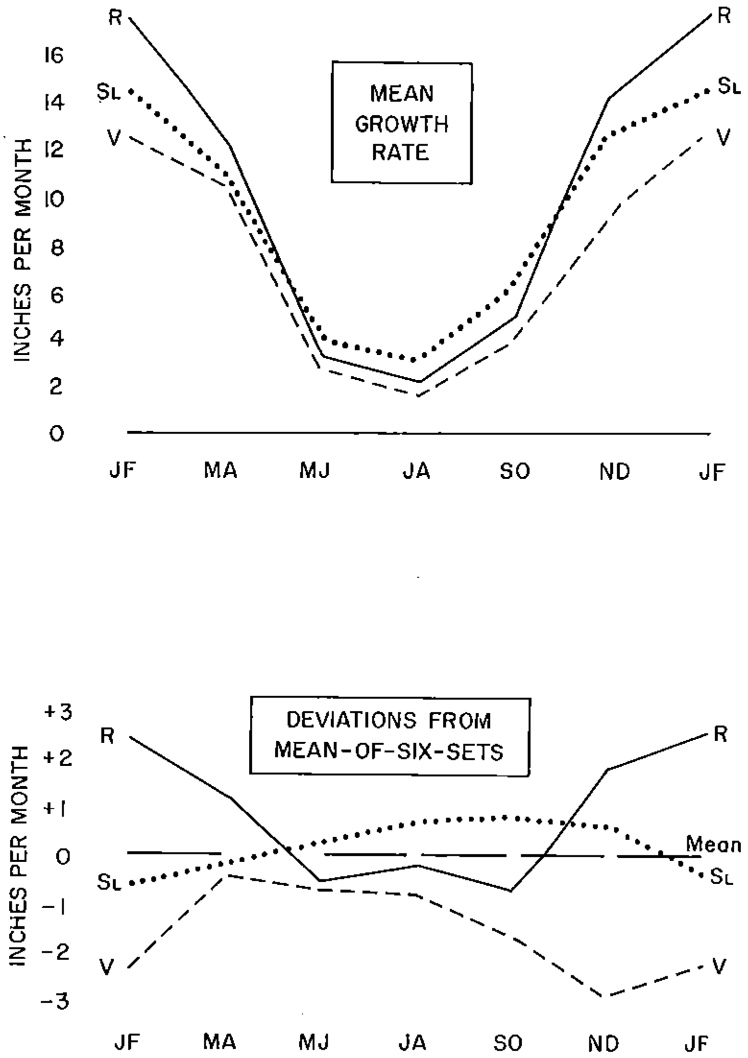
(a) Forecast of ranking – Murdoch (1960): W > R > C_L > K > S_L > V

Compare actual results : W > R > C_L > S_L > K > V

(b) Mean size 80 acres, all second ratoon or older

FIGURE 18

Ubombo Sugarcane: Seasonal March of Growth Increments



See also Table 50 whence these graphs are derived applications of water and into their second ratoon could be found. Sets with three or more sprinkled fields – see Table 49 – all show advantages in yield with this method. The greater cost of spraying must not be forgotten. To offset it, at Big Bend G.M. Todd (1968, private communication) considers that 500 pounds per acre per month extra cane growth, compared with gravity schemes, is required. But if the effect of overhead irrigation is to prevent or delay soil damage (waterlogging, salinity, erosion) as advocates of the system convincingly aver, then longterm profitability must handsomely recoup initial and recurrent outlay.

The median yield of all sprayed cane – about 7,900 pounds per acre per month – surpasses that of gravity-irrigated cane by more than 20%: as well as a general rise, there is a closing of the gap between best and worst fields in overhead as against surface schemes, and it is largely for this reason that, until more is known, soil ratings specifically in respect of spray irrigation are not being attempted, whether for sugar-growing or for any other farming system.

At one estate, Ubombo, a more detailed study of cane yields and growth increments has been undertaken in collaboration with P. Andries and D. Salkeld and colleagues. Figure 17 reveals that the pattern of yields on the six soil sets concerned is not very different from the national one adduced in Table 48, therefore the stick length measurements – Table 50 – may have a significance more general than purely local. Regarding the growth increments on three contrasting soils – Figure 18 – SL set overtakes R set at the beginning of May, then grows faster until the end of October, while V set is consistently slowest to gain height, lagging especially in early summer. Provisionally the good performance in winter of SL set, which is usually an upper slope soil, is attributed to better air drainage down its slightly steeper gradients, compared with the other sets whereon banks of cold air may be more prone to settle: but this is probably not the only factor involved. Overhead irrigation leads to taller cane, except during March and April, vis-à-vis surface watering, the sprinkler method being relatively most effective around September and October in promoting stick elongation.

AREAS AND PATTERNS OF LAND CLASSES:

The straightforward combination of five soil ratings and two slope categories on the Land Capability Map hides an anomaly that needs explaining. The ratings of soil sets are for surface irrigation, and in Table 39 slopes over 7% are suggested as often unfit for this method of water application. Yet 14% and not 7% is the boundary drawn at 1:125,000 between S and T. At one stage showing the 7% isocline instead was contemplated but the idea was rejected, since it seemed that too little of the country would then be represented as having ploughable slopes – from Figure 15 less than 1,600,000 acres, as against 2,500,000 using 14%. Because the Land Capability Map is intended to hint at the potential for dryland as well as irrigated rotation it was decided to let the "mistake" go through. One hopes that on Class MW – the 7% to 14% gradients, mostly ringing Class MT areas – the soil ratings might reflect not too badly the suitability for sprinkling, yields from which can perhaps be expected to have there a closer relation to type of soil and also a wider span than in the relatively flat sugarcane spraylands. But this is a surmise and excuse which cannot be tested on the ground until more overhead irrigation is installed. Of course surveys more detailed than the NSR take into account additional slope categories – e.g. all those of Baillie (1968) do have divisions at 7% on 1:50,000 maps – and nobody will be led astray if the 1:125,000 sheets are used only in the way intended, that is as guides to where more intensive soil investigation should be directed.

The acreages of the ten Land Classes mapped have been computed in exactly the same way as soil set areas – see page 157. Classes are given by regions and subregions in Table 51, by major catchments in Table 52, by land tenure and subregions in Table 53 and by Cores-Periphery zonation in Table 54. The focus narrows to three canal commands in Table 55 – see also Map 10. Comparative charting of all the foregoing, and also the Land Class acreages at the 26 centres of nucleated settlement (indicated on Map 10), are provided in Table 56.

As a byproduct of the Land Class area measurement it has become apparent that the random sample survey squares of Holleman (1964), occupying nearly 110,000 acres or 5% of CNL, are underendowed with good quality land. Only 50% of the entire area of the squares falls in Class GS, as against 56% of all CNL. The other half of the squares comprises 17% Class GT and 33% Class HM. Suspicion had been aroused that the random sampling was not very representative as it gave the low estimate for total Swazi population of at most 241,000 in 1960 or, using the current 2.8% annual increase, some 287,000 in 1966 – when in fact 352,000 Swazi were counted at the census. The 18% gap would be narrowed to less than 7% of the census figure by applying a corrective factor to the 241,000 proportionate to the difference in Class GS acreage between sample and whole. The correction could not be more than approximate because there are margins of error inherent in the Land Class mapping and because ITH Swazi (one fourth of the 1966 national total) are included in the populations cited.

The Classes are reduced to three – AS with BS, CS with DS, ES with MT – for plotting by both subregions and catchments in Table 57. Within each of the 29 subcatchments so formed Map 18 permits visual comparison between Classes AS plus BS and the total land area. All these text accompaniments are self-explanatory. Some of the most important inferences which may be drawn from them receive mention in the conclusion, page 287 ff. However, linking the Land Classes with places where each is commonest – or absent – will be helpful and the rest of this section is devoted to short-note narration of geographical distributions.

Class AS is most concentrated in (1) Ezulwini-Malkerns valley, (2) Umtilane valley, (3) Lomati valley except around Sihlela (B5) Hills, (4) Komati riparian strip from Avondrust downstream, (5) Hersov (H9) to Vuvulane, (6) scattered areas of Lubombo Range, Ravelston (NO) – Shololo being largest block, (7) Lismore (X9) to Nsoko and (8) Goedgegun-Dwaleni (X4). Large more isolated portions at Busaleni (S4) and Nkweni, Nkilije (J5), Mapobeni (R8), Ntshingila (V5). Less concentrated zones (1) whole of Eastern Lowveld, (2) Western Lowveld from Duze (Q7) southwards, (3) Tambendi (H8) to Likima, (4) Upper Ngwempisi valley, (5) Khumba (Q6) and Lesibovu, (6) belt from Sitshegu (P4) to Luhleko (N2). Note also areas at Nkalishane, Gege, Tandizwe (Z6) and Mahlangatshe. Biggest compact blocks at Hersov and Nsoko. Biggest tortuous blocks at Grootehoop (V9) to Zibe, Umtilane, Lomati, Balegane and Mapungwane (NO).

Class BS is most concentrated in (1) Nzoto (J9) to Vuvulane band, (2) Canterbury (V9) to Golela, (3) Old Zombode, (4) Zwartkop (P2) plateau and (5) Rampur (S4) to Ntungula (R3). Less concentrated zones include (1) whole of Eastern Lowveld and (2) Inkaba (G3) to Maloyo (K2). Biggest compact blocks are at Tambankulu (G9) and Zwartkop.

Classes AS and BS close together exhibit equality over most of the Eastern Lowveld and in minor areas e.g. Maloma (V7) elsewhere. BS supplements AS at Ezulwini-Malkerns, Umtilane, Goedgegun-Dwaleni, Nkalishane, Mapobeni, Tunzini (D7), Sipocosini and Hlambenyatsi. AS supplements BS at Mahlangatshe and Boshoek to Sidzakeni (R1).

Class CS is most concentrated, and apart from AS or BS, in the Lower Middleveld, especially a long strip from Insolambe (A6) to Lesibovu. Interrupted south of the Usutu, but perceptible in Sitobela-Kubuta embrasure and lower Mantambi. Also common round Sihlela and in Ngwempisi basin. Large pieces in Eastern Lowveld. Nearest to being completely isolated from AS and BS at Tabezimpisi (C6), Matendeli (L6) and Mgazini (S2).

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TABLE 51

Acreages of Land Classes by Regions

Class	Swaziland (a)	HV	MV	LV	LR	% (b)
AS	390,000	42,000	124,000	193,000	31,000	9
BS	260,000	88,000	40,000	124,000	9,000	6
CS	720,000	94,000	253,000	311,000	66,000	17
DS	880,000	73,000	99,000	697,000	7,000	20
ES	260,000	56,000	73,000	105,000	25,000	6
AT	70,000	34,000	36,000	1,000	2,000	2
BT	140,000	99,000	38,000	0	1,000	3
CT	250,000	104,000	117,000	6,000	23,000	6
DT	200,000	146,000	42,000	7,000	1,000	5
ET	1,140,000	541,000	319,000	93,000	182,000	26
GS(c)	2,250,000	297,000	516,000	1,325,000	113,000	52
GT	660,000	383,000	233,000	14,000	27,000	16
MT	1,800,000	924,000	552,000	107,000	209,000	42
HM	1,400,000	597,000	392,000	198,000	207,000	32
Total	4,300,000	1,280,000	1,140,000	1,530,000	350,000	100

TABLE 51 – Continued

Class	UM	LM	WL	EL
AS	81,000	43,000	84,000	109,000
BS	24,000	16,000	29,000	95,000
CS	64,000	189,000	132,000	179,000
DS	41,000	58,000	570,000	127,000
ES	41,000	32,000	49,000	56,000
AT	30,000	6,000	0	1,000
BT	27,000	11,000	0	0
CT	58,000	59,000	3,000	3,000
DT	33,000	9,000	7,000	0
ET	129,000	190,000	49,000	44,000
GS(c)	210,000	306,000	815,000	510,000
GT	148,000	85,000	10,000	4,000
MT	277,000	275,000	59,000	48,000
HM	170,000	222,000	98,000	100,000
Total	530,000	610,000	920,000	610,000

NOTES:

(a) This column and region and subregion totals are rounded to 10,000.

(b) National percentage.

(c) Here and in Tables 53-57 soil rating G is taken as A to D, so H equals E

TABLE 52

Acreages of Land Classes by Major Catchments

Class	Komati	Umbeluzi	No. Usutu	So. Usutu	Ingwavuma
AS	45,000	76,000	94,000	86,000	82,000
BS	21,000	60,000	62,000	71,000	50,000
CS	86,000	152,000	183,000	196,000	106,000
DS	100,000	246,000	217,000	176,000	119,000
ES	22,000	47,000	62,000	75,000	50,000
AT	26,000	13,000	18,000	10,000	7,000
BT	45,000	18,000	34,000	33,000	8,000
CT	39,000	49,000	55,000	80,000	29,000
DT	72,000	25,000	42,000	40,000	18,000
ET	180,000	198,000	220,000	389,000	135.000
Total	640,000	890,000	990,000	1,160,000	620,000

See Table 30 footnote: totals rounded.

TABLE 53

Acreages of Land Classes by Tenure and Subregions

Class	Tenure (a)	HV	UM	LM	WL	EL	LR
AS	CNL	24,000	53,000	29,000	56,000	46,000	17,000
BS	CNL	33,000	15,000	11,000	20,000	47,000	5,000
CS	CNL	42,000	34,000	138,000	89,000	95,000	34,000
DS	CNL	33,000	28,000	38,000	337,000	76,000	4,000
GT	CNL	145,000	95,000	52,000	7,000	4,000	20,000
HM	CNL	223,000	115,000	152,000	71,000	52,000	100,000
Total	CNL	500,000	340,000	420,000	580,000	320,000	180,000
AS	ITH	18,000	28,000	12,000	27,000	64,000	14,000
BS	ITH	55,000	9,000	6,000	10,000	49,000	4,000
CS	ITH	51,000	30,000	51,000	43,000	81,000	33,000
DS	ITH	39,000	15,000	20,000	231,000	48,000	2,000
GT	ITH	241,000	54,000	32,000	3,000	1,000	7,000
HM	ITH	376,000	54,000	69,000	26,000	47,000	110,000
Total	ITH	780,000	190,000	190,000	340,000	290,000	170,000

(a) CNL = Communal and National Land: ITH = Individual Tenure Holdings: CNL as mapped in the NSR is 54% of Swaziland and has 58% of all Class AS, 50% of Class BS, 60% of Class CS, 60% of Class DS, 53% of Class ES, 54% of Class AT, 41% of Class BT, 56% of Class CT, 43% of Class DT, 50% of Class ET, 56% of Class GS, 49% of Class GT and 51% of Class HM.

TABLE 54

Acreages of Land Classes by Cores and Periphery

Class	WC (a)	NW (a)	NE (a)	EC (a)	4 Cores	Periphery
AS	36,000	9,000	21,000	23,000	89,000	301,000
BS	22,000	4,000	18,000	15,000	59,000	201,000
CS	29,000	8,000	15,000	40,000	92,000	628,000
DS	18,000	5,000	63,000	27,000	113,000	757,000
GT	97,000	63,000	0	1,000	161,000	499,000
HM	124,000	34,000	6,000	22,000	186,000	1,214,000
Total	326,000	123,000	123,000	128,000	700,000	3,600,000

(a) West-Central: North-West: North-East: East Central Cores.

TABLE 55

Acreages of Land Classes by Three Canal Commands

Class	Acres	Principal Soil Sets (with Acres)					
AS	27,000	R 14,000:	M 9,000:	W 3,000:	L 1,000:		
BS	12,000	TL 6,000:	CL 4,000:	DL 1,000:			
CS	11,000	SL 4,000:	B 2,000:	JH 2,000:	O 1,000:	P 1,000:	
DS	28,000	ZL 10,000:	H 5,000:	K 4,000:	V 4,000:	E 2,000:	G 2,000:
GT	1,000	Various					
HM	11,000	I 5,000:	U 3,000:	Y 2,000:			
Total	90,000	R 14,000:	ZL 10,000:	M 9,000:			

North Lowveld Canal command taken as 48,000 acres: Big Bend Canal 19,000 acres: Malkerns Canal 23,000 acres. See also Table 14.

TABLE 56

Comparative Chart of Land Classes

Locality	Acres	Square Miles	Percentage of Area in Classes (a) AS	BS	CS	DS	GT	HM
SWAZILAND	4,300,000	6,720	9	6	17	20	16	32
Highveld	1,280,000	2,000	3	7	7	6	29	48
Middleveld	1,140,000	1,780	11	4	22	9	20	34
Upper	530,000	830	15	4	12	9	28	32
Lower	610,000	950	7	3	31	9	14	36
Lowveld	1,530,000	2,400	13	9	2	43	1	13
Western	920,000	1,450	9	3	14	62	1	11
Eastern	610,000	950	18	16	29	20	1	16
Lubombo Range	350,000	540	9	3	19	2	7	60
Komati-Lomati	640,000	1,000	8	3	14	16	29	30
Umbeluzi (b)	890,000	1,390	8	7	17	28	12	28
Usutu	2,150,000	3,360	9	6	17	18	14	36
North	990,000	1,540	10	6	18	22	15	29
South	1,160,000	1,820	8	6	17	15	14	40
Ingwavuma-Pongola	620,000	970	13	8	17	19	11	32

TABLE 56 – Continued

Locality	Acres	Square Miles	Percentage of Area in Classes (a)					
			AS	BS	CS	DS	GT	HM
Cores	700,000	1,090	13	8	13	17	22	27
West-Central	330,000	510	11	7	9	6	29	38
North-West	120,000	190	7	3	6	4	53	27
North-East	120,000	190	17	14	12	52	0	5
East-Central	130,000	200	18	11	32	21	0	18
Periphery	3,600,000	5,630	8	6	18	21	14	33
Communal-National	2,340,000	3,650	10	6	18	22	14	30
Individual Tenure	1,960,000	3,070	8	7	15	18	17	35
Three Canal Commands	90,000	140	30	14	12	31	1	12
Nucleated Settlements	110,000	170	17	8	11	15	20	29

NOTES: (a) Brief recapitulation of Classes – A good soil, B fair soil, C poor soil, D very poor soil, G soil ratings A to D, H unfit soil, S suitable slope, T too steep slope, M all slopes.

(b) Plus Nkalishane and Tembi.

TABLE 57

Land Capability by Subregions and Major Catchments

Place	HV	UM	LM	WL	EL	LR
Swaziland						
650	130	105	59	113	204	40
1,600	167	105	247	702	306	73
2,050	980	318	307	108	104	234
Komati	251	114	134	136	4	NIL
69	18	11	16	23	1	NIL
186	9	11	75	88	3	NIL
384	224	92	33	25	NIL	NIL
Umbeluzi	89	73	73	247	173	239
136	5	8	8	15	70	29
398	4	6	35	213	90	50
350	80	59	30	19	13	160
No. Usutu	270	128	108	243	157	81
156	26	42	8	22	48	10
400	34	26	47	187	90	15
431	210	60	53	34	19	56
So. Usutu	593	57	194	190	113	9
157	75	10	14	32	27	NIL
372	110	14	55	135	56	2
627	408	33	125	23	30	7
Ingwavuma	74	156	104	106	167	17
132	6	34	13	20	58	1
245	10	48	35	79	67	6
247	58	74	57	7	42	10

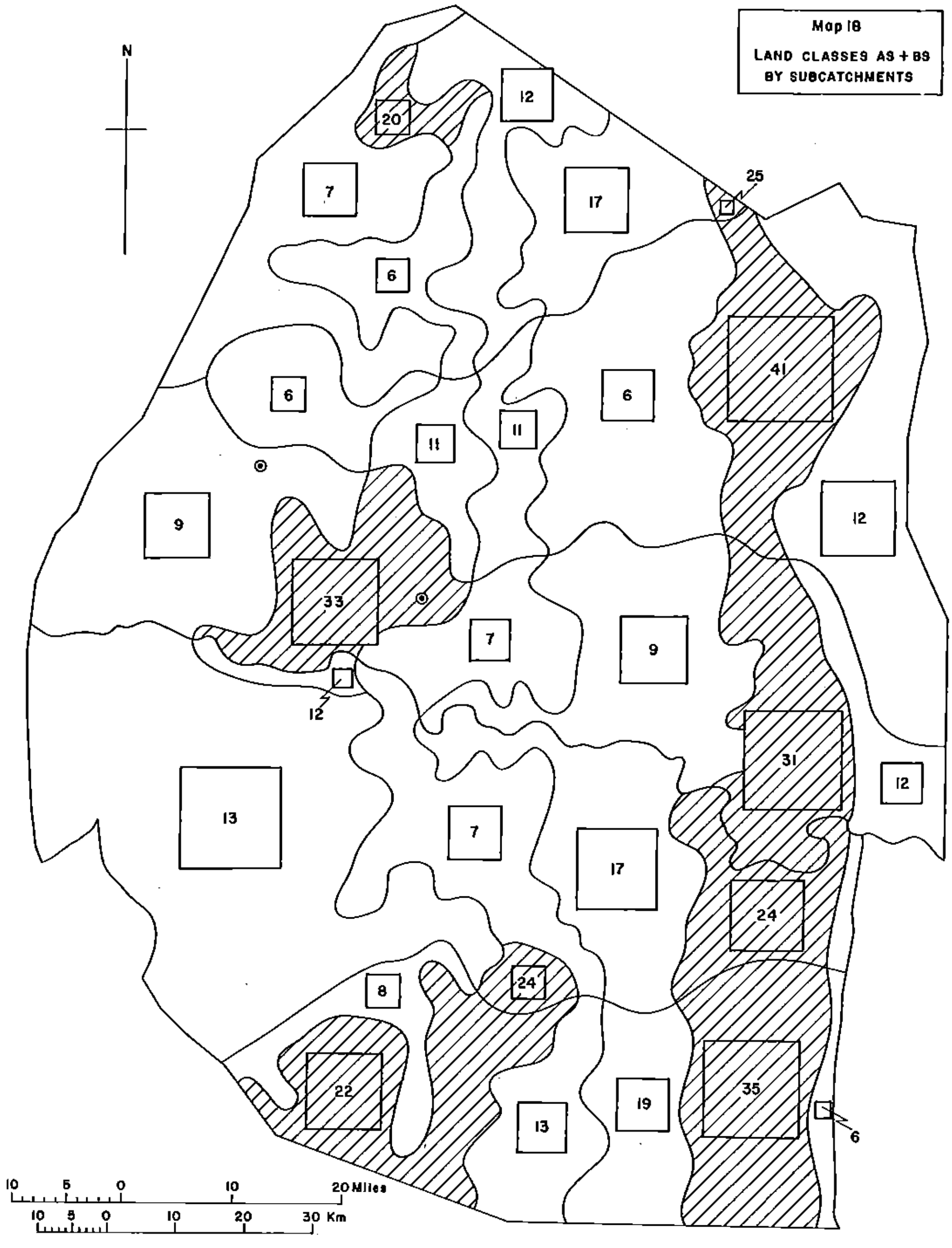
ALL FIGURES ARE THOUSAND ACRES

Key to Boxes	Place
	Cl.AS+BS
	Cl.CS+DS
	Cl.ES+MT

Key to Quartets of Numbers	Total Area
	Cl.AS+BS
	Cl.CS+DS
	Cl.ES+MT

Roughly Classes AS and BS = Better Arable
Classes CS and DS = Poorer Arable
Classes ES and MT = Grazing

For a cartographic presentation of the main features in this Table see Map 18.



Lattice of subregion limits (north to south) and major catchment boundaries (west to east), giving SUBCATCHMENTS

Squares represent Class AS + BS, from the Land Capability Map at 1:125,000, in true proportion to subcatchment sizes: numbers are % total acreage: shaded areas have 20% or more AS + BS

PORTIONS OF THE SPLIT UPPER MIDDLEVELD SOUTH USUTU SUBCATCHMENT HAVE BEEN TREATED SEPARATELY – KANDINZA (P4) AND VELABANTU (V6): IN THE NORTH UPPER MIDDLEVELD THE LOMATI/KOMATI INTERFLUVE HAS BEEN ADDED

Classes AS to CS are very intermixed in Western Lowveld, on Lubombo and in central and southern "eyes" of Upper Middleveld. Almost absent from (1) Mbabane to Hawane (H3) massifs, (2) North-West Ranges, (3) Tondozi to Busaleni, (4) smaller gaps in the Highveld around Siyame (B5), Torgyle (M2) and Umhlosheni Hills, in the Middleveld among Singceni and Ngudzeni (V6) Hills, and in the Lowveld centring on Sandriverdam Lake and Mbahane (N8) to Lunyawo (M8).

Class DS covers a vast stretch of the Western Lowveld, especially between the Komati and the latitude of Mbahane. There is no other large block. Note parcels at Paradys (Y5) – with tongue north to Bulongwane (V5) – and Cibide, Ngotshane (M1) to Ulundi (K1), Droxford (H2), Insolambe. Sinuous portions are common in the Eastern Lowveld, where lower Zibe has the biggest expanse.

Classes AS to DS – all the arable, for irrigation purposes – are strikingly concentrated in the Lowveld (except a belt including Nkondolo Hills (Y8), from Stratford (R9) via Yaningo to Mbandebande) and in the Lower Middleveld north of Sidvokodvo. Of 3 main Upper Middleveld "eyes" the central and southern show up well, but the Lomati valley is much more restricted to Class AS. Highveld south of the Great Usutu has many pockets, particularly in Ngwempisi basin: northwards there is less, virtually none in a band from Battleaxe (M4) to Sebulembu then Kamhlobane. Lubombo has scattered patches.

Class ES is most prominent in hilly zone Stratford-Yaningo-Mbandebande, largest single piece being southwest from Incandu (U8) summit. In the Highveld and Upper Middleveld bottomlands at e.g. Cibide and Forbes Reef are typically veined, as are occurences along with, especially, Class AS at its central and southern foci. More small scattered enclaves than in 4 Classes above.

Class AT is not extensive except in Highveld and Upper Middleveld north of Great Usutu. Occupies rim of massif radiating from Sibebu (J3). Largest pieces are in east of Peak Timbers, at Singweni (J5) and behind Mdutshane. Spotty throughout the South-West. Elsewhere negligible.

Class BT has rather similar distribution, but is more evenly spread over Western Swaziland, with many large portions in centres of hilly areas, not on fringes. Examples at Mdimba, Piggs Peak, Ngome (Q1), Hlatikulu, Luzinyane (P6) and, less nucleated, at Mbabane and Malandela (H5). Almost nothing in Lowveld and on Lubombo.

Class CT is most concentrated (1) both sides of Komati, some miles away from river, in Nginamadvolo (E4) to Edenvalley reach, (2) around St. Peregrine (E5) and both flanks of Lutosha Hills, also to Sitheni (J4) westwards, (3) between Dudusini (P2) and lower Ngwempisane, (4) at Bahwini, (5) at Bloemendal (S5) and (6) along Mantambi below Hluti: thus chiefly Middleveld. None in Lowveld and only patches south of Mapungwane on Lubombo. Eclipsed by AT and BT north of line Silotwane (F3) to Lester (D6).

Class DT lies mainly in the North-West. Chief concentrations Peak Timbers, Vusweni (C5) and Sangweni (E4): Brownhill (H5) to Embekalweni (L4): Usutu Forest North, and to lesser degree South. Largest portion between Piggs Peak and Endingeni. Note scattered areas in far north, Mdimba-Maphalaleni (G4), Bahwini and east of Hlatikulu. Close tie-up with CT.

Classes AT to DT have their biggest swathe through north-central Swaziland, from Kamhlobane-Sebulembu to Arizona (M6) and Sikosane (M5). After gap to west, they resume more brokenly. Mbabane-Sigangeni (K2) south to upper Ngwempisi, so forming selvage to entire northern Highveld, except Mdimba. Minor foci Madulini to Mavokutu (U5) and west of Hluti, but in south generally pattern is sparser. Lacuna along border from St. Stephen (S1) to Mzinsangu (Z5) extends northeast towards Madulini. Absent from Lowveld. Very little on

Lubombo, mainly in south.

Class ET stands out boldly on Highveld from Battleaxe to Silotwane and around Umbombwane (T3). Very prominent also in Lubombo dipslope ravines. Because it is such a steep declivity, Lubombo scarp face appears strangely narrow compared with e.g. Mdimba above Ezulwini or even Bulunga. Next largest areas include hills at (1) Umhlosheni, (2) Ngudzeni, (3) Singceni, (4) Nkweni, (5) Hlambo (Q5) to Tondozi and Ntungula, (6) the far north and – the only Eastern Lowveld stretch (7) Mbandebande, an extension of Magut district Rooirand in South Africa. Also worth mentioning, because relatively isolated, are (1) in Lowveld and Lower Middleveld Hlovane (B6), Nkambeni, Madlangempisi (F6), Lutosha, Dumezulu (M7), Lubedzi (P6), Inkomo (N5), Incandu, Nkutshini (X7) and thin Cislubombo ridges: and (2) in Upper Middleveld plus Highveld, often not so far from other ET, the Hluti ring, Vezi (X6), Vredisdal (X3), Mahamba, Towela, Mponono, Sitshegu-Lupondo-Nokwane (M4), Tateni, Kirkhill (L2), Makwane (J2), Lupohlo (K3) and the inverted U from Umshinande (C5) via Ngonini to south of Jekhi.

Remaining irrigated farming systems are now reviewed. The Land Classes above do not apply to them.

IRRIGATED RICE:

As a member of the Southern Africa customs union, Swaziland has access to the highly protected market for paddy in the Republic of South Africa, where current prices are about twice the world free trade level. This makes rice a profitable crop below 3,000 feet (the temperature-controlled altitudinal limit). The area is 7,000 acres and increasing, after having been static for almost a decade until 1968 largely due to weed infestations that are now being repulsed. In contrast to crops of other farming systems, rice benefits from low subsurface permeability, although completely stagnant water is not desirable. Soils relegated because of poor internal drainage when ranked for a rotation or for sugarcane are therefore upgraded – e.g. all series in H and K sets.

Coulter (1968) recommends that most ZL set be mapped with soil rating C or D for rice, because of its salinity hazard. Zwide series is now accordingly put as C in the 1968-1970 ratings, having been given B in 1964 and A earlier than that. Baillie (1968) retains the B rating for the best series – in the sense of least liable to go brack – viz. Zwakela. It has been listed as C, perhaps too cautiously, at Table 40. The column of ricefield ratings in that table refers only to rice but monoculture is not therefore upheld. Periodically changing the farming system, if possible, should help not only to banish aquatic weeds but also to delay the onset of manmade soil hydromorphism.

Because of the low water duty (sometimes only 20 acres per cusec, equivalent to more than 35 inches per month continuous flow), the acreage of surface-irrigated rice cannot safely be allowed to increase indefinitely. Sprinkling greatly reduces water consumption but is an innovation as regards rice, untried yet on a large scale and over many years.

IRRIGATED CITRUS:

Orange and grapefruit orchards cover 6,000 acres in Swaziland. Poor permeability in and below the root zone must be avoided. Deep soils of light to medium texture with free or even slightly excessive permeability are therefore given high ratings. Rondspring series is not an A because of its heavy texture (topsoil nearly 40% clay) although all the morphological indications such as colour, structure and consistence point to adequate drainage. Baillie (1968) notes that this stringency was justified by an outbreak of rootrot in some orchards on Rondspring following the exceptionally heavy and intense rainstorms early in 1966 over the Lowveld: trees on nearby Winn and Lesibovu series (topsoil 20% to 30% clay) did not succumb.

Not being closed-canopy, citrus needs less irrigation water than most other crops. The mean requirement is about 4 inches per month ex-river in the Lowveld, with peak demand only 5 or 6 inches in late summer — Brook (1965). Middleveld applications are even lower, about 3 inches per month, the maximum need being in July often, when 4 inches post-dormancy irrigation is the rule — Dodson (1964). And some growers further cut down water use by undertree sprinkling. Compare, from Table 14, the current Swaziland average for all irrigation — more than one foot per month.

Future expansion of citrus, economic factors permitting, will be easy and sound on series rated A in the Eastern Lowveld, the climatologically and pathologically most favourable subregion. But in the whole of Swaziland, during the next few decades, it is doubtful whether even 1% of the land surface will be given over to oranges and grapefruit.

IRRIGATED PASTURE:

There are few systematically irrigated meadows in Swaziland at present — certainly less than 1,000 acres — but they may shortly be employed more widely to finish off cattle from rough grazingland. Although total annual water needs would exceed those of e.g. citrus, individual irrigations could probably be lighter than in any of the foregoing farming systems, so soils are not severely downrated because of poor drainage. Moreover the choice of grasses is broad — I'Ons and Kidner (1967) — and types to suit most soil conditions will be forthcoming. For this and other reasons the ratings are more relaxed than for the perennial grass already discussed, sugarcane.

Many leguminous fodders, which have narrower soil requirements, may be better considered as equivalent to the irrigated rotation — see page 201. Other perennial crops under irrigation might become attractive. So far the most commonly grown is the banana, but with under 1,000 acres of groves in 1968. Reference to the crop rotation ratings would also be in order for bananas and for several minor tropical and subtropical fruits.

SOIL RESOURCES AND WATER SUPPLIES:

What is the maximum economically irrigable acreage in Swaziland? Clearly nothing like the 2,250,000 acres of Classes AS to DS on the Land Capability Map, both because of inaccessibility, here and there, to led or lifted water and, more restrictively, because there is not the flow in the rivers to serve such an area. It has been known since 1960 that water shortage and not the lack of good soil will eventually impose a ceiling to irrigation development. This is true of every river basin in the country. If all the 2,200,000 acre-feet per annum of utilizable undisturbed mean annual discharge, including accruals from the Transvaal, were to be spread over Classes AS plus BS it would be equivalent to 3.4 inches per month. Without the Transvaal contribution but also without the passage of any water downstream to Mozambique and Natal*

*Neither of these are more than theoretical provisions purely for the sake of the argument: they do not of course reflect Swaziland Government attitudes. It may be that what is agreed should flow to Mozambique and be used there will be almost exactly recompensable by Transvaal water allocations to Swaziland, but this is by no means certain and if it happened would be a coincidence.

the ration would be 2.0 inches per month on AS and BS.

The Komati-Lomati joint catchment has the most favourable ratio of water supplies to high-quality soil (at least 290,000 acre-feet per annum usable flow, excluding Transvaal headstreams, and about 70,000 acres of Classes AS and BS) but already this river system "lends" water – the rate at capacity is 180,000 acre-feet per month – to the Umbeluzi basin along the North Lowveld Canal. The worst catchment is the Ingwavuma-Pongola, where available water would cover all Class AS plus BS soils to the depth of a derisory 0.9 inch per month.

Which are the most useful water duties to select, then, to obtain an idea of the irrigable potential? On a regional basis it would seem from Figure 5 that the Lowveld must receive up to 68 inches nett irrigation annually, the Middleveld (and it may be supposed the Lubombo, if sufficient quantities of water could be got to any of its plateau soil) up to 54 inches and the Highveld – at least in its drier parts – up to 36 inches. Many questions have to be answered, however, regarding for example

(a) Proportion of time with incomplete canopy or no crop.
(b) Ratio of surface to overhead irrigation – at present 4:1 on an area basis in Swaziland.
(c) Transmission losses from rivers to fields, and return flow by seepage beneath irrigated land.
(d) Year-round water storage possibilities ... and evaporation from reservoirs.
(e) Interchanges of water between catchments and across frontiers.
(f) What costs, especially of large dams, can be borne.

If the total effect of the replies to these were to be that gross water outtake from the rivers should approximately equal the maximum nett requirements just quoted, then Class AS plus BS land would use 2,800,000 acre-feet per annum and Class AS alone 1,700,000 acre-feet per annum. Taking 1,250,000 acre-feet as an example of what the annual apportionable flow might be, after reservations made for domestic and industrial consumers, slightly less than 300,000 acres is arrived at as the ultimate irrigated area, four times the 1968 figure.

Showman and Khatibe (1966) give a much more conservative estimate of only 120,000 acres to which a firm supply of water could be guaranteed with some additional works, but not the storage capacity to beat a very dry season by holding water back over two or more summers. They base their findings on the worst drought-stricken quinquennium locally recorded (1930-1934). They add that "obviously if supplemental reservoir capacity can be obtained at low cost it could be used to provide an additional though unpredictable supply of irrigation water in many years".

Even if enough water could be channelled to half a million acres, an extremely unlikely eventuality, it is clear that only the best soils should be utilized for irrigation schemes, so that when the water is all shared out the maximum profits can be made from this, the most intensive form of land use. There is easily enough of Classes AS to CS (total 1,370,000 acres) and probably enough of AS plus BS (650,000 acres) to have irrigated fields and orchards virtually confined to the most promising parcels of land. But already some irrigators, large (see Table 55) and small, have developed poorer blocks, sometimes to their and the soil's detriment and sometimes as yet not.

The most calamitous soil misuse, leading to creation of Y set salty wasteland, was engendered largely through ignorance. It will not recur, one dares to hope, and even the soil now too brack to grow crops (between 1,500 and 2,000 acres) is diminishing yearly, as better infield and main drainage allows salts accumulated to be washed out and more careful watering upslope, often with lateral diversion ditches, prevents renewed sodium imports. The last few spots suffering from salinity, sometimes with alkalinity, may however need chemical amendments (sulphur compounds) before their condition is cured – Coulter (1968), and see also Richards et al (1954).

Less difficult problems on much larger acreages may turn out to be even more important, agronomically and financially. It is not uncommon for irrigated fields to have soils that are slightly unsuitable for the kind of farming carried on, or that are being rather inefficiently watered – particularly overirrigated by crude gravity methods, though here and there under-irrigated. Often in the latter case the farmer believes that a little irrigation is better than none at all. But irrigating once in two months needs the same water distribution network as irrigating weekly, so the saving in water is likely to be outweighed by an increase in capital and recurrent costs per ton of produce, especially as raising soil moisture supplies during a season from an average of say 50% of the root zone requirement (raingrown) to 70% (with minimal irrigation) will have far less effect on yields, even relatively, than the augmentation to 100% of needs brought about by a full, well planned irrigation cycle.

True supplementary irrigation, where a small topping-up of soil moisture from time to time is all that is necessary, will always be expensive and confined to high-value crops (potatoes, onions, cabbages and other vegetables, apple trees, possibly tea bushes) on the Highveld, where there are so few flat irrigable tracts, or to certain Upper Middleveld perennials (notably oranges, but also some avocados and pecans).

If piecemeal and at times injudicious deployment of energy and capital by irrigators were to persist, in the end the public of Swaziland and the treasury's coffers would be the losers. Fortunately there are irrigated farms, too, which have been models for foresight, planning, excellent husbandry and skilful water management. Examples have thus been set. As stated on page 61 water allocation is now a priority task of Government. Suggestions about specific localities which are still unirrigated but should be considered as possible projects in the near future are made in the conclusion on page 290.

THE POTENTIAL FOR RAINGROWN CROPS:

Six cropping systems are rated, five for field husbandry and the other – dealt with later on pages 256 to 261 – conifer afforestation. There are quantitative ratings in respect of maize and cotton. Otherwise assessments have perforce been made qualitatively, by taking into account the same soil criteria as for irrigability – essentially the depth, texture and moisture relationships of each series – and by noting crop performance. The latter may correlate with inherent fertility but, again as in the irrigability evaluations, downgrading a soil solely on analytical indications of poor nutrient status has whenever possible been avoided. Observations and trial results have thrown up no important series with insuperable fertility problems that is not already faulted on other counts.

The farming systems have been selected because of their present or potential economic importance. One of them – avocado growing – will probably always be restricted to a small acreage, although very lucrative per unit area. Mapham (1965) refers to the general agronomy of all the important dryland crops and Dodson, Stedman and I'Ons (1965) report on pineapples.

RAINGROWN ROTATION INCLUDING MAIZE AND BEANS:

Maize is well suited to the Upper Middleveld and Highveld but, as has been mentioned (page 71), unirrigated fields receiving less than about 30 inches mean annual rainfall will fail frequently. The ratio on more than 280,000 acres of rainfed ploughed fields between maize and other dryland crops, save cotton, is currently almost 6:1 and as yet therefore rotations are the exception, a more usual sequence being several years maize then a rather shorter period fallow.

Maize and the crops which can be alternated with it – beans and other vegetables (but potatoes only in high, cool areas) with some sorghum, groundnuts, tobacco and towards the limiting 30 inches isohyet cotton – require in general soils of medium texture, good to moderate permeability and a rooting depth of at least 60 cm (24 inches). As Baillie (1968) emphasizes, because the vegetal cover is sparse in the early part of the wet season, erodible soils are downrated. Series that are rather shallow are not severely penalized if they have good structural stability and high potential productivity – e.g. Sangweni.

The wealth of information from the 542 maize demonstration plot harvests is summarized in Tables 58 to 63, Figures 19 to 32 and Map 19. The writer has had helpful comments from A.K. Norden and his colleagues at African Explosives and Chemical Industries about this research and the chemists there have performed all the analyses (except organic carbon – see page 231) whose results are collated to set against yields below. On page 195 some information about the plots was given. To augment it from the agronomic viewpoint, the mean panel size has been 0.7 acre and the chief variety open-pollinated Ford Selection, although since 1962 hybrids such as NPP x K64r have steadily gained ground – and by 1965 were being planted in the vast majority of demonstrations. NPK fertilizer applied amounted to 200 pounds per acre per annum (mean composition, by elements, about 5:7:3) until 1964 whereafter the dose was stepped up to 430 pounds per acre per annum of 9:8:5 on average during the next two seasons. Since 1962 about one-sixth of the plotholders in any one year have put on dolomitic lime – mean dressing 1,180 pounds per acre. And about one in eight farmers use dung at an average rate of perhaps 4 tons per acre annually. Most plots are on 3% to 7% gradients in slope category X.

The mean yield (1,670 pounds per acre grain by series or 1,740 pounds per acre by individual plot-years) is about midway logarithmically between the Swaziland national average over the past decade of less than 500 pounds per acre and the record achievement, in 1965, of just over 6,000 pounds per acre by a demonstration plotholder, F. Mabhuza at Nyakeni (L5). Of all demonstration harvests 1957-1966 about 3% have been 4,000 pounds per acre or more. Irrigated maize, for comparison, has produced up to 8,200 pounds per acre in Big Bend research trials. Digital preference as regards yield (see Table 59) is explicable by the use of 200 pound bags for grain – approximations to one bag are common – and in lesser degree rounding to tens and dozens of 100 pound units. Under the next six cross-headings there are commentaries on the tables and figures.

MAIZE-SOIL RELATIONSHIPS IN GENERAL:

Mean maize yields on the best soil series are more than twice as great as on the worst – Tables 58 and 59. The Land Classes show, at Table 60, a progressive decrease in yield from AS to DS, although AS and BS have almost identical mean weights of harvest. BS is raised more than 70 pounds per acre because it contains the exceptional 6,000 pounds per acre reaped at Nyakeni (see above) from Sangweni series. For a hypothetical "average" Land Class (one with 136 plot-years) the 95% confidence limits, twice the standard error, are plus or minus 180 pounds per acre. For the actual data of Class CS the figures are plus or minus 200 pounds per acre: CS can therefore be pronounced significantly poorer than AS and significantly better than DS.

Of the two commonest demonstration plot series, Malkerns has the edge over Orrin. But Malkerns series has yielded at disappointingly mediocre levels. It has been pulled down by some very poor fields in the altitude belt which it dominates – 2,100 to 2,800 feet in the Upper Middleveld. There soil exhaustion is advanced as the same land has been cropped almost continuously for over a century. The apparent depression of yield, as suggested on Figure 24 between 2,300 and 2,800 feet, exceeds 300 pounds per acre. Moreover prejudice has built up against Malkerns series and other deep acid loams because of their susceptibility to Striga asiatica infestation and their high dolomitic lime requirement.

By contrast lighter Middleveld soils, mostly in Orrin series, have a good record – and a good name – because they are so often new lands, only now being ploughed as population pressure increases. Many farmers, even after wiping out the witchweed of Malkerns series (which was done successfully on most demonstration plots), will say that they prefer shallower greyish sandy loams because they seem to respond better to fertilizer and are less trouble to cultivate, once basic soil conservation measures have been taken. This response to added nutrients relates, however, mainly to a middle range of yields (about 1,500 to 2,000 pounds per acre) and not to high production: one fourth of Malkerns demonstration plot harvests exceeded 2,700 pounds per acre but only one seventh of Orrin plot-years.

Fortunately Malkerns is a rather stable soil so has not suffered sheet erosion commensurate with its impoverishment in plant foods. Getting the heart back into it should be a priority task in longterm agricultural planning, since its potential for dryland cropping, as for irrigation, is so much higher than that of Orrin, both theoretically and according to maximum yield trials already carried out.

Besides Malkerns several other series occupy anomalous positions in Table 60, even after the promotions and relegations of the past few years – Table 43 refers. The poor performance of Lowveld series, notably Rathbone in Class AS but also e.g. Canterbury, Lutzi and Zwide, is due to drought and perhaps these and allied soils should be excluded from calculations as they occur in ecological zones outside the "proper" dryland maize growing area, i.e. below the 30 inches isohyet or approximately 1,400 feet altitude. On Map 19 this is well illustrated: the Vuvulane, Big Bend and Hluti extension subdistricts have a median yield of less than 1,200 pounds per acre.

Unimpressive returns from some Lower Middleveld and Lubombo series may also be attributed partly to low, erratic rainfall – e.g. Lesibovu, Lomahasheni, Ludomba and Jovane. If the 14 highest-rainfall series are taken, their average yield (unweighted mean) is 1,830 pounds per acre. The soils involved are Alicedale, Cimurphy, Gege, Juweel, Malkerns, Mdutshane, Mooihoek, Mtilane, Nduma, Orrin, Pofane, Qolweni, Sangweni and Tateni.

Yields higher than average, for the Land Class, deserve note in the case of Sangweni, Mtilane and Juweel series. These soils, for reasons that are unclear (perhaps including particularly good management, by chance, on the relatively few plots concerned), equal or surpass in productivity Cimurphy or Nduma or Mdutshane series despite being shallower (Sangweni) or stonier (Juweel and Mtilane).

In Table 60 current productivity of maize and the ultimate potential are compared by the percentage scoring method of Riquier, Cornet and Bramao (1968). The better the Land Class the greater the augmentation of marks in the distant future that can be postulated, but the smaller the ratio between eventual and present scores. It is not known, of course, what the exponential component will be in the curve relating ultimate yield to Potentiality Index. Prediction of actual output several decades ahead cannot therefore be justified. Nevertheless, tripling the mean yield of Class AS so that it reaches 5,400 pounds per acre is certainly not beyond the bounds of possibility.

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TABLE 58

Mean Yields of Maize from Demonstration Plots 1957-1966 by Series

Soil Series	Harvests	Mean lb/ac	Soil	Harvests	Mean lb/ac	Soil	Harvests	Mean lb/ac
Alicedale	27	2,150	Lesibovu	33	1,700	Oldreef	2	1,700
Cimurphy	13	1,950	Lomahasheni	26	1,640	Pofane	15	1,690
Canterbury	6	1,490	Lutzi	6	1,070	Qolweni	26	1,580
Enkulunyo	14	1,180	Ludomba	7	1,510	Rathbone	8	1,160
Felwako	12	1,630	Malkerns	83	1,840	Stegi	3	1,470
Funebizo	3	1,570	Mtilane	22	1,920	Sangweni	25	2,180
Gege	9	1,570	Mooihoek	18	1,970	Tateni	6	1,380
Habelo	10	1,360	Mdutshane	29	1,800	Thorburn	3	1,400
Ingoje	3	1,600	Nduma	42	1,930	Vuso	3	1,230
Juweel	7	1,830	Otandweni	7	1,460	Winn	4	1,490
Jovane	7	1,300	Orrin	58	1,780	Zwide	5	1,040

Total number of harvests 542 from 33 series: unweighted mean yield 1,670 pounds per acre per annum.

Number of crop failures 18 (when less than 250 pounds per acre were reaped: four of the failures occurred in 1960 and another four in 1966).

Total number of demonstrations with records 560.

TABLE 59

Individual Harvests of Maize from Demonstration Plots 1957-1966 by Series

Series (a)	Sa	Al	Mo	Cm	Nd	Mt	Ma	Md	Or	Le	Po	Lo	Fe	Qo	Ha	Ek	(b)	All
Harvests	25	27	18	13	42	22	83	29	58	33	15	26	12	26	10	14	89	542(c)
lb/ac 6000	1																	1
5100									1									1
4200									2			1						3
4100					1								1					2
4000	1				2		3	2	1	2								11
3900	1		1			1											2	5
3800		1		1	3	1	1		1		1							9
3700			1					1	1									3
3600		1			2			1			1						1	6
3500		1					2					1				1		5
3400		1				1	2		2									6
3300								1		1		1						3
3200	2	1			2	2	2				1						1	11
3100	1							1									1	3
3000	2	2	1	1	1		6			1		1						15
2900				1	1		1	1		1								5
2800	1	3					2			2			1				1	10
2700	1	1	1			1	1		2									7
2600	1		1	1			1		1	1	1					1	1	9
2500			1		2		1		1								1	6
2400			2	1	1	1	4	3	3	1	1	2		3	1		3	26
2300					1				1			1		1			1	5
2200	2	1		1	1	1	6		1			1		1	1		3	19
2100			1	1	1							1		1			1	6

TABLE 59 — Continued

Series (a)	Sa	Al	Mo	Cm	Nd	Mt	Ma	Md	Or	Le	Po	Lo	Fe	Qo	Ha	Ek	(b)	All	
Harvests	25	27	18	13	42	22	83	29	58	33	15	26	12	26	10	14	89	542(c)	
lb/ac 2000	1	3			1	2	5	1	4	1	1	1	2	2		1	4	29	
1900		2			1							1	1			1	2	8	
1800			2	1		2	1	1	6	1		1		1	1		5	22	
1700							5	2	2								4	13	Mean
1600	2	2			3	2	3		2	3	1	1	1	2	2		6	30	Median
1500		1	1					2	2	3		1	1	1				12	
1400		1	1				6	1	1	2		1		1		1	4	19	
1300	1				1		1		2	1	1	2	2	1	1	1	4	18	
1200	1	2	1	1	1	2	5		3	4	1	1	1	1	1		9	34	Mode
1100					3	1	3	1	3	1		1		1			3	17	
1000	2		1	2	4	2	3	2	3	1		1	1				5	27	
900		1					4	1	1	1		1		1	1		2	13	
800	2	1	1	1	3		2	3	2		2	3	1	1			4	26	
700		1					4			3	1	1	1	1		1	5	18	
600					3		2	2	3		1			3		1	4	19	
500	1		2	1	1		3	1	2	1	1	2				3	5	23	
400	2	1			1	2	2	2	4	1	1			1		2	3	22	
300					2	1	2		1	1				1	2	1	4	15	
Rounded Means	2180	2150	1970	1950	1930	1920	1840	1800	1780	1700	1690	1640	1630	1580	1360	1180	1420	1740	

NOTES: (a) Abbreviations for 16 commonest series — see Table 58 list

(b) Remaining 17 series

(c) Mean 95% confidence limits (twice the standard error for a series with 32 harvests) plus or minus 370 pounds per acre

TABLE 60

Mean Yields of Maize from Demonstration Plots 1957-1966 by Land Classes

The 26 principal soil series, with 521 harvests, are taken. Columns A and B refer respectively to the Productivity Index and Potentiality Index of Riquier, Cornet and Bramao (1968) which are derived from percentage-score multiplication -- after the manner of Storie (1933) – using 7 internal soil variables viz. moisture, drainage, depth, texture, base saturation, salinity and organic matter. Scale divisions proposed are Very Good 99 to 65, Good 64 to 35, Fair 34 to 20, Poor 19 to 8 and Very Poor 7 to 0.

Class AS – 9 series

Yields lb/ac		A	B
Alicedale	2,150	36	96
Mooihoek	1,970	35	96
Cimurphy	1,950	25	77
Nduma	1,930	40	96
Malkerns	1,840	35	96
Mdutshane	1,800	35	96
Lesibovu	1,700	27	96
Lomahasheni	1,640	32	86
Rathbone	1,160	29	96

CLASS BS – 5 Series

Yields lb/ac		A	B
Sangweni	2,180	30	70
Mtilane	1,920	28	96
Felwako	1,630	22	70
Ludomba	1,510	27	96
Canterbury	1,490	23	77

Class CS – 5 Series

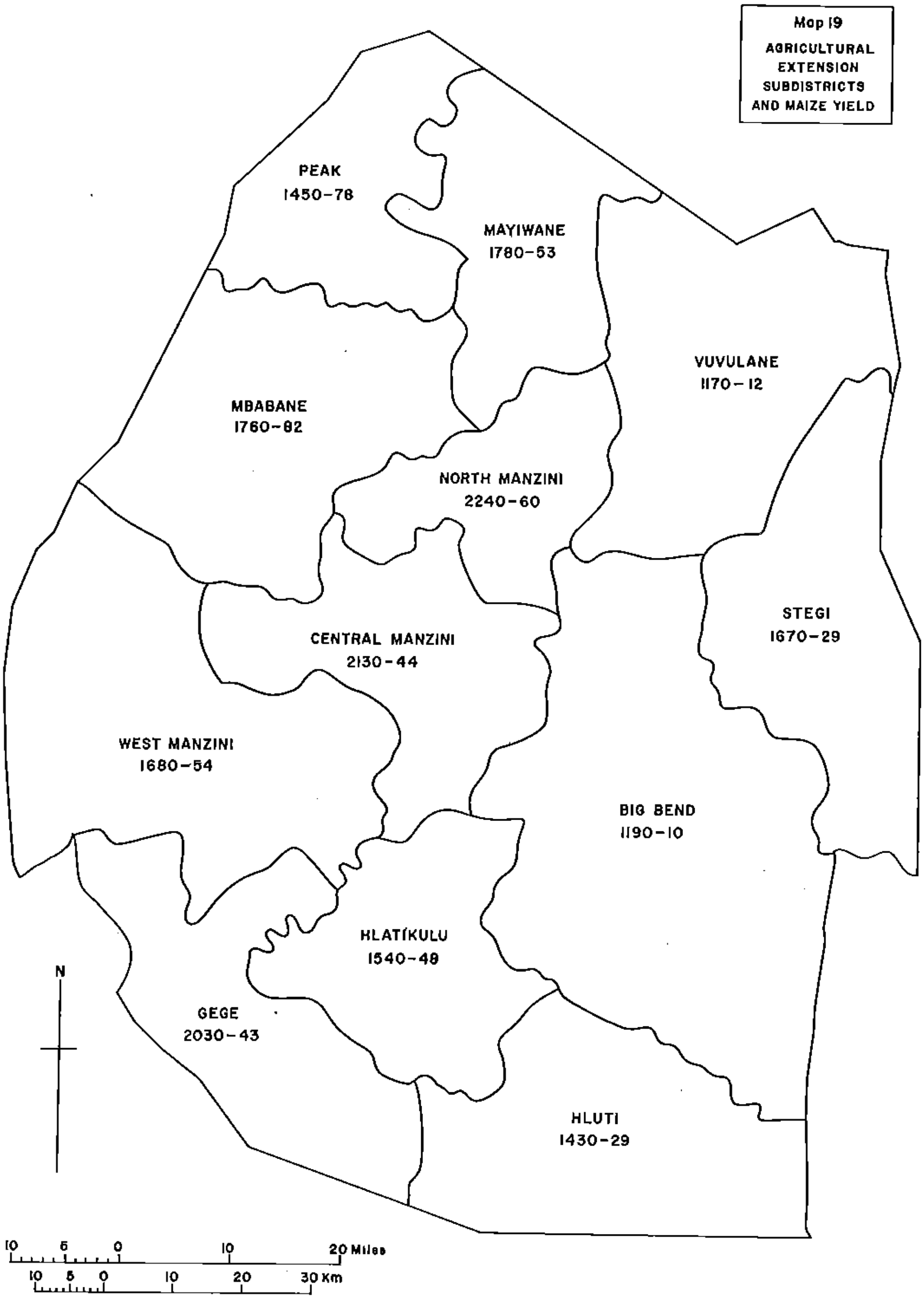
Yields lb/ac		A	B
Juweel	1,830	16	70
Orrin	1,780	15	38
Pofane	1,690	10	27
Gege	1,570	7	35
Lutzi	1,070	12	70

Class DS – 7 Series

Yields lb/ac		A	B
Qolweni	1,580	9	29
Otandweni	1,460	2	14
Tateni	1,380	3	19
Habelo	1,360	4	27
Jovane	1,300	6	26
Enkulunyo	1,180	4	17
Zwide	1,040	2	16

TABLE 60 — Continued

LAND CLASS (see also Figure 23)	AS	BS	CS	DS
Unweighted mean of yields in pounds per acre	1,790	1,740	1,580	1,320
Total number of harvests	279	72	95	75
Unweighted mean of (current) Productivity Index A	33	26	12	4
Unweighted mean of (future) Potentiality Index B	94	81	48	21
Difference between Productivity and Potentiality B-A	61	55	36	17
Ratio between Productivity and Potentiality B/A	2.8	3.1	4.0	5.3
Gross margin: rands per acre — see Figure 33	15	14	12	9



Subdistrict boundaries change periodically. Those indicated were used for maize yield-soil correlation (harvests from 1957-1966 demonstration plots) and the numbers, such as 1780-53, refer to mean yield of maize grain pounds per acre, followed by plot-years. Swaziland figures, for 542 harvests, are 1740 pounds per acre weighted mean, 1670 pounds per acre unweighted mean and median.

MAIZE-RAINFALL RELATIONSHIPS:

Supplementing what has been said in the last section regarding rainfall, Figures 19 and 24 present altitude data, converted to mean annual rain in accordance with the formula given on page 242. Superimposed on the Upper Middleveld "exhaustion factor" there is a suggestion in Figure 24 that yields taper downwards in the wet, cool Highveld. However if the poor upland soils Tateni and Qolweni are neglected (and the very good Sangweni series) Figure 19 portrays fairly steady altitudinal increments of yield, averaging some 70 pounds per acre for every 100 feet ascended in the Lower Middleveld, with a decrease to 20 pounds per acre per 100 feet over much of the Highveld.

In Table 61, constructed from Figure 19, the weight of maize produced from each 10 inches of mean annual rainfall, series by series, reveals some surprises. For instance Lesibovu appears to be extremely effective in utilizing moisture received despite the fact that it is a permeable loam. Some, though not a greal deal, of its superiority will be attributable to the better than average rains, for the altitude, which Lesibovu series plots in the Lomati valley must have received: Ngonini's annual mean exceeds 40 inches at 1,500 feet. Of the freely draining soils that are light in texture, Orrin makes particularly good use of root zone water supplies.

At the other extreme Zwide series, although a sandy clay at depth, gains less than 70% of the growth per unit rainfall that Canterbury clay attains. The appreciable salt content of Zwide is probably relevant: Piruzyan (1959) found that maize cob yields from slightly saline soil were only 62% of those from nonsaline soil. It is puzzling that Rathbone lags so far behind Canterbury: there may have been differences in the severity of droughts experienced.

MAIZE-TIME RELATIONSHIPS:

From Figure 25 it can be judged that the overall upward trend of yields in the past decade has been influenced by several factors. The use of hybrid seed after 1962 and the increase in fertilizer dressings after the 1964 harvest have already received mention on page 223. Rainfall during the decade was well below the longterm normal amount except in the season of the 1963 harvest. The next best years were those of the 1957 and 1958 crops.

Linear projection of the 1957 and 1966 mean yields gives 3,000 pounds per acre as the 1980 average on farms being managed at the level of the demonstration plots. Continued arithmetical progression into the 21st century would be necessary before they achieve the 5,400 pounds per acre average alluded to on page 224.

In the same decade (1957-1966) that Swaziland demonstration plot maize production increased by 45% from 1,370 to 2,000 pounds per acre on average, the world mean yield rose from about 1,600 to 2,070 pounds per acre or 29% – Food and Agriculture Organization (1968). Only in North America, Europe and Russia were 1966 harvests more than 1½ times as great per unit area as those of the middle 1950s. This shows that the country's leading farmers are keeping up well with rates of progress by developed regions in maize culture. Subsistence yields in Swaziland, however, may well be growing at no more than the African continental average, estimated at only about 10% from 1957 to 1966 – ibid.

MAIZE-NUTRITION RELATIONSHIPS:

The Walkley and Black determinations of topsoil organic carbon by P. Jackson and L.A. Whelan have proved to be in excellent agreement with yields, as Figures 20 and 26 bear out. Total nitrogen analyses of selected soil samples show that arable land has rather wide C/N

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FIGURE 19

MAIZE YIELDS OF SERIES
BY ALTITUDE

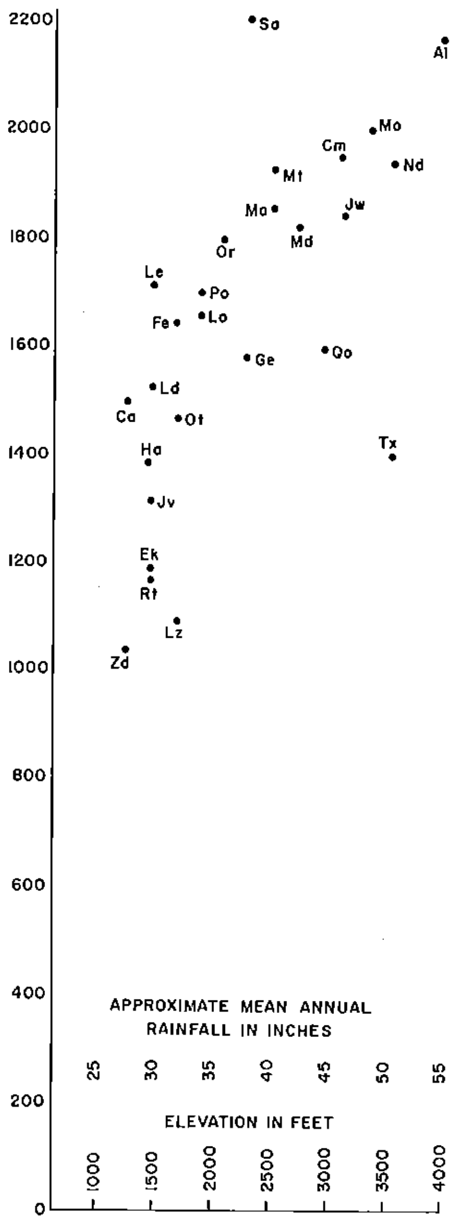
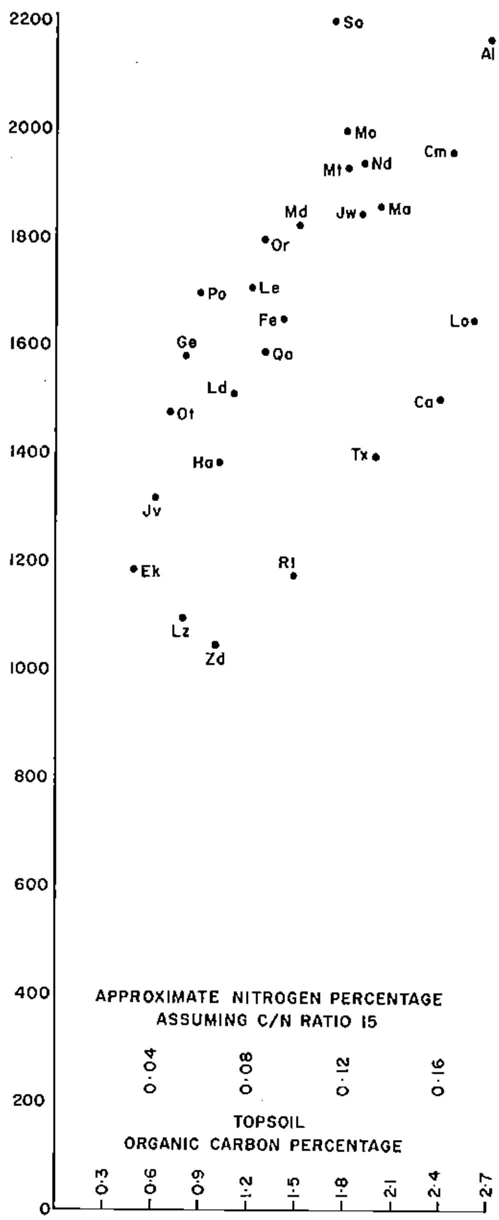


FIGURE 20

MAIZE YIELDS OF SERIES
BY SOIL ORGANIC CARBON CONTENT



At demonstration plots 1957–1966

Yields are mean pounds per acre per annum
Heights and carbon contents are medians

On vertical scale mean 95% confidence limits (twice the standard error for a series with 32 harvests) plus or minus 370 pounds per acre

FIGURE 21

MAIZE YIELDS OF SERIES
BY SOIL PHOSPHORUS CONTENT

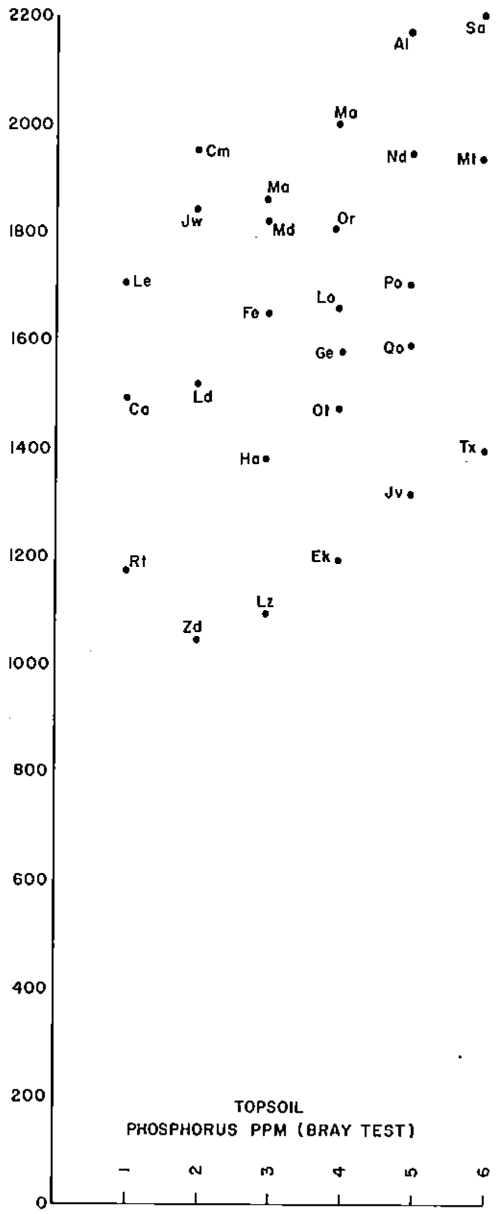
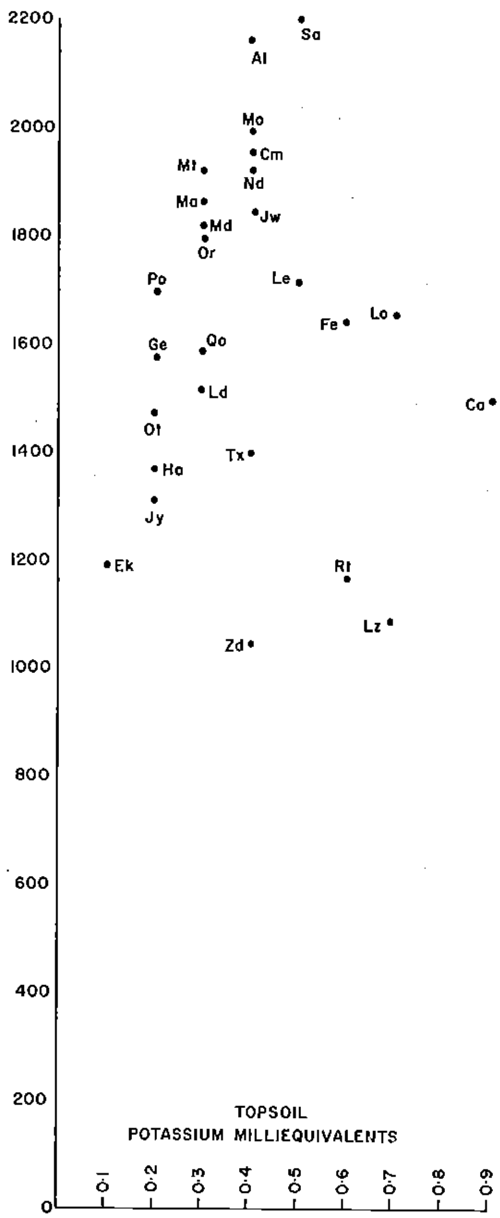


FIGURE 22

MAIZE YIELDS OF SERIES
BY SOIL POTASSIUM CONTENT



At demonstration plots 1957–1966

Yields are mean pounds per acre per annum
Phosphorus and potassium contents are medians

Footnote to figure 19 regarding statistical significance applies

GENERAL NOTES FOR FIGURES 23 TO 32

Demonstration plot maize harvests 1957–1966 for 542 plot-years are considered. Values in Figures 26 to 32 refer to topsoils. Numbers capping columns are mean grain yields to nearest 10 pounds per acre. Mean of all harvests is 1740 pounds per acre. Numbers beneath columns are percentages of all harvests

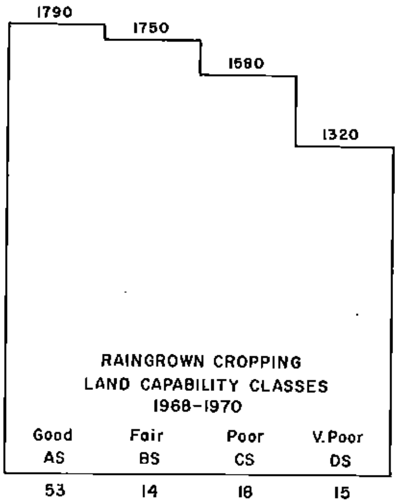


FIGURE 23

YIELDS AND LAND CLASSES

Mean 95% confidence limits (twice the standard error for a Land Class with 136 plot-years) are + or – 180 pounds per acre

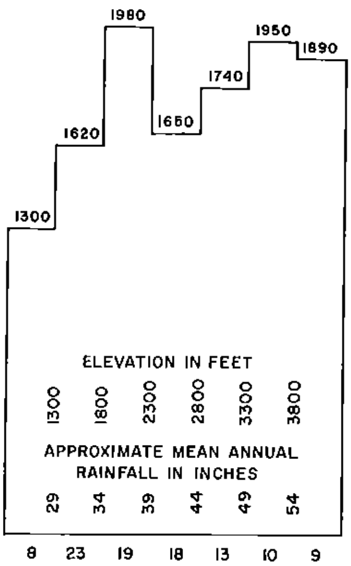


FIGURE 24

YIELDS AND ALTITUDE

Mean 95% confidence limits (twice the standard error for an altitude range with 77 plot-years) are + or – 230 pounds per acre

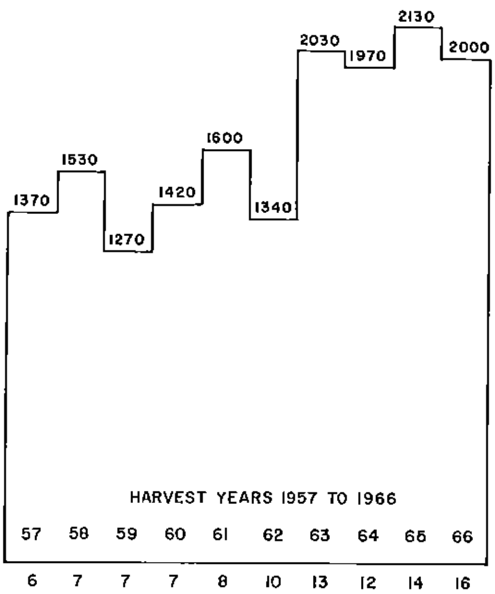


FIGURE 25

YIELDS AND HARVEST YEARS

Mean 95% confidence limits (twice the standard error for a harvest year with 54 plots plots) are + or – 260 pounds per acre

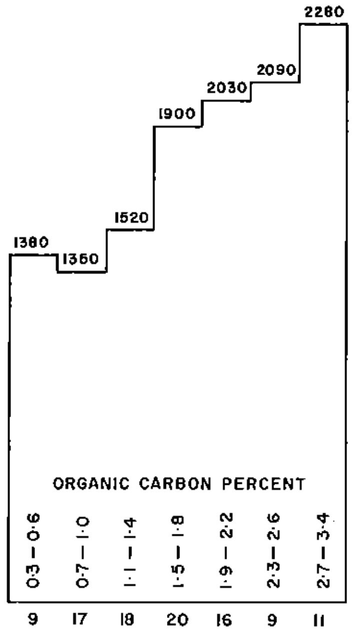


FIGURE 26

MAIZE YIELDS AND ORGANIC MATTER

Mean 95% Confidence Limits (twice the standard error for an organic C bracket with 77 plot-years) are + or - 250 pounds per acre

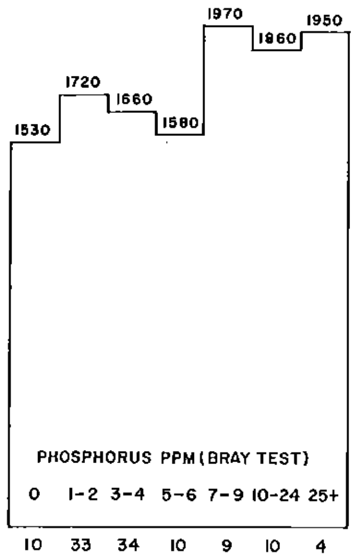


FIGURE 27

YIELDS AND PHOSPHORUS

Mean 95% Confidence Limits (twice the standard error for an available P bracket with 77 plot-years) are + or - 250 pounds per acre

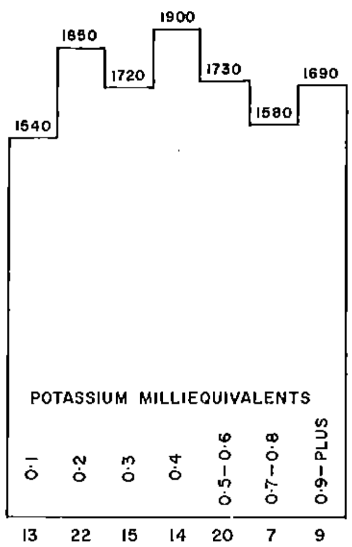


FIGURE 28

YIELDS AND POTASSIUM

Mean 95% Confidence Limits (twice the standard error for an exchangeable K bracket with 77 plot-years) are + or - 250 pounds per acre

FIGURE 29

YIELDS AND SODIUM

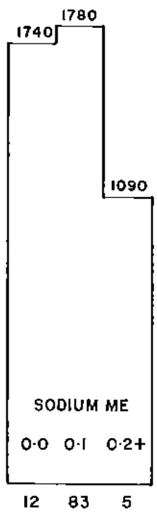


FIGURE 30

MAIZE YIELDS AND CALCIUM

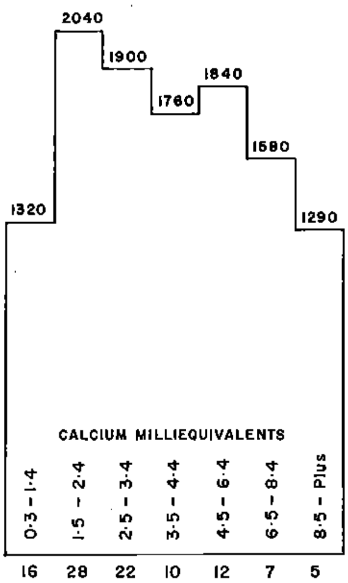
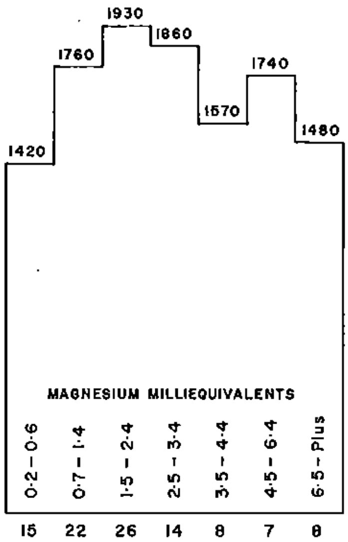


FIGURE 31

YIELDS AND MAGNESIUM



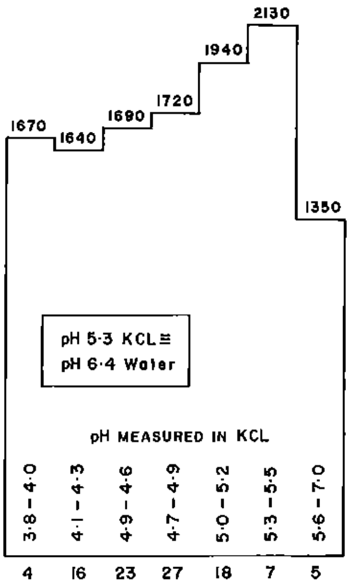


FIGURE 32

YIELDS AND SOIL REACTION

Mean 95% Confidence Limits (twice the standard error for a pH KCL bracket with 77 plot-years) are + or – 250 pounds per acre

TABLE 61

Maize Yield Increments per Unit Quantity of Rainfall by Series

The increments are pounds per acre grain for every 10 inches mean annual rainfall (determined from Figure 19) in respect of the 26 soil series of Table 60.

Sangweni	620	Habelo	490	Alicedale	420
Lesibovu	610	Malkerns	490	Juweel	420
Canterbury	580	Jovane	470	Rathbone	420
Felwako	550	Mdutshane	460	Nduma	410
Ludomba	540	Cimurphy	450	Enkulunyo	400
Pofane	530	Gege	440	Zwide	400
Lomahasehni	520	Mooihoek	430	Qolweni	380
Orrin	520	Otandweni	430	Lutzi	370
Mtilane	510			Tateni	290

TABLE 62

Organic Carbon and Phosphorus Status of Maize Demonstration Plots

An NP interaction is evident, based not on added nutrients (though that could be expected too) but on C and P contents in topsoils of plots. Combinations of organic C and Bray P are designated thus in the diagram below.

N1 = 0.3 to 1.2% C	P1 = 0 to 2 ppm P
N2 = 1.3 to 1.9% C	P2 = 3 to 5 ppm P
N3 = 2.0 to 3.4% C	P3 = 6 to 49 ppm P

Median yields in pounds per acre are given, and behind them, bracketed, the percentage of plot-years within each combination.

N3 P1 – 1,760 (15)	N3 P2 – 2,000 (10)	N3 P3 – 2,500 (7)
N2 P1 – 1,470 (16)	N2 P2 – 1,600 (8)	N2 P3 – 1,900 (10)
N1 P1 – 1,250 (13)	N1 P2 – 1,030 (16)	N1 P3 – 1,300 (5)

ratios throughout Swaziland, 15 being the mean value.

The median organic C content at demonstration plots is 1.6% with 0.5% semi-interquartile range. For all Swaziland topsoils, sampled mainly from virgin land, the median organic C found has been 1.7% — see Table 19. But of the 26 main maize plot series 8 have been depleted of humus to the extent of 0.3% carbon or more. Some are in the Lowveld, where rapid oxidation can be expected (e.g. Rathbone with 0.4% diminution), but the worst losses have been incurred by Nduma 0.8% and Qolweni 0.9% — both Highveld series. One concludes that while most maize plots have held their C great vigilance and actions to raise organic matter levels are necessary — dosage with artificials containing N, use of dung, avoidance of bare ground in midsummer, upkeep of anti-erosion measures, perhaps green manuring here and there.

Available phosphorus (Bray No. 2 method) is very low in most Swaziland soils, and even when phosphatic fertilizer is added, as on the demonstration plots, much is soon fixed. However, despite the dismal median of 3 ppm elemental P (lower quartile 1 ppm and upper quartile 6 ppm) there is a fairly close connexion between yields and P amounts — see Figure 27. The scatter of individual series on Figure 21 indicates, nonetheless, that yield predictions based on P content would be somewhat less reliable than those calculated from N status. Virgin soils have the same median of 3 ppm phosphorus. On cultivation only certain Lowveld series have apparently suffered serious losses of P, but as levels are all low this does not mean that other soils need less regular P fertilizer treatment.

An interaction between C and P, which could also be considered an NP interaction (and has been so termed in Table 62) is well spread through four strata of N and four of P — counting NO PO as one stratum, to be equated with poorer husbandry than the plotholders' and a maize yield not much above Swaziland's mean over the last decade, some 400 pounds per acre. That N is limiting to a greater extent in general than P may be gauged from the similarity of medians along the bottom line of the table, N1 P1 to N1 P3.

Ammonium acetate extractable K is not drastically deficient in the demonstration plot soils — median 0.4 me and semi-interquartile range 0.2 me. The virgin land median is 0.3 me. From Figures 22 and 28 it appears that no obvious correlation between yields and potash exist, although it is true that soil series with least K (only 0.2 or 0.1 me) are moderately-yielding or worse — less than 1,570 pounds per acre except for Pofane. Currently the highest potassium applications advised in Swaziland are on fields where lime or dolomite has been applied.

Where 0.2 me or more Na is present is topsoils maize yields are greatly reduced. This is due less to sodium toxicity, however, than to lack of rainfall, most of the sites concerned being in the Lowveld or on its rim.

Calcium is also especially abundant in low-altitude droughty soils — see Figure 30 — but the median value is only 2.7 me elemental Ca at maize plots (0.5 me less than the national median) with lower quartile 1.9 me and upper quartile 4.3 me: even so, maximum yields congregate around the lower quartile. Several trials have shown that no Swaziland soil requires heavier dressings of lime than one ton per acre periodically.

As with K, the Mg status does not seem to affect yields markedly, though on Figure 31 a muted curve of the Ca type can be inferred. It is a little unexpected that high magnesium (more than 6.5 me) does not reduce yields further: perhaps soils with medium quantities of Mg are just as likely to have bad Ca/Mg imbalances as those that are magnesium-rich. The median Mg content is 1.9 me (very slightly more than the national median) with 0.6 me as semi-interquartile range.

Between about pH 5.2 and pH 5.6 in KCl Figure 32 shows peak returns. Drought explains the plunge to less than 1,400 pounds per acre on average at higher pH values. There is no decided drop in yield as reactions more acid are encountered. The median for plot topsoils is pH 4.7 as against pH 4.9 for all Swaziland topsoils. The semi-interquartile range is 0.3 pH unit for plots.

To sum up, carbon (also probably nitrogen) and calcium have decreased by as much as 20% in the topsoils of many maize demonstration plots, compared with untilled surface soil. The erodible Qolweni series has had an apparent nett loss of 40% of its organic C. Malkerns series as a whole does not emerge as having been deprived of CPK, but this outcome hides two opposed processes, one the exhaustion of much Upper Middleveld cropland, the other deliberate heavy fertilizer applications to some fields as soon as the findings of Venn (1963) – that this easily recognizable soil had multiple nutrient deficiencies which could be overcome – were publicized. With these conspicuous exceptions, however, fertility differences between maize plots and nearby veld are small. Crop removals are being balanced more or less by fertilizer and manure inputs, to maintain but not in general to improve the productive capacity of soils on the plots.

MAIZE-PROFIT RELATIONSHIPS:

Gross margins were calculated, employing terms in the same sense as Mapham (1965), for all the 1965 harvests from maize demonstration plots and, as a check, on another 20 in 1966. The check gave exactly the same pattern as the previous year's.

The 1965 results, displayed in Figure 33, are about R 2 per acre more optimistic than Mapham's. There is a rather high breaking-even point, at approximately 1,400 pounds per acre, but this assumes relatively large inputs (R 13 to R 15 variable cost on top of R 10 fixed cost per acre) and where commercial farmers spend less than that the yield at which nett maize income falls to nil will decrease quite sharply, e.g. to less than 1,000 pounds per acre if variable cost is halved.

The linear regression of gross margin against yield, as shown in the figure, is a simplification even within the middle range charted (700 to 4,000 pounds per acre) and should not be extrapolated to very high production per acre (for lack of data on when diminishing returns set in) or to crop failures (which can occur even if variable cost exceeds R 20 per acre and the rain does not come). Considering that many dots on the graph represent rough estimates by junior extension staff, the degree of clarity in this general picture of maize economics is satisfactory. From the formula it would appear that the gross margin on Class DS is likely to be only 60% of that on Class AS land – see Table 60.

MAIZE FIELDS BY SOIL SETS:

By piecing together information derived from local knowledge and from the distribution of maize plots by soil series, weighted according to extension subdistricts, the proportion of the national area of each common soil set under maize has been elicited. Since fallow land is almost all ex-maize, it seemed practicable to estimate the 1968 percentage of raingrown maize plus associated fallow by sets, and Table 63 shows that the favourite soils are undoubtedly red to yellow loams, despite the maligning of M set that is frequently heard.

L set, whereof more than half is growing maize or is fallowed, will prove less easily exhaustible than M, but nonetheless guarding against losses of its fertility will be advisable. O set would be demoted from seventh to tenth place in the table if its Lowveld sector, of which only about 3% has maize or fallow, were to be included: the fraction of O set as a whole under maize and fallow would then be 12%.

FIGURE 33

Gross Margins at Maize Demonstration Plots 1965

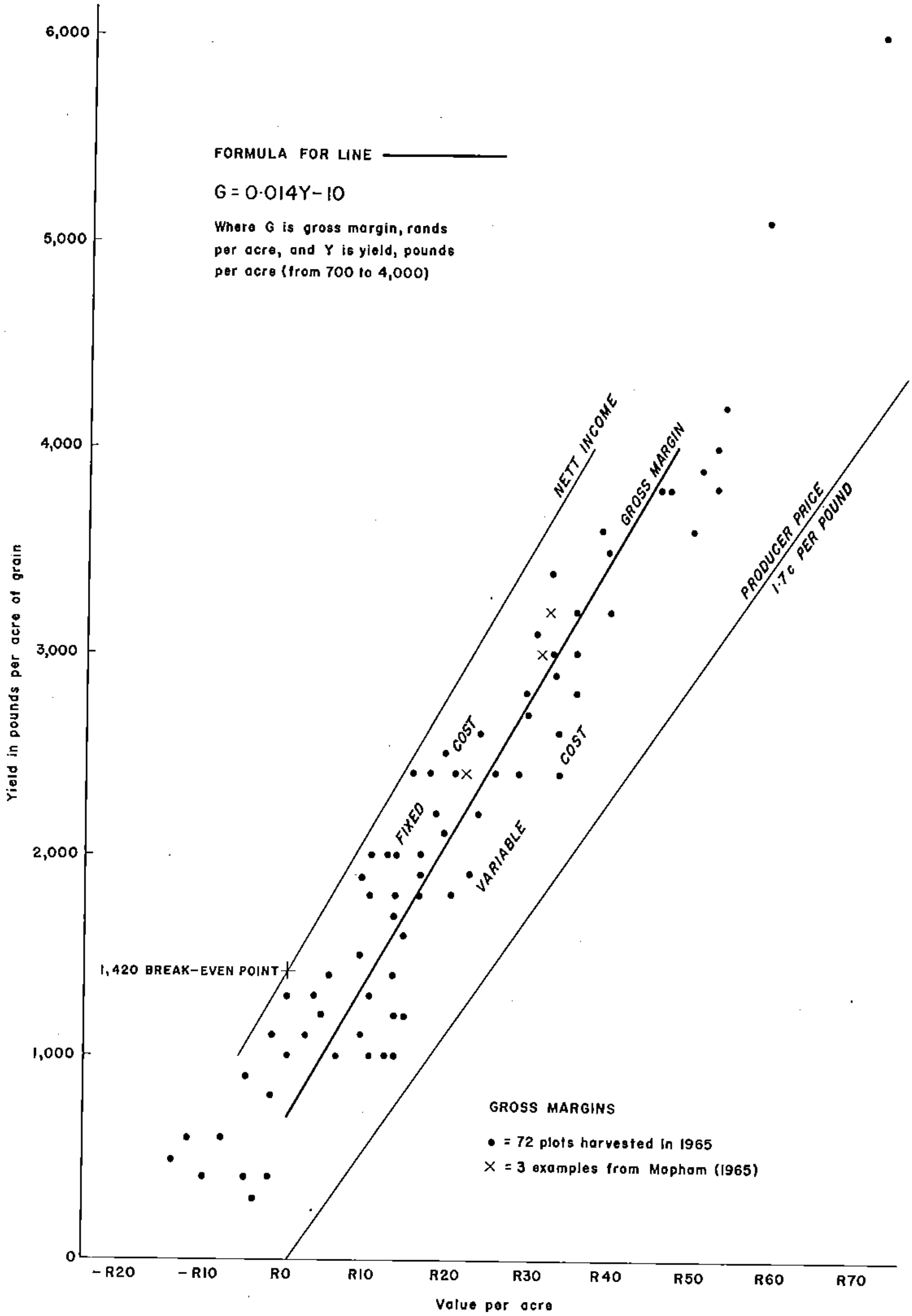


TABLE 63

Percentage of Each Soil Set under Maize and Associated Fallow

1968 ACREAGES

Soil Set	Maize plus Fallow (a)	National Total	%
	M	N	100 M/N
L	57,000	99,000	58
F	15,000	32,000	47
M	94,000	198,000	47
A	18,000	40,000	45
NH	37,000	102,000	36
SH	25,000	84,000	30
OY(b)	66,000	387,000	17
P	13,000	77,000	17
E	8,000	50,000	16
QH	22,000	146,000	15
G	8,000	72,000	11
JH	8,000	92,000	9
TH	8,000	117,000	7
R	8,000	143,000	6
H	10,000	217,000	5
Rest (c)	43,000	1,045,000	4
All (c)	440,000	2,900,000	15

NOTES: (a) Raingrown maize 235,000 acres and fallow 205,000 acres

(b) O set except in the Lowveld – see also Table 42

(c) With soil ratings A to D

LAND CLASSES IN RURAL DEVELOPMENT AREAS:

Maize, beans and accompanying minor crops are being recommended for rotation on arable land in special Rural Development Areas, established during 1966 and intended as the "shop windows" of CNL. The policy of self-help and the non-imposition of any change until the communities, mostly single chiefdoms, decide for themselves that they want it, are central to the RDA concept. This is laudable, but not surprisingly opening gambits have been long drawn out and each RDA has got off to a slow start.

Semidetailed or detailed soil series mapping was done in a dozen proposed RDA, in extent about 12,000 acres each on average, and Table 64 indicates the Land Classes for the eight which in 1966 seemed to have the most likelihood of implementing area plans: see also Map 20. It is interesting that the first one to do so was Bulandzeni, where the generally poor soil and low yields therefrom are considered by local leaders and progressive farmers as a challenge to be taken up. The next four to proceed with steps – some firmer and more advanced than others – to improve their agriculture have been Engcina, Madulini, Mahlangatshe and Sipocosini.

The RDA with the best potential of these eight, Bekinkosi, and the only one which could support a sizeable irrigation project, Nkweni, along with Statweni – all three are "red soil" localities – will hopefully follow suit. Delays have occurred for purely economic reasons at Nkweni (no irrigation finance as yet) and for reasons that are tribal (to do with chieftainship succession) and perhaps demographic (population pressure on the existing arable) in the other two. Engcina has been enlarged to accommodate neighbouring chiefdoms – Polonjeni (N9) and Kadangwe (M8) – westwards so that veterinary and cattle advisory services can be shared, and fenced gracing camps and new access tracks, important features of the area plan, can be extended rationally.

RAINGROWN ROTATION INCLUDING COTTON AND SORGHUM:

This is the recommended counterpart of the maize-beans rotation for low rainfall areas to which irrigation water cannot be brought. The main legume that can be grown, though not with the expectation of high yields, is the groundnut. The upper rainfall limit at which cotton thrives is 40 inches per annum: rank growth occurs and few bolls form in moister areas.

Soil requirements are fairly similar to those of the preceding system, but because of rainfall unreliability and scantiness the available water holding capacity of root zones is of great importance. Deep soils and those with heavy texture (as long as structure is not too impaired) are therefore upgraded.

The 2:1 cotton to sorghum ratio on the 60,000 dryland acres of these crops is not, sadly, an indication that they follow each other in purposeful rotation. Moreover while cotton is expanding, sorghum – which is used mainly for home brewing – has declined since its zenith, presumably last century, partly due to the availability of commercially manufactured beer. It is not easy to suggest equally drought-hardy plants to supplement cotton and sorghum in semi-arid parts of the country, with more than 80% chance of summer drought – Map 4. Groundnuts, sesame, maize and tobacco can be raingrown on a small scale, however, in areas receiving not much less than 30 inches of rainfall annually. But until that critical isohyet is crossed basing one's income predictions upon success with e.g. maize or groundnuts cannot be justified.

The 180 cotton demonstration fields have not been studied in quite such detail as the maize demonstrations (pages 223 to 240). In Table 65 mean seed cotton yields per soil series are given and in Table 66 individual picks. Table 67 indicates the relationship with Land Classes

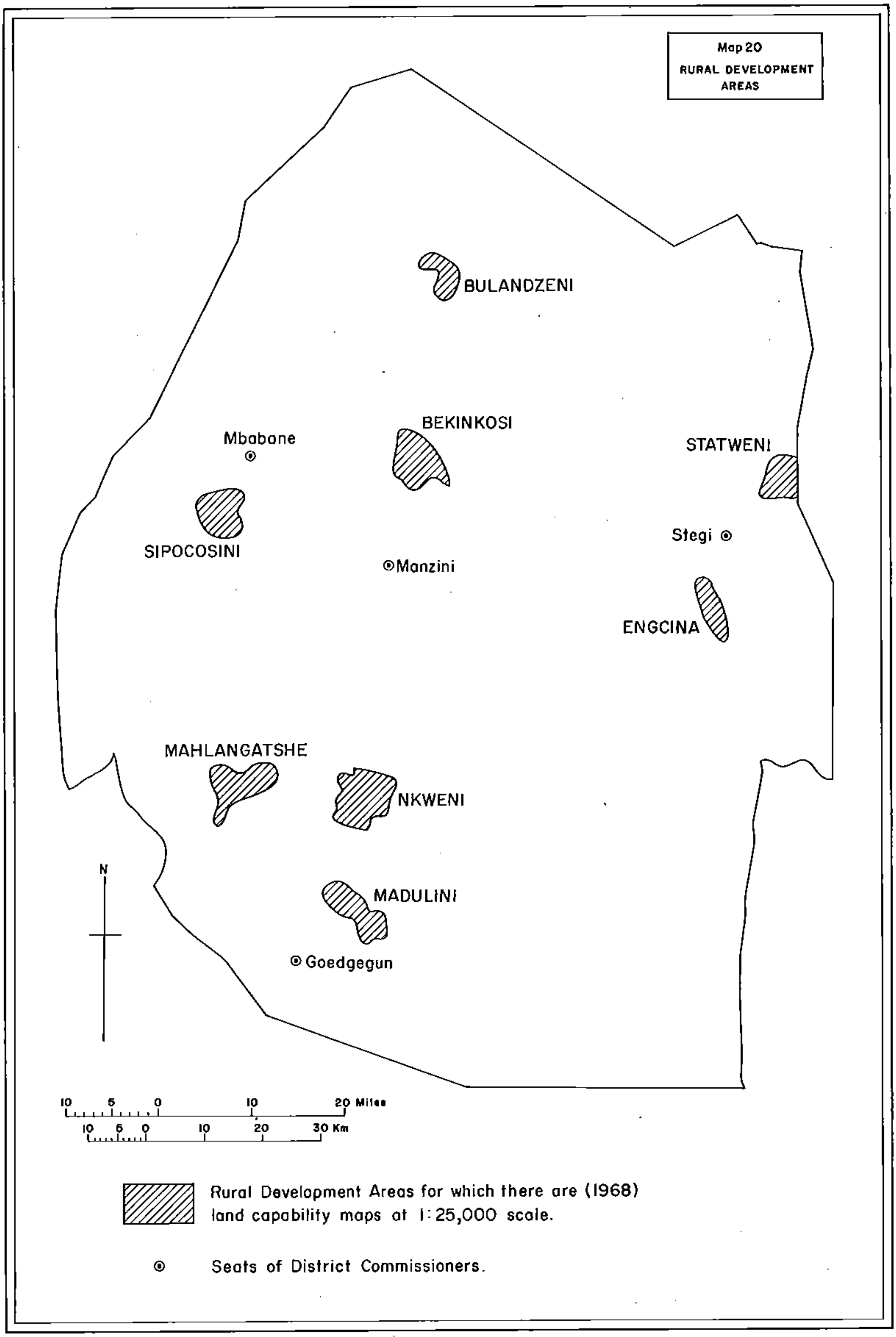

Map 20
RURAL DEVELOPMENT AREAS
BULANDZENI
BEKINKOSI
Mbabane
STATWENI
SIPOCOSINI
Stegi
Manzini
ENGCINA
MAHLANGATSHE
NKWENI
N
MADULINI
Goedgegun
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
Rural Development Areas for which there are (1968) land capability maps at 1:25,000 scale.
Seats of District Commissioners.

TABLE 64

Land Classes in Rural Development Areas

District	Hhohho		Lubombo		Manzini		Shiselweni		Swaziland
RDA (a)	Bul	Sip	Eng	Sta	Bek	Mah	Mad	Nkw (c)	All
Class AS	320	240	840	420	4,480	1,500	740	1,080	9,620
Class BS	710	2,300	2,940	280	1,970	2,800	1,600	1,420	14,020
Class CS	400	170	3,570	1,040	1,890	1,240	2,030	610	10,950
Class DS	660	940	280	360	2,200	700	1,020	3,300	9,460
Class GT	1,580	900	0	100	3,120	400	2,730	150	8,970
Class HM	2,030	8,250	270	9,300	2,240	7,160	4,390	12,040	45,680
Total (b)	5,700	12,800	7,900	11,500	15,900	13,800	12,500	18,600	98,700

NOTES:

(a) Numbers are acres: farming system is raingrown maize-beans rotation except at Engcina, where Classes refer to raingrown cotton and sorghum: abbreviations are for Bulandzeni, Sipocosini, Engcina, Statweni, Bekinkosi, Mahlangatshe, Madulini and Nkweni respectively.

(b) Rating G is A to D, H is E and F: S and T are divided at 22% slope.

(c) On 1,260 acres of Nkweni RDA with irrigation prospects, at Busaleni, Land Classes for an irrigated rotation of crops comprise AS 700 acres, BS 280, CS 90, DS 60 and ES 130 acres.

and Table 68 that with time. Over the past decade plots have been on average 0.7 acre and the chief variety was Loco, replacing earlier Kapel and Muka strains. NPK fertilizer applied amounted to about 170 pounds per acre per annum until 1964, whereafter the dose was increased to 300 pounds per acre during each of the next two seasons – composition 6:6:2 approximately, with least emphasis on N and K in the driest areas. About one in eight farmers have used dung at an average rate of possibly 5 tons per acre annually.

COTTON-SOIL RELATIONSHIPS:

The mean yield of demonstration plots at 710 pounds per acre is not vastly superior to the national average for 1957-1966 of about 400 pounds per acre, and it is much lower than the record pickings at 2,300 pounds per acre dryland, by both V. Twala of the Lomati valley and B. Sihlobela of Gundwini (N5) in 1966. The mean for plots bears no comparison at all with irrigated panels, which in experiments have given 5,200 pounds per acre. At a field scale S. Mahlobo of Zakhe (W9) and M. Tomlinson of Bovane (O6) have attained 3,100 pounds per acre under irrigation.

One reason for the fairly low overall production is recurrent drought, which has been severe in the cotton growing areas (the eastern two thirds of the country) during most years. Only the 1963 harvest had satisfactory rains throughout the Lowveld. The next best seasons there were the first two, ending 1957 and 1958. Another reason will have been variability in pest control, for until recently insecticide spraying was by no means a routine operation on cotton demonstrations. As Table 68 indicates, the last four years examined have had a mean yield some 15% above the decennial average.

In the circumstances the pattern of yields by Land Classes is considered very significant, the outstanding apparent misfits being reduced to Jovane and Enkulunyo series. That these deep sands have done better than other series in their Classes suggests that there may be wisdom in some farmers' deliberate selection of coarse, even gravelly, soils for cotton. But several clays and clay loams outyield Enkulunyo series nonetheless. Remarks about Productivity Index, Potentiality Index and gross margin for maize (pages 224 and 239) apply in general to cotton also. A 1966 check for comparison with the previous year's cotton costing corroborated the relationship shown in Figure 34. The ratio between yields of Classes AS and CS is 1.3 (as against less than 1.2 in the case of maize). This is almost the same as the 1.4 production ratio between Capability Units in Classes I and III of the American Soil Conservation Service, as studied by the writer when visiting Texas (means of 6 series on gentle slopes in Class I and 5 series on gentle slopes in Class III). Dryland returns are however all considerably higher in Texas, their Class III soils having about as heavy cotton crops as Class AS in Swaziland.

RAINGROWN AVOCADOS:

At one time it was thought that this crop would be highly profitable in the Upper Middleveld, but marketing and agronomic problems have proved intractable and there are still not 1,000 acres of avocado orchards. The trees are highly susceptible to rootrot and any soils with a suspicion of imperfect drainage have been downrated. Very deep and medium to light textured series are favoured – see Table 40.

RAINGROWN PINEAPPLES:

A very promising crop in the Upper Middleveld, pineapples can be expected to increase

To page 251

TABLE 65

Mean Yields of Cotton from Demonstration Plots 1957-1966 by Series

Soil Series	Harvests	Mean lb/ac	Soil Series	Harvests	Mean lb/ac	Soil Series	Harvests	Mean lb/ac
Alicedale	1	700	Habelo	9	570	Otandweni	9	470
Bushbaby	1	600	Juweel	1	750	Orrin	37	800
Canterbury	5	920	Jovane	4	870	Pofane	12	600
Coseni	1	500	Kwezi	2	930	Qolweni	3	440
Daputi	2	550	Lesibovu	26	950	Rathbone	6	690
Enkulunyo	7	660	Lomahasheni	7	720	Tateni	1	350
Felwako	5	730	Lutzi	1	300	Winn	5	890
Gubane	3	530	Ludomba	9	580	Zwide	4	420
			Malkerns	19	620			

Total number of harvests 180 from 25 series: unweighted mean yield 710 pounds per acre per annum seed cotton.

Number of crop failures 12 (when less than 80 pounds per acre were picked: three of the failures occurred in 1958 and another three in 1960).

Total number of demonstrations with records 192.

TABLE 66

Individual Harvests of Cotton from Demonstration Plots 1957-1966 by Series

Series (a)	Le	Or	Lo	En	Ma	Po	Ld	Ha	Ot	(b)	All (c)	
Harvests	26	37	7	7	19	12	9	9	9	45	180	
lb/ac 2300	1	1									2	
2000		1								1	2	
1900	1										1	
1800	1									1	2	
1700		1									1	
1650			1								1	
1600	2	1		1							4	
1550											0	
1500	1									1	2	
1450											0	
1400	1	1									2	
1350											0	
1300	2						1			1	4	
1250											0	
1200		3				1		2			6	
1150	1				1						2	
1100		1						1		1	3	
1050										1	1	
1000	2	1	1		2			1		2	9	
950										1	1	
900		3		1	1	2	1			2	10	
850		1					1			1	3	
800	2				2				2	2	8	
750		1		1	1					3	6	
700	1	4	1	1		1				3	11	Mean
650		1			2					2	5	
600	1	1			3	4			1	4	14	Median
550		1					1			2	4	
500	2	5	2	1	2				1	3	16	Mode
450		1						1	1	2	5	
400	4	2	1				2			4	13	
350		1			1	1		1	1		5	
300	2	2			2			1	1	2	10	
250	1	1	1						1	1	5	
200		2			1	3	3		1	4	14	
150					1			2		1	4	
100	1	1		2							4	
Rounded Means	950	800	720	660	620	600	580	570	470	680	710	

NOTES: (a) Abbreviations for 9 commonest series — see Table 65 list

(b) Remaining 16 series

(c) Digital preference is strong for pounds per acre ending 00 rather than 50

TABLE 67

Mean Yields of Cotton from Demonstration Plots 1957-1966 by Land Classes

The 17 principal soil series, with 170 harvests, are taken. Columns A and B refer respectively to the Productivity Index and Potentiality Index of Riquier, Cornet and Bramao (1968) – see explanation at head of Table 60.

Class AS – 6 Series

Yields lb/ac		A	B
Lesibovu	950	27	96
Canterbury	920	23	77
Winn	890	27	96
Lomahasheni	720	32	86
Rathbone	690	29	96
Malkerns	620	35	96

Class BS – 3 Series

Yields lb/ac		A	B
Orrin	800	15	38
Felwako	730	22	70
Ludomba	580	27	96

Class CS – 4 Series

Yields lb/ac		A	B
Jovane	870	6	26
Pofane	600	10	27
Habelo	570	4	27
Qolweni	440	9	29

Class DS – 4 Series

Yields lb/ac		A	B
Enkulunyo	660	4	17
Gubane	530	2	14
Otandweni	470	2	14
Zwide	420	2	16

TABLE 67 – Continued

LAND CLASS	AS	BS	CS	DS
Unweighted mean of yields in pounds per acre	790	700	620	520
Total number of harvests	68	51	28	23
Unweighted mean of (current) Productivity Index A	28	21	7	3
Unweighted mean of (future) Potentiality Index B	91	68	27	15
Difference between Productivity and Potentiality B-A	63	47	20	12
Ratio between Productivity and Potentiality B/A	3.2	3.2	3.9	5.0
Gross Margin: rands per acre – see Figure 34	32	28	23	17

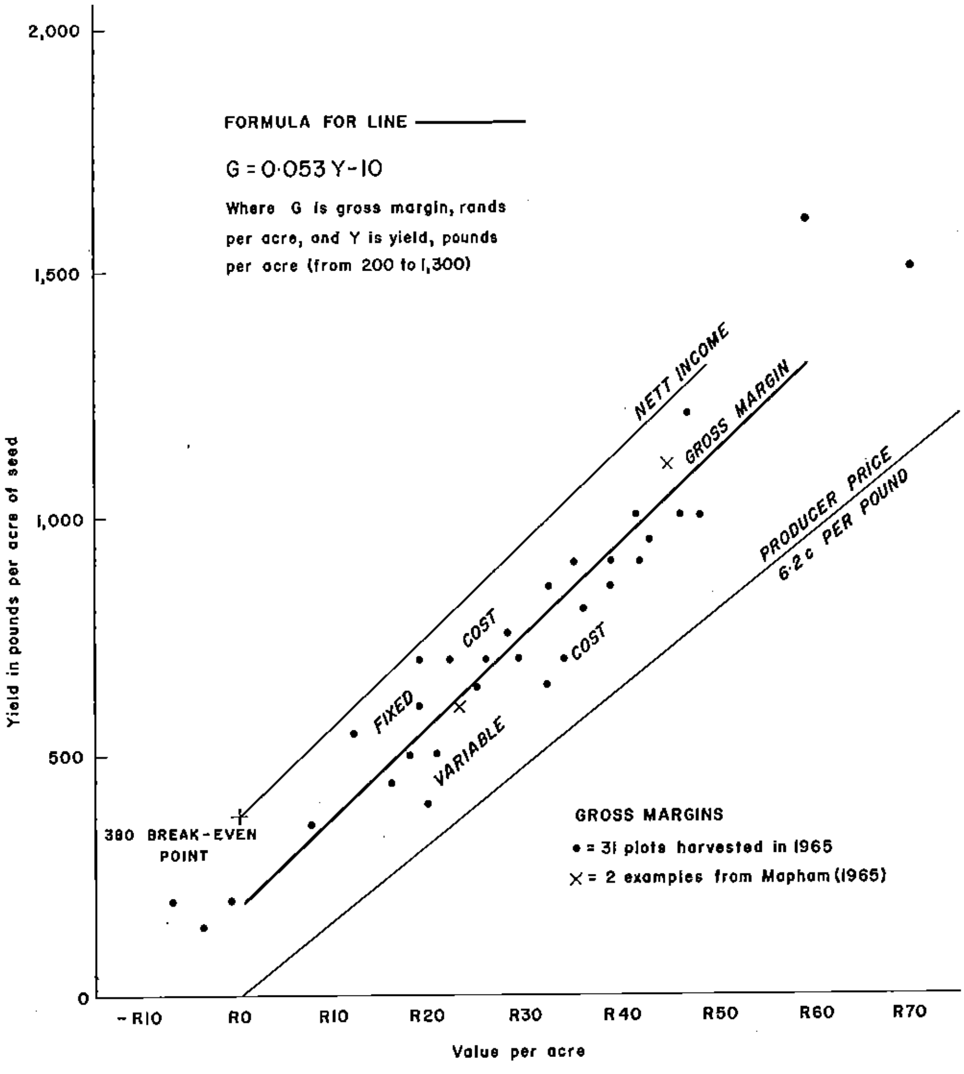
TABLE 68

Mean Yields of Cotton from Demonstration Plots 1957-1966 by Harvest Years

Season Ending	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Pounds per Acre Seed Cotton	580	600	520	540	720	690	930	740	740	830
Number of Plots	3	16	18	19	10	16	17	23	31	27

FIGURE 34

Gross Margins at Cotton Demonstration Plots 1965



in acreage, perhaps substantially, provided canning arrangements materialize. The 2,000 acres planted is a small fraction of the potentially useful soils, which exceed 100,000 acres between 1,800 and 3,200 feet elevation, already referred to on page 22 as the optimum thermal range. In fact the danger of sunburn, which makes the fruit uncannable, rather than high temperature per se, causes the lower altitudinal limit to be placed where it is – Dodson and Murdoch (1967). The Hawaiian pineapple industry is the world's largest with 950,000 tons of fruit harvested annually but even there less than 100,000 acres are required for the crop.

Pineapples make fairly heavy demands on nutrient elements, especially potassium and nitrogen, and they are sensitive to poor drainage. The crop itself has shallow roots, but ensuring a permeable subsoil is so essential that better ratings have been accorded to deep, well drained soils of medium to light texture than to any soil, even if more fertile, with only moderate drainage or with hard rock under a thin solum.

RAINGROWN PASTURE:

At present there is very little improved grassland relying solely on rainfall in Swaziland (and not much more that is irrigated – see page 220). However, it is hoped that the practice of thinking about areas to be grazed as cropland will increase with intensification of the livestock industry. The process may well not be rapid. I'Ons and Kidner (1967) point out that although perennial pasture needs care in establishment, land preparation costs are not recurrent, and if legumes are included in the mixture, fertilizer requirements should be less than for annual crops. The lower capitalization envisaged and the possibility of ringing the changes on many pasture species and strains lead to upgrading of some shallow, not well drained soils for this system. Soil conservation advantages of improved pasture with a good ground cover percentage, both basal and interceptive, will be great. By comparison unimproved grazing often has only 20% or less basal cover. Erodible soils are thus less harshly rated than they are for other crops. Stock farmers in the Highveld, the wettest region, are the likeliest to go in for improved pasture, and rainfed its extension below 2,500 feet is highly problematical, due to dieback and the shrivelling of roots in the very dry winters.

FUTURE DRYLAND CROPPING:

With A.V.R. Dicks and colleagues the writer helped in 1967 to produce a map showing the dryland annual crop zonation of Swaziland, based on current plantings but with an eye to future economic prospects, compatibility and balance of crops in rotations proposed, and diet changes – to more varied foods and in particular less maize. The suggested cropping patterns are outlined in Table 69, and Map 21 refers. The initial objective was to give Ministry of Agriculture staff a national review of raingrown crop potential, with indications of where "campaigns" to grow particular crops should be restricted to in future. Past propaganda has been too vague in this respect (e.g. cotton and groundnuts recommendations) or has been countrywide when it should have been directed to certain ecological zones only (e.g. maize extension work).

All the farming systems so far dealt with are and will continue to be intricately combined in the landscape. Rather few soils are rated E or F for every purpose, in terms of numbers of series. From Table 40 it seems that 9 series (Darketown, Gongola, Qualm, the three in U set, Xulwane and the two in Y set) are totally unfit as fields or orchards. Of course the steep portions, over 22% gradient, of other series should likewise be left unploughed, and perhaps a more useful way to consider the "uncultivable" is as irrigability (1:125,000 map) Class MT

TABLE 69

Dryland Annual Cropping Zones (a)

ZONE (b)	BEST PROSPECTS	ALSO RE-COMMENDED	OPTIONAL ADDITIONS
A – Highveld Mountains	Be Po	Ma	So
B – Highveld Southern Fringe	Be Ma	Po To	So
C – Highveld Valleys	Be Ma To	Gr	Co So
D – Upper Middleveld Red Loams (c)	Be Ma To	Co Gr	So
E – Upper Middleveld Other Soils	Be Gr Ma	Co To	So
F – Lower Middleveld Red Loams (d)	Co	Gr Ma To	Se So
G – Lower Middleveld Other Soils	Co Gr	Ma So	Se To
H – Western Lowveld Red Loams (d)	Co	So	Gr Ma
J – Western Lowveld Other Soils	(e)	Co So	Gr
K – Eastern Lowveld	Co	So	Gr
L – Lubombo Red Clay Loams (d)	Co Ma To	Be	Gr So
M – Lubombo Other Soils	(e)	Co Gr Ma	So To

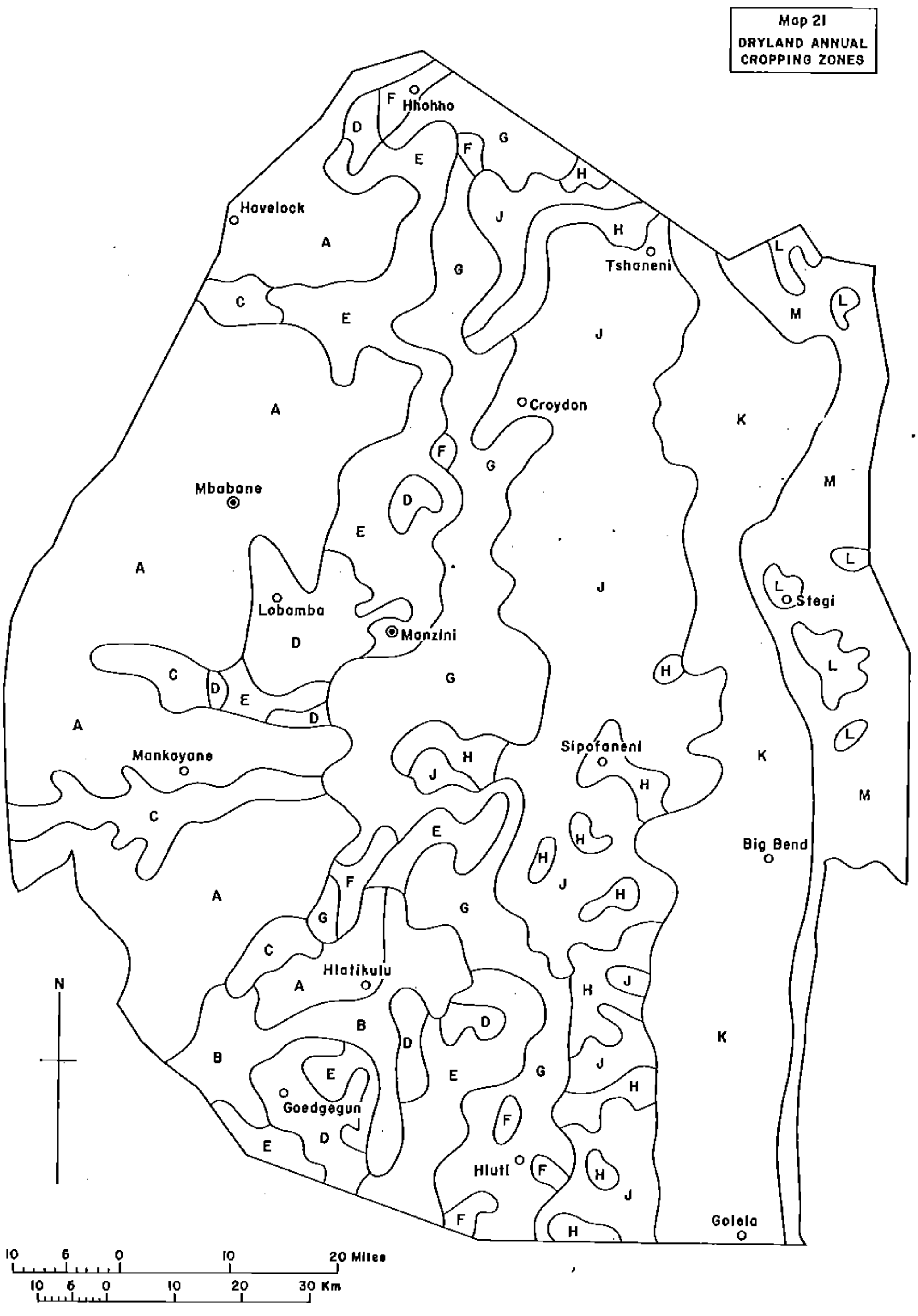
NOTES: (a) Be = Beans, Co = Cotton, Gr = Groundnuts, Ma = Maize, Po = Potatoes, Se = Sesame, So = Sorghum, To = Tobacco.

(b) Lettered as on Map 21

(c) Mainly M set

(d) Mainly L set

(e) No crop can be strongly advised



For key see page opposite.

Zones with Red Soil are highly generalized—even more so than in Map 23.

minus a category of land that is Class GV – arable on 14% to 22% slopes. This is merely an approximation, because the Land Capability Map is not specifically intended to relate to rain-grown crops and also because Classes ES and FS for dryland farming are neglected, but in the national perspective it should suffice. Class MT has 1,800,000 acres including Class GT covering 660,000 acres (from Table 51). Class MV is 370,000 acres and so probably contains at least 120,000 acres with a G soil rating. The completely non-arable portion of Swaziland may therefore be reckoned as 1,670,000 acres.

In the foreseeable future fields and orchards are certain not to expand into more than a fraction of the gross area available to them – some 2,630,000 acres theoretically. The nett arable will be far below this. Forest and woodland, of which even now at least 20% or 70,000 acres occupies arable soils and slopes, will need to be deducted, as will nonagricultural land, currently an estimated 250,000 acres.* Nor are these pockets, punctuating the arable, of forests, towns, villages going to remain static. Except for indigenous timber, they are more likely to grow than to contract. Arbitrarily doubling them (and in the process permitting them to overrun as much Class ES for agriculture as possible) leaves approximately 2,000,000 acres as the nett arable potential.

However, another cautionary subtraction should be made of a proportion of the Lowveld arable, it is felt, for the 2,000,000 acres includes no less than 1,250,000 acres which are in this, the least attractive climatic region for rainfed crops. True, irrigation will spread, but (see page 221) very possibly not to more than 300,000 acres in the whole country. Even if 80% of the ultimately irrigated cropland is located in the Lowveld, at least 1,000,000 acres of dryland fields are being proposed, and this appears excessive. Cattle ranching on unimproved pasture must surely continue to be the principal type of land use, as regards acreage, in the Lowveld. Developed countries, notably the United States and Australia, retain much rangeland in similar environments. An allowance of 40% of the entire region for arable, including improved pasture, seems generous enough for decades to come, and means that crops will take up 600,000 and not 1,250,000 acres there.

Modification of the national total to 1,350,000 acres is therefore suggested. Excision of any remaining Class ES plus FS land, unavoidable losses along field and orchard boundaries, and other attritions (due e.g. to industrial expansion or to the making of new roads, railways and airfields) might well reduce this further – say by 12% to 1,180,000 acres or 27% of Swaziland.

There is absolutely nothing decisive, naturally, and despite its exactitude, about the total of 1,180,000 acres which has been produced. By the end of this century that much cropland may still be far from being reached: on the other hand, it might have been surpassed before then. The value of these hypothetical calculations, backed by Land Capability Map acreages, is solely in suggesting that, for national planning purposes, something of the order of a doubling of present cropland, with temporary fallow, may be taken as practicable. If the fallow becomes ingested into mixed farming rotations (or into planned monoculture), so that it is not resting but producing, it would be safe to say that an eventual trebling of the cropped acreage is predictable. Table 7 indicates that a doubling (or nearly so – the early maize underestimates prevent one from being precise) of the area of fields and orchards has in fact occurred over the past two decades. The increase in tillage to say a million acres could happen more quickly than many might expect.

*Less than the figure in Table 7 by 10,000 acres, to allow for slopes greater than 22% that have buildings etc. on them.

THE POTENTIAL FOR STOCK-REARING:

There will be a direct relationship between the amount of improved pasture grown and the eventual numbers of livestock that Swaziland can support. Writers on the country's veld carrying capacity – I'Ons and Kidner (1967) and Van Biljon (1962) are among the latest – have had no difficulty in seeing overstocking as a tremendous problem whose solution, however, is not visible without either drastic culling of cattle and goats, or supplementing the unimproved grazing with other fodder sources, or both.

Better use of crop residues for winter feed will go some way to improving the position, as would a more even distribution of herds, if it can be achieved satisfactorily, across land tenure divisions (see pages 45-46), but even the average 1968 density of some 570,000 livestock units on 3,300,000 acres of permanent grazing plus fallow (one animal to less than 6 acres) is rather high. If the 400,000 acres of Class FM is taken away from the pasturage, the livestock pressure becomes nearer one to 5 acres.

I'Ons and Kidner (1967) give mean optimal stocking rates as follows: one animal unit to 11 acres in the Lowveld, one to 5 acres in the Middleveld (for 8 months per annum) and one to 4 acres in the Highveld (for 6 months per annum). The Highveld and Middleveld rates may at first sight seem easily attainable, but the dry winter months without palatable grass on the open veld are crucial. Neglect of the welfare of cattle – fodder, water, warmth – at this time leads to deaths which vitiate the high stock density supportable in summer.

Erosion is the main observable soil problem on grazing grounds, although it does not seem to have worsened appreciably over the past 15 years. This welcome slowing down of soil loss is due to several factors, e.g. resting of some badly gullied land (especially in the southern Middleveld), graded shallow drains and other runoff control measures by soil conservation heavy units, campaigns to exterminate harvester termites, fencing in some parts of the country, and the beginnings of a more rapid turnover of livestock, with increased use of Impala and Golela fattening camps and, very recently, of finishing-off ranches run in conjunction with Matsapa meat works.

But erosion has not been conquered and many scars remain, the ugliest near the 580 diptanks and thousands of watering points, mostly along rivers. No soil is immune from denudation at such places. However, the gullies on trails leading to them occupy only a fraction of the area which devegetated and sheet-washed veld does. Whether eaten out or trampled out or both, the thousands of acres affected represent an irreplaceable plant and animal nutrient loss. Qualitatively one can distinguish very bad areas as often having poorly structured or apedal soils of light texture on steep gradients – TH QH O E in approximate order of susceptibility. The worst of these, TH set, is notoriously unstable too as wall material for road or railway cuttings. Another category of soils, possibly as erosive, has strongly Two-Deck morphology with a shallow, sandy top – H G ZL P again roughly in order of erodibility. These four sets, and the parts of O and E in eastern Swaziland, may be quite gently sloping and yet subject to rilling and topsoil sheet movement because of their poverty in binding agents such as humus and the low basal cover caused by a combination of overgrazing and recurrent droughts.

The six sets E G H O P ZL are also those whereon bush encroachment is heaviest – see page 39. Their restoration as productive pasture, once thorny scrub has displaced edible grasses and forbs, has been long debated – Irvine (1943) – and is very difficult.

Graziers on red soils cannot be exonerated from strictures as some of the most conspicuous barren hillsides in fact comprise M set. Where steepness alone does not seem to be sufficient reason for their plight it can often be elicited that exhausted, abandoned fields occupy the area concerned. But the proportion of M set that is ravaged in this way is not large: the bright colour of exposed Malkerns series makes eroded areas catch the eye.

On the credit side, certain soil sets are definitely associated with better than average unimproved grazing. In alphabetical order they include B CH CL DL F K L NL R SH SL TL V W. Some of these probably have carrying capacities, if well looked after, of the order of one animal unit to 7 acres in the Lowveld, rising to one every 3 acres for Highveld summers.

AFFORESTATION:

Little is known of the soil preferences, series by series, of gum or wattle or poplar trees, far less indigenous timbers. Among the latter only Pterocarpus angolensis (umvangati or kjaat) has been commercially exploited on a relatively large scale in Swaziland – at Boma (C6) there was a shortlived furniture-making enterprise during the 1940s. Gums are being planted in sizeable blocks of the southern Highveld and Cool Middleveld and a survey of their yields on various soils will be worth mounting as they mature.

Conifers are the main trees grown – virtually all within several Pinus species originating from the Gulf of Mexico littoral and West Indies. In 1967 pine tree growth was correlated with soil series on Usutu Pulp, Peak Timbers and Ruby Creek (Swaziland Plantation) – which together own more than 90% of the country's pinewoods – and on Swazi National Forest blocks adjacent to them at Waverley (K1) and Silwane (L1) and around Piggs Peak township. Results are presented in Table 70, and see also Map 22.

As stated in the introductory paragraph on pine yields (page 196) the units in this investigation are 734 subcompartments. Their average area is 80 acres and all were first-rotation stands when measured. In each of them mean stem height has been derived from random sample counts ten or more years after planting, during the period 1962-1967. The Site Index (mean height in feet at 20 years) has been computed from standard Southern Africa tables in respect of unthinned stands planted 9 feet by 9 feet. This is the sylvicultural practice on almost 70% of the subcompartments concerned. The rest, all in northern Swaziland, are pruned and thinned to produce large-diameter structural timber and 8 Site Index units have been subtracted from their measurements to take account of this removal of small trees, which leads those left to grow approximately that much taller.

The subcompartments with Pinus patula number 548, P. elliottii 152 and P. taeda or others 34. The growth habit of P. elliottii is known to be low compared with P. patula, perhaps on average 6 Site Index units less, but there is a good scatter of P. elliottii over the main forest series, so it has not been omitted from Table 70.

Effects of drought and of hail-induced Diplodea damage are most severe among pines on soils shallow to hard rock – Ungabolima and Oldreef series, placed in Classes EM and DM respectively. On the other hand 4 out of 5 series in Classes AM and BM are very deep. The Site Index range between Coseni, the best pine soil, and Ungabolima rockly land is only 13 units. In America larger differences are apparent, e.g. Pinus ponderosa stands growing on Ustoll stony loams of the Zuni Mountains, New Mexico, have a Site Index (feet at 100 years) which varies with soil depth from 54 on Kiln series (hard rock at 10 inches) to 72 on Tampico series (thick alluvium) – Williams et al (1965). As well as depth, the texture of the solum and the land slope have been correlated with pine productivity by Zahner (1957).

An independent check on the ratings accorded to Swaziland series has been obtained by ascertaining the soils in which 60 plus trees are growing. Half are found on Malkerns series and no less than 7 are on Coseni series. The pine forest soil set acreages from the 1:125,000 Soil

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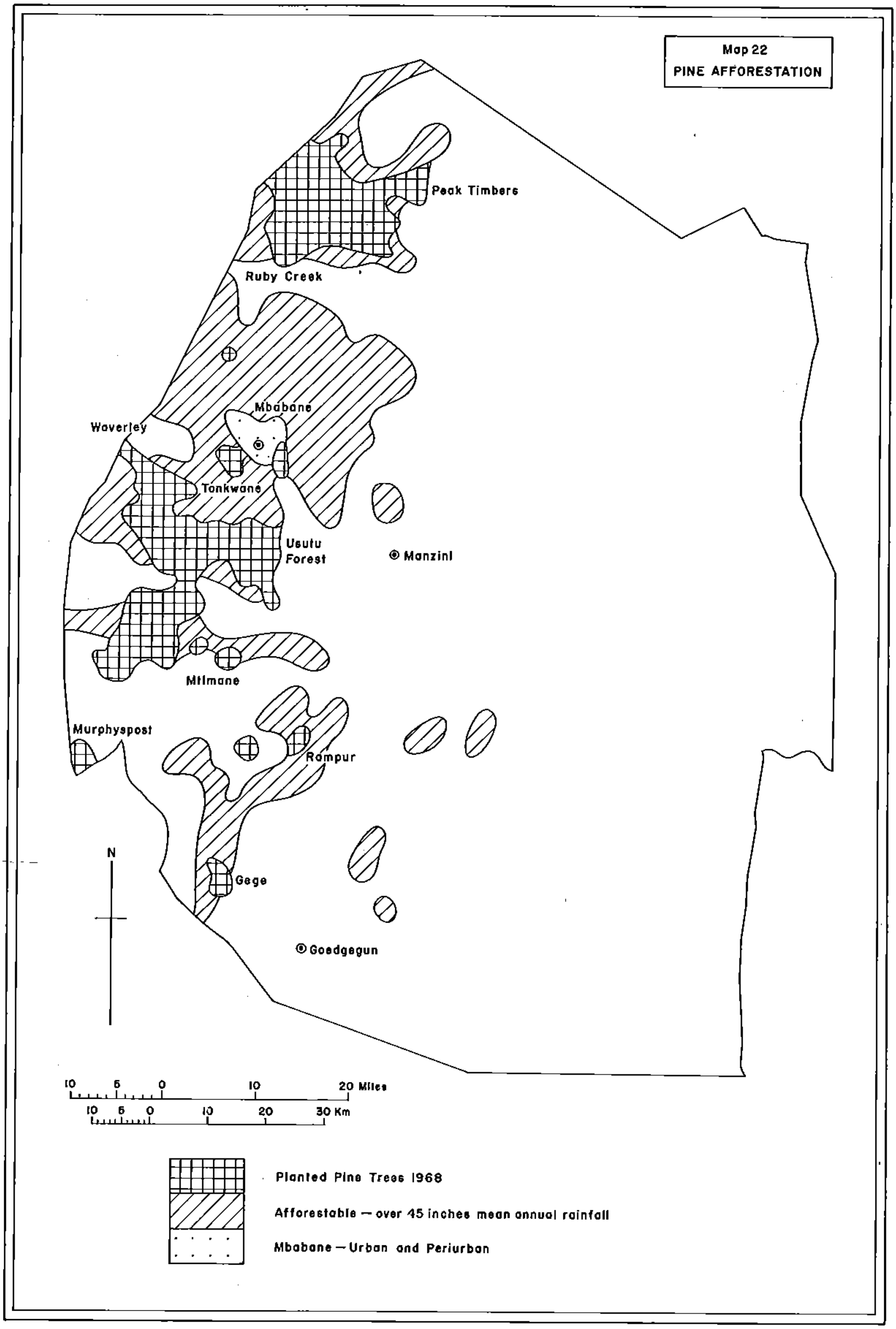

Map 22
PINE AFFORESTATION
Peak Timbers
Ruby Creek
Mbabane
Waverley
Tonkwane
Usutu Forest
Manzini
Mtimane
Murphyspost
Rampur
Gege
Goedgegun
N
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
Planted Pine Trees 1968
Afforestable — over 45 inches mean annual rainfall
Mbabane — Urban and Periurban

TABLE 70

Pine Tree Growth by Soil Series

Series (a)	Co	Ma	Am	Sa	Nd	Qo	Uc	Tx	Jw	Ol	Un	All
Classes (b)	---- AM ---		-------- BM --------			---- CM ---		-------- DM -------			EM	All
Subcomps.	14	138	25	35	82	98	123	112	39	23	45	734
	152		142			221		174				
90 (c)		5		1	1							7
85	1	4	1	1	1			1				9
80	3	18	1	1	5	7	1	4	1	1	1	43
75	3	34	5	4	12	19	10	13	4	4		108
70	2	33	9	16	28	27	25	19	6	4	3	172
65	5	32	6	8	25	27	35	41	12	4	6	201
60		10	2	2	8	12	34	23	9	4	19	123
55		2	1	2	2	5	15	8	6	5	13	59
50						1	2	3	1	1	2	10
45							1				1	2
Medians	72	70	69	68	67	68	64	65	63	63	59	66
(c) (d)	71		68			66		64				

TABLE 70 – Continued

NOTES: (a) Abbreviations for respectively Coseni, Malkerns, Amuke, Sangweni, Nduma, Qolweni, Upcountry, Tateni, Juweel, Oldreef and Ungabolima.

(b) Suffix M signifies that all slopes are, pro tempore, taken as suitable for forestry. Timberjack tractors can be employed on the steepest gradients which are soil-covered. On occasional patches of precipitous U set felled trees are mule-drawn and manhandled down slip paths to less awkward localities.

(c) First column and bottom row indicate Site Index, mean height in feet to tip when 20 years old.

(d) While the best Land Class has 20% better Site Index than the worst, its volume under bark to 3 inches diameter is about 50% greater. Enough volume measurements have now been made for approximate relationships, within the Site Index range of most forestland (55 to 80), to be known. For unthinned pulpwood cubic feet per acre per annum = 8S – 275 on average, where S is Site Index. Thus Class AM is expected to yield about 293 cubic feet per acre per annum, Class BM about 270, Class CM about 253, Class DM about 237 and Class EM about 198. Fairly wide variations from these increments can, however, be expected.

TABLE 71

Acreages of Soil Sets and Land Classes in Pine Forests

Class (a)	Acres	Soil Sets (with Acres)
AM	27,000	M 24,000: CH 3,000:
BM	39,000	NH 23,000: A 9,000: SH 7,000:
CM	67,000	Part of U 45,000: QH 20,000: ZH 2,000:
DM	56,000	TH 37,000: JH 10,000: O 8,000: G 1,000:
EM	21,000	Part of U 15,000: I 6,000:
Total	210,000 (b)	U 60,000: TH 37,000: M 24,000: NH 23,000:

NOTES: (a) For coniferous forest. From the 1:125,000 Land Capability Map irrigable Classes in pine plantations are AS 7,000 acres: BS 14,000: CS 7,000: DS 9,000: GT 65,000: HM 108,000 acres. This demonstrates that although pines may be competing with irrigated crops for water, they are certainly not competing for land, since only one sixth of present timbered areas could conceivably be irrigated.

(b) About 30,000 acres more than the nett pinewoods (see Table 10) because firebreaks, roads, buildings and some unplanted sectors within forests are included.

Map — see Table 71 — suggest that an average share, out of 60, for these two series might have been 8 and 1 respectively. Their superiority is proved without a doubt.

By the same token U set had only 2 plus trees, on Upcountry not Ungabolima series, whereas proportionately it occupies 18 area units out of 60. About 20% of the 734 subcompartments are in Class AM but throughout the pine forests only 13% of Class AM land has been mapped. This is explained by preference for the best soils in early plantings (1948-1956), which are the only ones old enough to qualify for inclusion at Table 70. The converse is true of U set, much of which has been left as grassed firebreak corridors: it comprises 23% of measured subcompartments but 28% of the pine-covered properties.

The quick action of Usutu Pulp management in tackling an incipient soil erosion problem on slip paths and steep slopes — Keet (1967) — and the awareness by foresters in Swaziland of soil and water conservation needs are encouraging. Murdoch (1956) reported pH reduction of 0.6 unit under pines 10 years old on Mtilane series, compared with adjacent virgin land, and since then the dossier on local forest soil fertility has grown commendably, thanks to H. Wilhelmij in particular.

Applied pedology is being further served by forest research workers P. Germishuyzen and J. Evans, who have embarked respectively on cause and on effect studies in second-rotation pine blocks which appear to be unthrifty. Inter alia plant nutrient removal by the first crop and by needle leachates and nitrogen loss in the slash-burning that follows clearfelling on some plantations will be investigated.

What is the maximum afforestable area in Swaziland? Rainfall limits appear to be 40 inches or a little more for good pine trees and 35 inches mean annual total for gum. This means that the Highveld and Upper Middleveld may be adjudged plantable, except for the 12 series listed as Class EM in Table 40. These unfit series occupy less than 800,000 acres, the Highveld and Upper Middleveld area of the sets they fall in — DH E G I U X (discarding Wisselrode series). This leaves more or less 1,000,000 acres with eminently to moderately suited soils.

However, foresters will be obliged to avoid populous Middleveld localities where food crops must continue to be cultivated, and even in the Highveld the 45 inches isohyet may be more realistic to follow as a safe limit for future pinewoods. Above 45 inches lie some 710,000 acres, including all except perhaps 30,000 acres of existing pine plantations — see Map 22. If unfit soils have the same proportion over these wettest localities as they do over the Highveld generally, then 350,000 acres are ruled out and 360,000 acres gross are found suitable as regards both edaphic and climatic environment. Nonagricultural land use (Mbabane, Havelock and other population centres included) now takes up perhaps 40,000 acres. Allowing for urban expansion, and for some transgressions below the 45 inches isohyet, a doubling of the current pine acreage can be forecast, provided other factors do not intervene.

These other factors will include negative ones — competion for the land by cattle and sheep rearers (they could not make it yield better economic returns, but there may be nowhere else in the country for them to keep their stock) and competition for water to transpire by irrigated crops. This last may now be put in perspective. If all that was going to be lost was enough river water for 20,000 acres — see reference on page 61 to Banks and Kromhout (1963) — the matter would not be too serious, but should further Transvaal pine and gum plantings take place, commensurate with those in Swaziland catchments, a situation where 80,000 acres or more of irrigable land had been imperilled would result — almost a third of the total (high estimate) area that could economically be irrigated with the 1950-1960 undisturbed stream flow. Resolving this question mark that hangs over two main commercial land users, the sugar and the timber industries, will be a boon to both in their longterm planning and Government's.

Positive reasons exist too, of course, for more not less woodland. The outlook in printing and packaging is on the whole bright — though manufacturers would relish fewer fluctuations — and sawn logs and other timber products are in steady demand locally. As with other crops whose yields have been studied, future concentration of pine trees on series known to be those where they do well will help not only to ensure greater output from the soil but also to minimize protestations on the part of claimants to the same land or water.

Chapter 4

TRENDS IN THE RURAL ECONOMY

Past and Present and Future Growth Patterns Related to Soil

THE QUESTIONS TO BE ANSWERED:

Of the many questions that bristle as soon as one begins to try to predict the course that agricultural progress either will take or ought to take in Swaziland, this Chapter attempts to answer two principal ones and several supplementaries. The two are – What lessons from the past record of soil and land use are the most valuable for tomorrow's farmers to grasp? What do the soil set and Land Class distributions imply should be the areas where Government and the rural community will be best advised to concentrate on improved husbandry and greater profits from agroforestal enterprises?

In the next 5 pages the first question is tackled, but even tentative responses to the second require so many qualifications and assumptions that the lines are cleared before recording opinions on it by investigating one by one the main variables, other than soils and land capability, preconditioning an answer.

PHASES OF SETTLEMENT AND SOIL USE:

Lessons of the past are undoubtedly for the most part minatory rather than hortatory. Otherwise, if all had always gone well, there would be no need now to bother about learning from history. There follows a commentary upon prominent agroforestal events, with the soil sets and series most affected by them, in each of nine chronological phases of settlement by the Swazi and later comers.

Clans of Sotho, Pedi and Bushman stock were ousted or assimilated by Swazi when the latter entered what are now Lubombo District, say 1700, and Shiselweni District, about 1750 onwards. Bushman rock paintings and Pedi stonemounds are commonest in the Highveld, but these nomads have left no other imprint on the landscape. By 1880 families solely of Bushman origin had died out in the country.

(1) THE PERIOD OF PRIMITIVE AGRICULTURE AND VAST GRAZING GROUNDS 1700-1850:

The choice of Lomahasheni series, one of the country's most fertile and stable soils, as pasturage and fields by perhaps the first Swazi clans to settle permanently with the object of cultivating land may have been fortuitous. It was certainly fortunate, as their descendants – the Mahlalela people around Namaacha and the Maziya* around Stegi – live in comparative prosperity. Holleman (1964) found that the Lubombo Range, more than any other region, produces surplus maize and sorghum for export to other parts of Swaziland.

The remaining 15 original clans, the main body of the Swazi tribe, settled around 1750 in the Cool Middleveld sector of good soils, although capitals tended to be southeast of the largest Mooihoek and Malkerns series block. Next, when forced northwards (see page 40) Qaboneni was the tribe's resting place for a brief spell, possibly 1820-1823 – an inhospitable

*The names commemorate their hiving off: hlalela to sit down, ziya to hesitate.

mountainous area soon abandoned for the richer lands of the Central Middleveld horseshoe, made by the well-watered Ezulwini and Umtilane valleys, where nearly all royal villages have since been sited. This is the largest single piece of land with high agricultural potential in the kingdom – mainly Malkerns series. The Central Middleveld, with extensions a few miles north and south in the same altitudinal zone, is known simply as Live or "The Nation". Its location, between Manzini and Mbabane, is shown on Map 6.

The only capital of a king outside Live since 1823 has been Hhohho (B5), selected as a military headquarters when the Swazi were at the height of their power and northward territorial expansion, about 1842-1850. Even Hhohho is surrounded by excellent soils, primarily Lesibovu series, in the Lomati basin.

Thus all five choicest arable areas with mean annual rainfall exceeding 30 inches had been tribe or clan nuclei by 1850. Swazi are pastoralists, but have not been purely pastoralists for two or more centuries and their crop husbandry – first millet and sorghum then maize – has been concentrated on what are, or were in the virgin state, better than average soils. Land use has long reflected land capability.

The main mistake, so far as one can judge, that the early Swazi settlers made – and it has cost them dear – was to give no plant food back to the soils of M and L sets whence most of their crops were reaped. There are no records of the use of dung or any other fertilizer until well into this century. M set in particular – less well endowed with nutrients to start with – has been impoverished by this neglect throughout the Upper Middleveld: see Figure 24.

Fields were almost certainly confined at first to environs of capitals and other villages but cattle, kept by Swazi since antiquity, roamed far and wide, especially one supposes in dry years when grass was scarce. Indeed after droughts of the 1820s – see Uys (1956) – relative overstocking may have triggered off Swazi "empire-building" in the middle of the last century.

Jones (1968) indicates that King Sobhuza I had less than 2,000 followers in the 1830s, but with Pedi and other vassals perhaps 10,000 inhabitants of the country then is not an inflated estimate. A doubling thereafter every 20 years, due more to immigration than natural increase, would result in the 100,000 mark being reached at the turn of the century.

(2) RUDIMENTARY STAGES IN AGRICULTURAL EVOLUTION THROUGH OUTSIDE CONTACTS 1850-1880:

Iron ploughs had been introduced to the Swazi by 1853 and as fairly peaceful conditions ensued and boundaries began to assume their present shapes, settled community life may well have begun to be the norm. Soil exhaustion, especially on M set, will have been hastened by the influx of those Swazi who retreated from outlying areas into the constricted kingdom after the land losses of 1855, 1866 and 1880 (see page 40).

Communications with the outside world were established. T. Rathbone made trading trips Utrecht-Live-Hhohho from 1862 onwards and white miners appeared about 1867, seeking gold and then tin. The west to east route Ermelo-Live-Stegi and so (partly by launch down the Tembi River) to Lourenco Marques was fully operational by 1884.

(3) THE PERIOD OF GRAZING AND FARMING CONCESSIONS 1880-1890:

The grant of land rights to Europeans began in 1860, but the deluge of fortune hunters – Europeans, Coloureds and some individual Africans – came in the last few years of King Mbandzeni's life. Concessionaires' sheep grazed Highveld slopes and summits and their cattle were pastured in portions of Middleveld valleys not already being cultivated by Swazi.

The mark of this episode most clearly discernible is the distribution of "trek sheep farms" on Tateni, Nduma, Qolweni and other series of Highveld uplands. However, extensive ranching is more and more being replaced now by afforestation, which appears to be the optimum land use for the region. Serious field husbandry was not carried on by the earliest white settlers, the word "farming" in deeds of grant or transfer being synonymous with cattle speculating, plus garden-scale tillage.

(4) THE PERIOD OF RINDERPEST AND FAMINE 1890-1900:

Droughts during this decade, coupled with the rinderpest which reduced Swazi-owned cattle from over 100,000 head in 1893 to less than 40,000 in 1897, drove many adult males to seek wage employment in the Witwatersrand goldmines (opened 1886) and set the fashion that has become a sociological trait here and throughout Southern Africa of earning money during several spells, totalling half one's working life, and eking out subsistence on one's pieces of land the other half.

The segment of Swaziland which has consistently, this century, supplied most recruits to the mining and other industries is exactly that triangle in the south, with apices Gege and the Singceni Hills and the vicinity of Starvation Camp (Z6), which has longest been inhabited by Swazi. The fact that population pressure, human and livestock, had literally worn out tracts of Swazi Area in this part of the country was all too obvious when soil conservationists began to examine the extent of erosion – Evans (1932) and Faulkner (1944). On rock-free grazing grounds TH and QH sets have often fared worst, but have generally retained their identity as profiles, albeit truncated. Not so some rocky terrain: from the present-day appearance of many hillfoot strips mapped as U set they must once have had a soil cover – O or ZH or SH set. This is a feature of southwest Swaziland seldom repeated elsewhere in the kingdom.

(5) THE INTRODUCTION OF ELEMENTS NECESSARY FOR AGRICULTURAL PROGRESS 1900-1920:

The cadastral survey attendant on the 1907 partition performed a great service to landowners. And the partition itself, though unaccepted by the Swazi (see pages 42 and 266), was at least scrupulously equitable in one respect, for there is no question of the blacks having been pushed by white settlers on to land in its entirety steep or having bad soils. The Swazi were allocated 38% of all land and at least 42% of the best soil for agriculture, in Classes AS and BS.

Control of stock diseases has been strict since 1910, when cattle branding and dipping were made compulsory. More than 2,500 Swazi owned iron ploughs by 1914 and at least three North American improved strains of maize were widely planted by 1918. Pioneers such as A. Miller and J. Fullerton began to talk about the irrigation potential of the Lowveld and the former undertook the first methodical cattle-ranching in Swaziland at Natalia (S8) near Big Bend as from 1912. Ever since then the biggest ranches have been established on sweetgrass parkland with SL and R and CL sets in preference to other soils and vegetation types, provided water is near or can be supplied.

(6) RANCHING WITH EXOTIC CATTLE AND PLANTATION CROPPING 1920-1930:

Abortive attempts to achieve a satisfactory mixed breed by crossing Nguni cows with Friesland, Shorthorn, Hereford, Aberdeen-Angus and Devon bulls were made between World

War I and the slump. Most ranchers then cut their losses and reverted to Africander-Nguni rearing. Beef cattle were first sent to Johannesburg in 1920. They headed the catalogue of exports until displaced by asbestos in 1940.

More lasting in its effect was an increase of cash-cropping and its introduction among the Swazi during this decade. Dark aircured pipe and snuff tobacco in the Cool Middleveld on Mooihoek and Malkerns series, and cotton mainly it would seem on O and P set sandy soils in the Lower Middleveld, yielded record total harvests just prior to 1930. Cotton did not climb again to the same tonnage until 1954 and the tobacco peak (nearly 700 tons of leaf in 1928) has not been topped yet. Agricultural research began in 1926 at Aird (M5), where R.C. Wood undertook cotton variety trials.

(7) GRADUAL REALIZATION THAT BETTER FARMING RAISES LIVING STANDARDS 1930-1950:

When the shock of the depression had worn off, and after prompting by a Swazi deputation to King George VI, the colonial government turned its attention in 1943 to purchasing farms and allocating Crown Lands for a "Native Land Settlement" project (NLS). Alas, this ambitious scheme fell on the rocks of austerity after World War II. But there had also been a lack of identification with the project's aims by Swazi being settled, and selection of poor soils for arable blocks. Neither soil maps nor any other basic environmental data were gathered together, before or during the implementation of NLS. Out of 580 square miles only about 30 square miles of fields had been laid out for 2,000 registered families by 1955, when NLS terminated and was absorbed by the extension division in the Department of Agriculture. The spadework of Pim (1932) deserved a better sequel.

Nevertheless, an appreciation that land use needed planning if the maximum benefits were to be derived by the maximum number of farmers had taken root. This was to have sequels after 1950.

The Swazi authorities had not been required to ratify the partition proclamation and before NLS protested against it in petitions to London on four occasions. After NLS some of the sting was withdrawn temporarily from the lost-lands problem, and it became clear to Swazi leaders that not merely extension of "Native Area" limits but gradual agrarian reform was needed to better the lot of the people. In 1950 the first of several decrees by Sobhuza II relating to soil conservation, protection of marshes and sponges, dam-building and veld-burning was promulgated.

Further signs that general improvement in rural conditions could be expected from national participation in food production schemes were afforded by wartime maize selfsufficiency campaigns (not maintained afterwards) and by the successful, if very small, dairy industry started in 1937, based on Manzini butter factory. Soon more than 100 cream separating depots were scattered over CNL, supplying the factory weekly. They have proved most popular in the poorest parts of the country with road access, notably the Western Lowveld, adding a much greater percentage to the cash income of inhabitants there than in places with large areas of Class AS or BS land. Out of 148 depots operating over the past decade 62 are in the Western Lowveld and another 35 in the Lower Middleveld.

(8) THE PERIOD OF DIVERSIFICATION AND MODERNIZATION 1950-1960:

Major irrigation schemes were inaugurated, growing rice and citrus and after 1957 sugarcane. Dryland cotton revived. Concurrently in the Lowveld better roads, new bridges and the elimination by 1954 of endemic malaria led to selective migration into that region. Highveld afforestation took place.

Anti-erosion measures stabilized fields on CNL. Basically the grass contour-strips 6 feet wide at 4 feet vertical interval, compulsory by edict of Ingwenyama Na Libandla (1953), ensured soil and water conservation on all African-owned arable. Between 1948 and 1956 junior agricultural extension personnel, using artillery rangefinders then Dumpy levels, brought about the protection of 330,000 acres of cropland and young fallow. In 1952, the zenith year of this activity, almost 70,000 acres of "stripping" was done by about 70 Land Utilization Officers.

Farmers Associations grew. Good seed and a modicum of fertilizer was bought collectively. Agricultural industries appeared on the scene – sugar, chipboard, woodpulp, canned pineapple. Soil and botanical surveys began in 1955. River gauging stations were constructed 1952 onwards.

The soils chosen for capital-intensive agriculture and sylviculture were of paramount importance in determining the course of each new venture. The main defect on irrigation sohemes has been inadequate provision of drainage to dispel surplus water in Sol Lessivé and Vertisol areas (H ZL K V sets), sometimes leading to salinization – creation of Y or QL set. For pine trees and soil interrelationships see pages 196 and 256.

The impact on Swazi fields of modest fertilizer dressings, usually less than 40 pounds of elemental NPK per acre, was remarkable during this period. Many demonstration plots yielded over 3,000 pounds per acre maize grain, whereas hitherto 1,800 pounds per acre had been reckoned excellent. In particular the widespread O and P set Middleveld soils, as well as QH set, were stimulated and became more esteemed than before as cultivated panels. A little NPK fertilizer on almost any Lowveld soil greatly increased raingrown cotton yields – see page 35 of Murdoch and Andriesse (1964).

(9) REORGANIZATION OF FARMING AND PLANNED USE OF SOIL RESOURCES 1960 ONWARDS:

The present is a time of profounder changes in agricultural mores than any previous period. All major schemes are either adequately founded now on results of research or else somebody is quick to suggest what surveys and trials should be put in hand to back them. FAO and UNICEF, Freedom From Hunger and Oxfam have lent their weight to rural betterment programmes. And yet many small farms, particularly in isolated portions of CNL, remain untouched by the surge of development. This seems inevitable, not least because the soil resources of such marginal farming localities will often be unfit for intensive cash cropping over wide areas.

Two planks in the Ministry of Agriculture's land use policy are (a) provision of know-how and capital, the latter from the Credit and Savings Bank set up in 1965 with R 700,000 worth of unrecallable assets, to all farmers who can show that they will benefit: and (b) the passage of at least 400 Swazi farmers per annum through the Short Course Centre opened in 1966 adjacent to Luyengo Agricultural College. Most government revenue (both local and from Britain, the World Bank and other sources) continues to be used to improve communications and to educate both children and adults. Hidden benefits agriculture derives from these endeavours are by no means slight.

In terms of soil, Coulter (1968) advises anticipatory irrigated trials on some sets not now used at all for irrigation, but having large riparian areas that could be physically commanded with ease, notably JL: and also experiments to find out how best to manage other soils with rather low ratings -- H K SL ZL sets in the Lowveld, to which might be added O and JH in the Middleveld. The first of these attempts to think beyond current irrigation schemes in order to have ready research results when irrigators catch up is being devoted to the suitability of SL set on the Lowveld Experiment Station for a range of crops and irrigation methods.

Notwithstanding this concentration of research on problem soils – which is certainly needed – the prime objective in soil utilization is now being seen as a channelling of the soundest, most profitable farming systems to the best land (especially among the 650,000 acres of Classes AS and BS) with extensive agriculture elsewhere, mostly ranching. Lessons of the past epochs in Swaziland's agroeconomic history are thus in part negative, since so many activities were examples of what not to do, as hindsight indicates, but in part highly positive, for soil limitations are even more important to recognize than trouble-free land.

FURTHER POINTERS TO THE FUTURE:

The variables referred to on page 263 can now be taken up. They affect answers to the second question posed – What are the geographical inferences of the soil and land capability classifications? Page numbers bracketed below refer to previous exploratory comments on these issues: they are

The Swazi traditional hegemony
Type of farming, mixed (page 54) or specialized
The fertilizer outlook (pages 139 to 143)
Size of holdings and of management units
The rural-urban imbalance of earning power (page 45) and migrant labour (page 65)
Core expansion (page 70) and increasing nonagroforestal land use (page 174)
Soil conservation, land planning and the technical proficiency of farmers and foresters
Land tenure (page 42)

THE SWAZI HEGEMONY:

The feelings of reverence and patriotism which the people have for Live, the cradle of the modern nation, mean that if land use changes are to be put in practice this must be one of the first exemplary areas where the new in agriculture replaces the old, in order to achieve the maximum impact on the country as a whole. The fact that there are over 35,000 acres of Class AS plus BS within the Ezulwini-Malkerns-Umtilane heart of the West-Central Core makes it even more imperative that fuller use be made of this excellent resource base.

Water, communications, power, labour force all exist to complement the soil potential. Every factor, indeed, which Fair (1965) takes as a prerequisite for the continuing development of a Core is present. Live could be the launching-pad for more diverse and interconnected industrial and agroforestal progress than is to be found almost anywhere else in Southern Africa, provided Swazi leaders signify their desire for it.

Conversely if Live is neglected in the near future – or becomes mainly a museum of tribal custom (preservation of the traditional must have its due place, of course) – the overall acceptance of new ways is bound to suffer a setback. And ironically should the neglect be at the expense of bolstering the three resource-frontier Cores – North-West, North-East and East-Central – which are the parts of the country least bound to the hegemony, the have versus have-not (and probably youth versus age and rank) confrontations will be exacerbated.

MIXED OR SPECIALIZED FARMING:

Diversification is a watchword in Swaziland today. Can one then foresee truly "mixed" farming as being just around the corner, with rotations of crops in predetermined optimal cycles and complete integration of livestock with arable production? Experience elsewhere in Africa suggests that this is unattainable for several reasons. Compared with the European or North American prototype mixed farming zones -- even in those continents not a large proportion of the total area -- there are either more climatic fluctuations or smaller or farther markets or simpler dietary habits or less capital available for setting up medium-sized farms (as opposed to large management units or smallholdings) or combinations of these. Moreover if mixed farming is understood to include prominently crops for stock, it is clear how woefully Swaziland trails behind many African countries, with her 2,000 acres at most of improved pasture and almost no haymaking or stall fodder provision. Zero grazing is simply unknown.

One or two farmers here and there, especially in the Upper Middleveld, could attain a very balanced economy from many lines of output, but the farming systems that will be easier to extend from their present footholds will undoubtedly be the specialized ones, and all the signs are that they will be just as profitable. The specializations that are relevant include most of those for which land capability is already being assessed, notably irrigated sugarcane, irrigated citrus, irrigated or raingrown cotton with subsidiary annuals, raingrown pineapples and conifer afforestation.

The near-monoculture of cotton, in particular, on dryland farms is unlikely to be a really longterm proposition, but under irrigation cotton every year can be recommended provided precautions are taken -- strict observance of the close season (August to October), adequate fertilizer dosage and efficient pest control.

The rotation of food crops and cotton under irrigation may be thought of as "specialized" in another sense, for it involves high input, high levels of skill and high returns. Not every farmer would succeed in it -- far fewer than might be expected to do well, at a lower economic level and in the right climatic region, with dryland maize and beans and cattle-rearing on unimproved pasture. The most meaningful division is thus likely to continue to be between advanced farms, both mixed and specialized, and the ruck of subsistence homesteads and holdings that are marginal producers for one reason or another.

THE FERTILIZER OUTLOOK:

Since 1960 data on imports of artificial fertilizer (none is manufactured locally) have been hard to come by. Trade returns have usually given higher estimates of tonnage than agricultural censuses. However, enough is known for an attempt to be made, in Table 72, to adduce 1960 and 1967 NPK consumption -- in the latter year on average about 60 pounds per acre of 8:3:2 on fields not planted to sugarcane. And from Table 20 the ideal fertilizer treatment (an unweighted mean) would appear to be of the order of 300 pounds per acre 7:9:4 for maize and related annuals.

Over the past few years on CNL fields there has been an alarming relative drop in the P applied, but a gratifying increase of N. Cane growers have cut down on K since 1960. Taking their 13:6:5 ratio as optimal (it must be conceded that their yields are high by world standards) and adding the recommended application for maize, one arrives (see Table 73) at a rough idea of the leeway which farmers, mainly on CNL, still have to make up to reach the desired NPK input. On a national scale this would involve spending nearly three times the amount on fertilizer

TABLE 72

NPK Consumption 1960 and 1967

Year	Crops	Acres	FERTILIZER IMPORTED Tons	lb/ac	Composition (a)
1960	Sugarcane	17,000	8,000	940	13 : 5 : 10
1960	Other ITH	63,000	5,000	160	9 : 3 : 4
1960	CNL (b)	200,000	1,000	10	2 : 7 : 3
1960	Total	200,000	14,000 (c)	100	10 : 4 : 7
1967	Sugarcane	38,000	15,000	790	13 : 6 : 5
1967	Other ITH	67,000	7,000	210	8 : 3 : 2
1967	CNL (b)	265,000	2,000	15	6 : 5 : 3
1967	Total	370,000	24,000	130	11 : 5 : 4(d)

NOTES:

(a) Elemental nitrogen: phosphorus: potassium in artificials. Dung (kraal manure) is excluded.

(b) Except for less than 500 acres sugarcane.

(c) Compare earlier amounts – 3,000 tons in 1953 and 1,000 tons in 1946.

(d) Throughout Africa the mean composition was then about 9:5:6 – Food and Agriculture Organization (1968).

TABLE 73

NPK Recommendation 1967

Crops	Acres	FERTILIZER TO APPLY Tons	lb/ac	Composition (a)
Sugarcane	38,000	15,000	790	13 : 6 : 5
Maize and Others	332,000	49,000	300	7 : 9 : 4
Total	370,000	64,000	350	9 : 8 : 5

(a) Elemental nitrogen: phosphorus: potassium.

as in 1967 – about R 8 instead of R 3 per acre of cropland. But on CNL alone more than 20 times the present applications are apparently called for.

Kraal manuring must reduce the leeway; but not perhaps by much. The composition of local dung and the quantities spread can only be guessed. If the national average were one third the rate on maize demonstration plots (see page 223) it would be 330 pounds per acre annually. This amount is approximately equivalent to 60 pounds per acre of 9:2:14 annually, using Natal data of cattle faeces and urine analyses – Malherbe (1962). Thus to actual 1967 dressings of NPK artificials a third or a half might have to be added in order to include organic fertilizer as well, although the relative depression of phosphorus in dung means that its increase in 1967 from this source might have been as little as one sixth. With "ideal" 1967 applications dung at the present rate would account for less than 20% of all NPK given. Even if these calculations are wrong by a factor or two, farmyard manure is seen to supplement other plant foods rather than be the major source of N or P.

Currently commercial fertilizer distribution points are 140 country stores well scattered throughout the kingdom. Some, however, have very large hinterlands, exceeding 200 square miles, and so do not serve the remote farming areas, particularly in CNL. Government abdicated from fertilizer "trading activities" in 1960 but it is for consideration whether extension sub-districts should renew their agency, in the limited sense of establishing depots where shops are lamentably far apart to ensure that supplies penetrate to every fulltime farmer.

Farm profits will become an even closer reflexion of land capability once cash to buy NPK fertilizer (and calcium, magnesium, zinc) in the quantities needed is circulating among rural Swazi. That day could be not too far off. Already in 1967 about 5% of all homesteads in the RDA nearest Manzini (Bekinkosi) were using dolomitic lime where nobody had heard of it in 1962.

FARM SIZE:

The cultivated land on an average ITH farm amounts to 70 acres (page 45) whereas in CNL 8 or 9 acres is the mean area of tillage per homestead. A sample survey being conducted by R. I'Ons is revealing that the Middleveld has least ploughed fields per CNL farm (about 7 acres) and the open expanses of the Lowveld most (over 10 acres). The same research is clarifying the amount of fragmentation within CNL cropland, and the average homestead is found to have 3 scattered panels cultivated. Consolidation of all farms is plainly an aim which will demand great efforts from the people, their chiefs and extension workers. Probably it will take a long time to achieve.

The farm sizes to have as targets for advanced agriculture will depend entirely on economics. The related question "What should farm income be?" needs answering first. On CNL R 300 per annum nett profit from raingrown farming operations is a possible choice as a basis for calculating land requirements. The statutory minimum wage of many urban unskilled workers is R 200 per annum so placing farm earnings much below R 300 would be senseless: there is no incentive among progressive Swazi to stay on land that yields so little. On the other hand an increase to R 400 or R 500 per annum is coming close to the income small-scale irrigators are enjoying, and this too becomes unrealistic, needing too much land and work per family to fulfil the output.

Venn (1968) gives acreages per holding that would be required to make R 300, assuming that mean yields of crops are at current demonstration plot levels*, that there is no im-

*An approximation: rounded yields taken include maize 1.2 tons per acre grain UM and LR, 0.8 HV and LM, 0.4 WL and EL and seed cotton 0.5 tons per acre LM, 0.4 UM and LR, 0.3 WL and EL.

proved pasture, that overwintering of stock is however achieved by feeding crop residues and supplements of urea, molasses and minerals, and that all ploughing is done with oxen, whereof one is required per 2 acres cultivated. In fact more than 20,000 acres or 7% of CNL cropland are already tractor-ploughed, so the grazing requirement can be reduced proportionally. And while no revolution in mechanized farming is foreseen, a gradual increase in the number of CNL tractors will surely take place, especially in the flatter localities. Subtracting 10% for tractor tillage from the veld data of Venn (1968), the nett requirements are of the following order (Classes AM to EM but not FM) — Highveld 70 acres, Upper Middleveld 60 acres, Lower Middleveld 80 acres, Western Lowveld 120 acres, Eastern Lowveld 100 acres and Lubombo Range 60 acres.

An average farm of 80 acres, with 10 acres ploughed and 70 acres grazing, does not seem to be a bad foundation for later arithmetic regarding rural population capacity, see page 285. Whether the pasturage is owned individually or is communal will probably not matter much while it remains unimproved. As can be seen from the Land Capability Map some parts of the country have small patches of good soil encircled by grazing land — often 40 to 150 acres of arable, which would need 300 to 1,000 or more surrounding acres of veld. But the main areas of high-quality cropland are so large — more than a square mile — that a separation of pasture from arable will be obligatory, otherwise the former will have too great a share of the best soils. At such places split holdings might have to be retained, with community grazing attached, as now, to several score homesteads but with the arable panels consolidated.

Soil rating and slope category descriptions in Table 38 refer to rather-better-than-average landholders working commercial farms and forests to a "reasonable standard" — see page 175. The land capability classification is also, however, fitted to a broad middle size category of rural property possessing roughly 70 acres plus of dryland fields or 40 acres plus irrigated.

With Coulter (1968) and colleagues, the conclusion has been reached that when soil surveys deal with management units that are very small, soil ratings should be interpreted more strictly than when bigger farms and estates are being examined. Moreover for the largest well-run management units, whether individual holdings or settlement schemes, exceeding say 300 acres irrigated or 600 acres dryland fields, some relaxation of soil rating sanctions is permissible. An estate with 1,500 acres of which 80% is Class AS to CS and 20% Class DS and ES is obviously at a great advantage compared with a similar block of smallholdings, say 10 acres each, wherein 30 families (perhaps more, depending on the configuration of the poor soil) would be farming land that could not be expected to give them their livelihood.

Terms used to describe the ratings might be staggered as in Table 74, the MEDIUM column being that to which published ratings refer. Alternatively, as A.V.R. Dicks (1968, private communication) has suggested, on settlement schemes Class AS could be reserved for single plots while Classes BS to DS form blocks of estate-managed fields. Yet another possible course would be to restrict each individual smallholding to cropland of which say less than 10% was Class CS or worse, while allowing large units to contain, in their total cultivated area, up to 30% or 40% of Class CS and worse.

Regarding optimum size of the most intensively farmed, specialized plots, the Kenyan experience — Ruthenberg (1966) — is that irrigated smallholdings have yielded returns, both in additional marketed production and in revenue to the treasury, which are double the benefits of low density resettlements. The best of the latter projects yields 9% annually to farmers, 4% to government in added income. All 20,000 acres of irrigation at Mwea (mainly rice) and Perkerra (mainly maize, beans, onions) yield 18% and 7% under those heads. Tea smallholders at Ragati

TABLE 74

Soil Ratings According to Size of Management Unit

RATING (a)	SMALL (b)	MEDIUM (c)	LARGE (d)
A	Good	Good	Good
B	Fair to Poor	Fair	Good
C	Very Poor	Poor	Fair
D	Not Advised	Very Poor	Poor
E	Waste	Not Advised	Very Poor
F	Waste	Waste	Waste

NOTES:

(a) On suitable slopes i.e. all six add up to Class MS.

(b) Say 2 to 40 acres irrigated or 3 to 70 acres raingrown crops. Gardening on tiny areas to supplement income is outside the scope of these soil ratings. Many of the hundreds of CNL vegetable plots, on average about 0.5 acre in extent, are irrigated, manured and cared for so diligently that the high standard of management precludes comparison with ordinary farmland.

(c) Say 40 to 300 acres irrigated or 70 to 600 acres raingrown crops.

(d) All acreages exceeding the upper limits of (c).

are doing even better. The ex-Director of Settlement in Kenya, A. Storrar (1968, private communication) underlines the fact that it is particularly on the better soils that the cost-benefit ratio of new investment in high density schemes is superior.

A gross area of 20 acres per farm seems ample for calculations involving future intensive agricultural development in Swaziland. This is one fourth of the area taken for the average more extensive farm – page 272. It may even err on the high side, as some Vuvulane plotholders with 8 acres each are making a very good living.

RURAL-URBAN COUNTERATTRACTIONS:

From the countryside to the towns the traffic of persons and families on the move is almost entirely one-way at present, although this is a recent phenomenon. Up to 1960 or even 1963 the urban areas did not have the pull that they now exert (witness their low populations until the last few years) and it was possible to observe distinct new rural communities being built up by e.g. cotton planters in the Lowveld and Lower Middleveld or seekers of maize-growing land among virgin O set soils north of Manzini, outwards to beyond Luve (K6).

If these rural interchanges continue they will become increasingly puny compared to the townward flow, and for this agricultural planners can be thankful – provided of course that the towns are ready to receive the newcomers with work and amenities, a topic outside the scope of this memoir. For the good of both cities and rural areas, some way must be found of reducing migrant labourers' oscillations from "home" in CNL to the compounds of large estates or to lodgings in the shoddier suburbs sprawling around the towns. More married quarters for employees, more on-the-job training and other socioeconomic advances are recognized as essential by Government and by enlightened private employers. The latter will certainly, according to present policies, be encouraged to contribute to the country's development in this manner.

The choice will then lie before about 30,000 rural homestead heads – whether to stay and farm or whether to go and sever most ties with the countryside, as many people in Mbabane and Manzini already have done. Over the next generation it will be remarkable if more than a small minority elect to continue their seasonal meanderings. How many the nation can afford to absorb into city life is beyond the terms of reference set here, but how many could be accommodated on, or should be induced to remain on, farmland is discussed later, page 287.

CORE EXPANSION:

The Primate Core will have to consolidate its position and develop further internal connectivity and a greater density of industrial and agroforestal activities before it extends its boundaries appreciably. Routes out of it to Mankayane and Sidvokodvo, and those two villages themselves, might soon be assimilated, however, the former by the push of forestry south from Usutu Pulp, the latter by virtue of its railway marshalling yard and nodal status since the new road link to Hlatikulu and Goedgegun was forged in 1967.

All three subsidiary Cores are in much the same predicament, though with fewer interior gaps in their economic fabric (except the East-Central). The North-West could take over the Lomati valley with ease once irrigation is afoot there at more points than presently. Also, given bridges across the Umbeluzi to Ngomane and across the Usutu to the Mapobeni and Little Bend sectors of the right bank, the North-East and East-Central Cores respectively could disseminate their irrigation techniques on more CNL. The Mlawula (H0) and Phuzumoya (Q8) areas have been mooted as future industrial townships (indeed Mlawula has a few factory stands already laid out) but their development does not appear to be imminent.

If the existing Cores are not going to do more than settle and shake out their fringes a little in the next few years, what of the prospects for a fifth Core? They are undoubtedly best in the South-West, centred on Goedgegun, with the mainstay timber and possibly some of the few mixed farming concerns that will be practicable in the country (see page 269), growing maize, beans, tobacco, groundnuts and on a small scale irrigated pasture, and rearing dairy cattle — probably Jersey herds. But prerequisites will include better communications and changes in attitude there among many people — migrant workers and some "poor white" inhabitants. Plucking the latter from their desperate straits to work for well-run large concerns is one solution, and the entry of CDC as the gum-planting vogue continues could mark a significant juncture in the affairs of Goedgegun and vicinity.

The conurbation that is likely to grow along the axis Manzini-Lobamba-Mbabane will swallow up several thousand acres of high-quality soil, it can be confidently forecast, by the end of the century. But this is a long ribbon of developable land — more than 30 road miles from Makolokolo (J3) to Helehele (M5) — and there should be plenty of room too for intensification of agriculture, some of the farming systems being geared to feeding the string of towns.

Avoidable use of the best agricultural land for housing, industrial estates, communications, game sanctuaries, etc. is to be deplored. Away from the Manzini-Mbabane corridor it should be feasible to retain for rural communities almost all ground eminently suited to farming. Exceptions will be the environs of three places with 2,000 population or more in 1966 — Stegi, Goedgegun, Hlambenyatsi — which are virtually surrounded by Classes AS to CS, and also villages here and there whose expansion cannot but be on good arable land.

FARMING STANDARDS:

Further assumptions made are as follows:

(a) Soil conservation works will be maintained on arable land and increased on pasturage so that there is no worsening of the effects of erosion and devegetation.

(b) Basic land use planning in the subsistence sector will continue — the division into arable, grazing and (often strung out as an embryonic street-village between the two) the residential area. Resiting some homesteads is generally involved, e.g. as successfully counselled by Dicks and Xuba (1954) at Palati (S0) and by other extension workers since then at various places throughout the country.

(c) More sophisticated farm plans will be available, at government expense, to cash croppers who desire them and will use them. On CNL clients for this kind of planning will continue to be individuals and small groups probably, as no existing entire RDA or larger tract warrants the expenditure of time and staff. Quite complex area planning partway between farm and regional levels, may however prove useful to portions of RDA (e.g. of Bekinkosi, Nkweni), to advanced chiefdoms or to local administration units of parish type, once they come into being.

(d) The "good average" husbandry currently being practised by perhaps 5% to 10% of all rural homesteads will, by extension precept and by example, become the norm, so that future standards of farm management are more uniform and the word "average" can be used with greater significance, there being a much less skew distribution curve along the axis excellent to poor than there is today. A need for different land capability terminology in respect of small and large farmers would still be felt. Indeed Table 74 could be applied even more effectively to holdings with more nearly constant management.

Some of the above may seem rather optimistic prognoses, but no rigid timetable is attached to their achievement. In the last 20 years enormous changes have taken place everywhere except in the remotest corners of the kingdom. Why should there not be equally rapid evolution to the 1980s and beyond? This is no idle speculation, in view of the quintupling of primary and secondary school pupils from 13,000 in 1948 to 70,000 in 1968 and the proportionately even greater emphasis which is about to be placed (see page 65) on higher education and vocational training.

LAND TENURE:

Emotions are stirred by this problem as by no other in Swaziland. Is the "right of avail" to land which is in the gift of a hereditary chief sufficient security in this day and age for bona fide advanced farmers? Should ITH, or large portions thereof, be expropriated?

Taking present CNL first, the writer is convinced that the nettle should not be grasped, at least as yet. The political climate is calm and favours the status quo. Moreover, if the authorities were to alter overnight the status of all Swazi farmers to individual tenure landowners nothing at all would be gained in the direction of agricultural advancement, unless every change in attitude which CNL dwellers must undergo can be induced to take place as well.

Rather than a wholesale tenurial revolution, the main things to ensure will be that the initiative of everyone, commoner and aristocrat alike, is not stifled and that those who can and want to are permitted to progress materially to Master Farmer level. This rural meritocracy is already tacitly regarded as a government objective. The King wishes to curtail the stewardship of chiefs over some Lifa land and is seeking a means, on CNL that has never been alienated, whereby agriculture might be stimulated within a framework of community development — Sobhuza II (1968).

Several leading parliamentarians would welcome long leaseholds in Swazi Area at suitable places and for suitable persons. It would not greatly matter for a decade or two whether the titles other people have to their fields and homes are held by tribal elders in their heads or are registered at a deeds office.

Admittedly no details of possible lessee agreements have as yet been worked out (although ad hoc arrangements have already been arrived at with e.g. some Swazi irrigators in the Ingwavuma basin) but if the leasehold principle is accepted no further and more vital incursions into tenurial reform appear to be called for immediately. Of course, the aspirations and actions of a majority of the next generation of homestead heads may cause a land ownership crisis, if that is what there is to be, to come before this century's end — it really is impossible to foretell.

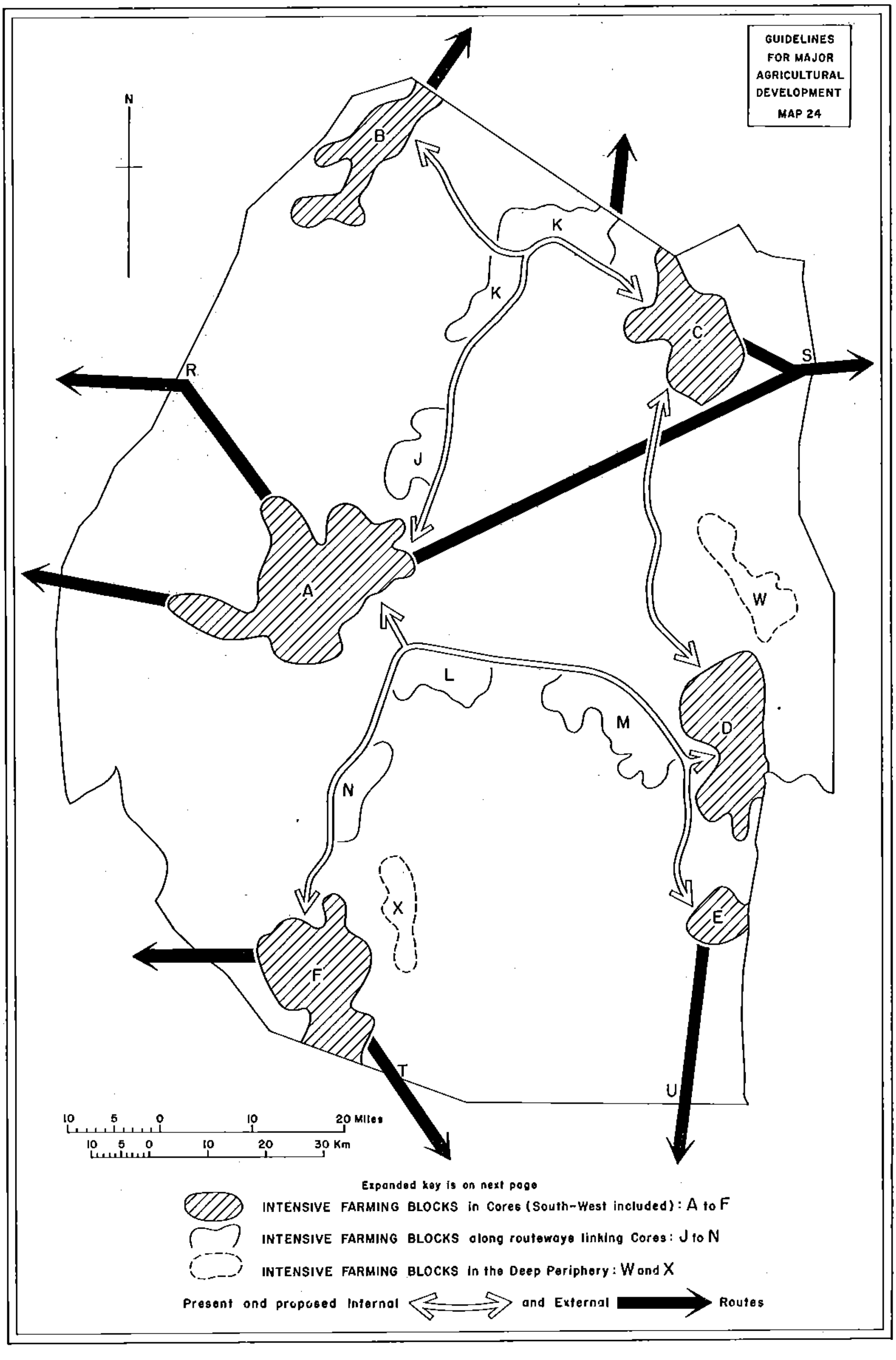
As to procuring more ITH, that is mainly a political matter outside the purview of this memoir. Reference to the Land Capability Map will, however, show whether farms which the Swazi Nation wishes to incorporate are suited to the purpose envisaged. Many overspill grazing grounds, for instance, could be provided and in the writer's opinion should be, to help redress old wrongs, with adequate compensation to freehold title holders and other safeguards. But there are far fewer underused (and therefore cheap) private properties with a high potential for irrigation or intensive raingrown cropping.

NEW USES FOR LAND:

Turning now to the second question put on page 263, and to soils and Land Classes, Map 23 depicts generalized areas, each more than one square mile in extent, of the best soil —

To page 280


GENERALIZED LAND CAPABILITY
MAP 23
Raingrown Cropping plus Irrigation Where Needed
30 INCHES ISOHYET
Irrigation Essential for Intensive Agriculture
N
Hhohho
Havelock
Tshaneni
Bulegana
Vuvulane
Tambonkulu
Mbabane
Waweni
Lobamba
Siegi
Manzini
Bunya
Malkerns
Sidvokodvo
Sipofaneni
Mankayane
Big Bend
Hlatikulu
Nsoko
Goedgegun
Hluti
Golela
10 5 0 10 20 Miles
10 5 0 10 20 30
Classes AS and BS
Good to fair soils on gentle to moderate slopes
In Cores
In Periphery


GUIDELINES
FOR MAJOR
AGRICULTURAL
DEVELOPMENT
MAP 24
N
B
K
K
C
S
R
J
A
W
L
M
D
N
X
E
F
T
U
10 5 0 10 20 Miles
10 5 0 10 20 30 Km
Expanded key is on next page
INTENSIVE FARMING BLOCKS in Cores (South-West included) : A to F
INTENSIVE FARMING BLOCKS along routeways linking Cores : J to N
INTENSIVE FARMING BLOCKS in the Deep Periphery : W and X
Present and proposed Internal and External Routes

KEY TO MAP 24 – GUIDELINES FOR MAJOR AGRICULTURAL DEVELOPMENT

Surfaces, Nodes and Networks with their Possible Future Roles as Locations for or Stimulants to High-Value Commercial Farming

INTENSIVE FARMING BLOCKS IN THE CORES (South-West included) – generalized Classes AS and BS from Map 23

- A Primate West-Central Core and fringes: intensified dryland cropping and irrigation: also afforestation
- B North-West Core and fringes: intensified dryland cropping and irrigation: also afforestation
- C North-East Core (main part): intensified irrigation
- D East-Central Core (main part): intensified irrigation
- E East-Central Core (southern appendage): intensified irrigation
- F Possible South-West Core: intensified dryland cropping and limited irrigation: also afforestation

INTENSIVE FARMING BLOCKS ALONG ROUTEWAYS (existing and new) linking Cores – generalized Classes AS and BS from Map 23

- J Bekinkosi and Luve: intensified dryland cropping
- K Lower Komati Valley: spread of irrigation upstream from west fringe of East-Central Core
- L Sidvokodvo and Khumba and Lesibovu: intensified irrigation and limited dryland cropping
- M Sipofaneni and Mapobeni and Little Bend: spread of irrigation upstream from west fringe of East-Central Core
- N Nyonyali and Busaleni and Nkweni: intensified dryland cropping and limited irrigation

INTENSIVE FARMING BLOCKS IN THE DEEP PERIPHERY – Classes AS and BS

- W Stegi and Palati and Jilobe: intensified dryland cropping
- X Tonjeni and Ntshingila and Kagwegwe: intensified dryland cropping and limited irrigation

CHIEF FRONTIER POSTS existing and proposed

- R In the west: Oshoek-Johannesburg link
- S in the east: Lourenco Marques link at Umbeluzipoort: alternative is Namaacha, 15 miles further north
- T In the south: possible new connection from South-West Core via Pongola irrigation scheme to Durban.
- U In the south: Golela rail terminus, another Durban link

PRESENT AND PROPOSED INTERNAL ROUTES – highly generalized

AJKB, AJKC, ALMDE and ALNF are possible trunk road realignments: the most important roads away from the Primate Core will be CD (along which limited dryland cropping could take place) and BKC

PRESENT AND PROPOSED EXTERNAL ROUTES – highly generalized

Main 3 in future could be AR westwards, AS eastwards and ALNFT southwards: railhead at U would have relatively minor role if Durban motor traffic switched to new frontier crossing T

SMALLER INTENSIVE FARMING PROJECTS would occupy parts of gaps between routes indicated, especially at W and X, and in western lacunae forestry would expand and some pasture would be improved. Mineral, power, urban and other developments are not taken into account specifically, but foci and routes shown will, with a few modifications and additions, fit new structures expected in those sectors of the economy.

Class AS plus BS — in an attempt to produce from the complicated pattern of the 1:125,000 Land Capability Map its essential message, in a rather more refined manner than by the sub-catchments of Map 18.

Areas where the most intensive agriculture should be promoted become clearly apparent by taking Map 23 and constructing Map 24 from it. In the process agroeconomic criteria that are consequences of the discussions under the last 8 cross-headings were utilized, as well as purely pedological and physiographic evidence. Hereafter these areas are termed Intensive Farming Blocks (IFB).

The IFB comprise the three Middleveld "eyes" — marked A and B and F on Map 24: the good soils in and near the North-East and East-Central cores — marked C and D and E: Bekinkosi — marked J: the Lower Komati riverain — marked K: a string of localities along the Usutu in the tongue of Lowveld at Khumba-Lesibovu and downstream beyond Sipofaneni to Mapobeni and Little Bend — marked L and M: a lesser succession of choice areas up the Assegai valley — marked N: Stegi to Jilobe — marked W: and Kagwegwe with Tonjeni — marked X on the map.

Acreages of Class AS plus BS in each IFB are listed at Table 75. Perhaps the most meaningful "order of merit" to place them in is according to Class AS acreage — see Table 76. On that basis none of the 13 IFB has less than 4,000 acres gross of the best land.

In their areas of dispersed settlement the IFB possess 226,000 acres of Classes AS and BS, and in toto 240,000 acres. Although agricultural development of the most intensive kind will not be confined to those two Land Classes, and in places may not reach some of the better arable land that is tucked away e.g. behind the Cislubombo Ridges or within the pine forest perimeters (the south of B and the west of A on Map 24), the simplification that high value crops will be coextensive with the 240,000 acres is perhaps admissible, at least as an anchor for arguments on future IFB land use.

Nearly 40,000 acres (dispersed plus nucleated) of Classes AS and BS in the IFB are currently served by the three major canals, and for the most part planted to sugarcane, rice and citrus. Another 90,000 acres lie below the 30 inches isohyet, in the Lowveld, and will have to be irrigated to aspire to the status of intensive cropping sectors. These are gross acreages. The nett area to which water can be brought will be about 15% less. This leaves as irrigable, in the light of water supplies, an area which probably could not exceed 190,000 acres (giving a total of 300,000 acres — see page 221) and might be as little as 10,000 acres (giving a total of 120,000 acres) throughout the rest of the country, including the Primate Core outside the Malkerns canal command (i.e. essentially the Ezulwini and Umtilane valleys), the Lomati basin and Busaleni-Nkweni. Raising the low national estimate half as much again to 180,000 acres (some of which would be at risk in very dry years) and allocating those Middleveld IFB 40,000 acres would leave 30,000 acres for deeper Periphery irrigation schemes.

Such an arrangement would mean too that some 90,000 acres of IFB rainfed cropping would be envisaged, much of it in the Upper Middleveld though including over 10,000 acres of the Lubombo Plateau. The IFB take up 69% of all Class AS and BS land in the existing Cores, and 27% of the Periphery's AS plus BS. They occupy 16% of the four Cores total area but less than 4% of the whole Periphery.

These acreages and percentages are not hard and fast, of course. As regards water use and soil to irrigate it would be well to compare several models of the eventual situation to ascertain which is the most feasible. For an American example of this kind of empiricism see Runkles and Smerdon (1965).

Routeways shown on Map 24 are diagrammatic, and while some could easily be made

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TABLE 75

Land Capability by Intensive Farming Blocks

INTENSIVE FARMING BLOCK (a)	A	B	C	D	E	F	J	K	L	M	N	W	X	All
Total thousand acres	105	39	74	68	20	70	18	38	14	38	12	27	17	540
Class AS %	35	39	27	23	30	24	35	35	30	37	38	39	37	32
Class BS %	7	2	35	18	34	9	12	9	0	6	0	4	9	13
Class AS + BS %	42	41	62	41	64	33	47	44	30	43	38	43	46	45
Class AS thousand acres	37	15	20	16	6	17	6	13	4	14	5	11	6	170
Class AS + BS thousand acres	45	16	46	28	13	23	8	16	4	16	5	12	8	240(b)
Cl AS+BS thousand acres: Dispersed CNL	22	10	10	9	2	12	6	10	2	11	5	6	7	112
Dispersed ITH	17	6	36	18	10	9	2	5	2	5	0	3	1	114
including pine forests	2	3	0	0	0	0	0	0	0	0	0	0	0	5
including canal commands (c)	8	0	17	7	0	0	0	2	0	0	0	0	0	34
The Four Cores 1968 Dispersed	30	7	30	19	6	0	0	4	0	6	0	0	0	102(d)
Core Fringes 1968 Dispersed	9	9	16	8	6	0	0	11	4	10	0	0	0	73
Deep Periphery 1968 Dispersed	0	0	0	0	0	21	8	0	0	0	5	9	8	51
Nucleated	6	0	0	1	1	2	0	1	0	0	0	3	0	14

TABLE 75 – Continued

NOTES:

(a) Lettering as for Map 24. Blocks are also named in Table 76.

(b) Gross area. By regions EL 95, UM 86, WL 27, LM 13, LR 12 and HV 7. By river basins Usutu 103 (Great Usutu and Little Usutu and Usutu in Lowveld 98, Assegai 5), Umbeluzi 54, Ingwavuma 42, Komati 17, Lomati 15 and Tembi 9.

(c) Three major canal commands of Table 55.

(d) Out of 148 thousand acres of Classes AS and BS in entire Cores – see Table 54.

TABLE 76

Ranking of Intensive Farming Blocks

INTENSIVE FARMING BLOCK		Class AS 000 acres
A	Primate West-Central Core and Fringe	37
C	North-East Core (Part) and Fringe	20
F	Possible South-West Core and Fringe	17
D	East-Central Core (Part) and Fringe	16
B	North-West Core and Fringe	15
M	Sipofaneni-Mapobeni-Little Bend	14
K	Lower Komati Riverain	13
W	Stegi-Palati-Jilobe	11
E	East-Central Core (South Limb) and Fringe	6
J	Bekinkosi Portion of RDA	6
X	Tonjeni-Ntshingila-Kagwegwe	6
N	Busaleni (Portion of Nkweni RDA)	5
L	Sidvokodvo-Khumba-Lesibovu	4

IFB	Class AS %	IFB	Classes AS+BS 000 acres	IFB	Classes AS + BS %
B	39	C	46	E	64
W	39	A	45	C	62
N	38	D	28	J	47
M	37	F	23	X	46
X	37	B	16	K	44
A	35	K	16	M	43
J	35	M	16	W	43
K	35	E	13	A	42
E	30	W	12	B	41
L	30	J	8	D	41
C	27	X	8	N	38
F	24	N	5	F	33
D	23	L	4	L	30

to conform to existing road and rail alignments it may be that two brand-new highways would serve such an excellent purpose that they would be worth constructing (mostly ab initio) despite the great cost. One is Manzini-Bekinkosi-Balegane-Lubisane-Sihoya-Tshaneni (AJK) to supplant the present zigzagging Manzini-Mpisi-Croydon-Tshaneni road. The other is Manzini-Sidvokodvo-Khumba-Mapobeni-Omhlandlu-Ubombo (ALMD), for much of its length along the south bank of the Usutu, rendering obsolete the twisting Helehele-Sipofaneni section. From the vicinity of Lubisane a new link to Ngonini (KB) would have the effect of usefully connecting the Primate Core by one route both to the North-West (replacing the Manzini-Mbabane-Inkaba-Peak-Ngonini connexion to some extent) and to the North-East: the latter Core's southern portion would also be joined to Manzini by the Transterritorial Highway, as now.

What objectives are attained by selecting these IFB and not other segments from among the better arable land? The main advantages would be

(a) Identification of the Swazi heartland with modernity and progress.

(b) Strengthening of the existing Cores of economic activity.

(c) Forging of links between these Cores – and to a fifth South-West one from the Primary Core – which are broader than a mere roadwidth, thus reducing the Periphery from an enveloping matrix to a number of discrete parcels of land.

(d) Easy provision, because development is not dissipated spatially, of all the aids and services which a new advanced farming community will need, from transport and the best possible local markets to handiness for extension work and agricultural education: by concentrating on the Cores, their fringes and their links, far less organization of scarce manpower resources in Government will be called for than by initial large-scale attempts to uplift agriculture substantially in every corner of the kingdom at once.

This is not to say that such general economic benefits as better fertilizer distribution, extended feeder roads and more advice on improving basic husbandry should be withheld from the remaining Periphery. A great deal can be done cheaply to raise production and profits there, but progress beyond a certain level (perhaps the nett annual income of R 300 per homestead mentioned on page 271) cannot be expected from ordinary measures.

However, if it is to the extraordinary that IFB must turn to maintain Swaziland's fast economic growth rate, what guarantee is there for success? The training of Swazi irrigators has yet to begin in earnest, there seems to be a hiatus in the appearance of new crops and new agricultural investment, after the spate of the 1950s and early 1960s, and even though it is to some degree irrelevant, the land tenure issue, unresolved, may well put a brake on the activities of individual farmers eager and able to improve their lot.

Moreover, the best crops to grow in the IFB do not immediately present themselves, and after careful thought they are recommendable only in the most general terms. There will continue to be much uncertainty until the ills of the world's fitful stop-go economy are nearer to being cured. Taking a selection of crops already tried out, the catalogue of woes that afflict their producers is long. In the following list cotton seems on the whole to have the least burden of disadvantages at the time of writing, but even this may be a transient boom-crest assessment. It is assumed that the crops commented upon will, where necessary, be irrigated with optimum quantities of water and that management will be at the "reasonable standard" referred to on page 175.

Avocados	A few thousand acres would flood the market.
Beans	Prices for fresh pods fluctuate: a cannery would not need a big acreage.

Citrus	Economics and diseases are problems.
Cotton	Good prospects below 40 inches isohyet, especially if ginning is decentralized: dangers of monoculture, when appreciated, should be surmountable.
Groundnuts	Not particularly lucrative per unit area.
Maize	Profit per acre not high: once elasticity in local demand has been assuaged, overproduction of irrigated maize might pose a threat.
Pasture	Must await development of quality beef and dairying.
Pineapples	Cannery economics have been difficult: if they improve the chances of expansion are good.
Potatoes	Good prospects on a limited acreage: market tends to be fickle, but more often firm than not.
Rice	High water consumption: how long will the protected rand currency area market last?
Sesame	Fair prospects on a limited acreage.
Sorghum	Modest value, rather low demand.
Sugarcane	Quota restrictions and price instability: otherwise great extension possible.
Tobacco	Finicky to grow, prone to diseases and to hail injury: will smoking decline?
Vegetables	Perishability and distance to large, brisk markets are obstacles.

For all these reasons, it must be confessed that no precise timetable of intensive development in rural areas can be issued. But the impetus of the Primate Core, in particular, is strong enough and its economic foundation is broad enough for one to be optimistic that further prosperity will be engendered among the 55,000 persons there (in 1966). And the outlook for that prosperity spreading to some or all of the other areas of promise on Map 24 in the not too distant future is good. Elsewhere in the world, following the trigger action which starts off the career of a Core, it has been axiomatic that land of high quality within (and eventually around and radiating from) that Core will find users.

Tempering optimism with caution is nonetheless prudent. It may seem ludicrous that a period of trial and error still has to be endured before an agricultural economy — which it is known could flourish — "takes off" with an inglorious trail of more and more government subsidies for fewer and fewer farmers, but it is bitterly true. Many a developing country or region, with soil resources matching those of Swaziland, from Colombia to Kenya and Kazakhstan, is struggling to get primary production smoothly moving. That does not reflect land capability, nor is it "inevitable" owing to incompetence or backwardness. Rather it constitutes an indictment of money and trade systems chiefly, and of military powers' defence spending.

Reverting once more to hopes and their fruition, one is now able to make an appraisal of how land could be allotted to sectors of the economy in Swaziland about a generation (perhaps more) into the future, starting with the most intensive forms of land use. The provisional nature of this inventory must be stressed.

(a) Urban and other nonagricultural — half as much again as the present figure, about 400,000 acres or 9% of Swaziland.

(b) Irrigation 120,000 to 300,000 acres — say 180,000 acres or 4% of Swaziland: almost 90% of the irrigated total will be in IFB.

(c) Dryland crops 880,000 to 1,060,000 acres — say 1,000,000 acres maximum, from which must be subtracted perhaps 50,000 acres for afforestation, leaving 950,000 acres or 22% of Swaziland: less than 10% in IFB.

(d) Coniferous forest 360,000 acres and eucalypts say 70,000 acres (this may be on the low side): total timbered 430,000 acres or 10% of Swaziland.

(e) Fallow reduced to about 90,000 acres or 2% of Swaziland.

(f) Unimproved pasture all but 380,000 acres of the remainder (the 380,000 will have soil rating F) – therefore 1,870,000 acres or 44% of Swaziland.

Whether or not there actually comes into being, before or after the 21st century dawns, a landscape exactly resembling this is immaterial. One simply wishes to state that such a pattern *could* emerge, and in the light of present soil-gepgraphical knowledge it would be one of the best of all possible future land use divisions. In Table 77 potential surface area utilization, on this basis, is contrasted with present-day acreages of various land use categories.

Some indication of the production income, at current price levels, from arable land when it is utilized to the degree suggested in subheadings (b) and (c) above may be had by putting the average output of an acre no higher than at present – irrigated R 130 gross revenue and raingrown R 12. The national total then emerges as R 35,400,000 per annum as against R 12,800,000 in 1967. Of course the cost of producing the extra crops will be substantial. The fertilizer bill would rise to R 9,600,000 for about 200,000 tons of 9:8:5 – cf. the 1967 sales of R 1,100,000 or so (but note also that the ultimate consumption should result in greater profits per acre, so comparison with the R 35,400,000 putative earnings is not in order).

WHAT SIZE OF RURAL POPULACE CAN BE SUSTAINED?

In 1966 there were 259,000 inhabitants in CNL areas of dispersed settlement. This is equivalent to just over 90 acres per family of 7. The 1968-1972 Swaziland Development Plan makes an assumption which the writer intends to follow. It is that 70% of the total rural population will eventually (some decades ahead) be farm dwellers, who on CNL will continue to occupy homesteads of 7 persons each, although the ratio of farmers to hired labour may well decline markedly.

Resident ITH landowners numbered at most 500 in 1966. About 16,000 farm workers and 3,000 forest workers (outdoor not mill, office etc. employees) were then engaged on properties in dispersed-settlement areas of ITH. There are thus 100 acres per worker on ITH farms and 70 acres per worker in manmade forests. Some virtually uninhabited trek sheep farms and other unused properties account for the lower density on farmland than woodland. The ITH mean is 90 acres per person, exactly as on CNL, but of course ITH family sizes are pulled down by the large proportion of unmarried or migrant labourers. The average kinship unit cannot exceed 3 people as dispersed ITH total 1966 population was only 58,000.

Looking to the time, also several decades from now, when all the IFB of Map 24 are functioning, they and the small amount of additional irrigated land in the Periphery could contain 13,000 families at 20 acres per farm (see page 274). The remaining agricultural area – both CNL and ITH (since their present overall acreage per head-of-family is so similar no compunction is felt to keep the two kinds of tenure separate: however, forests are excluded) – could support either (i) about 35,000 farm families at 80 acres each (see page 272), who would cultivate only some 350,000 acres of dryland crops if they had 10 acres of the average holding under the plough, or (ii) more than 80,000 farm families if mechanization and the growing of improved pasture were to free enough grazing land outside IFB to permit rainfed cropping of the maximum 870,000 acres – from head (c) on page 284.

In (i) and (ii) above, and with regard to the IFB too, it is accepted that a proportion of

TABLE 77

Land Use 1968 and Potential

	Thousand Acres		Difference	
	1968 (a) X	Potential (b) Y	000 ac. Y – X = Z	% (c) 100 Z/X
Nonagricultural Land	260	400	+140	+ 50
Irrigated Crops	75	180	+105	+140
Dryland Crops (d)	315	950	+635	+200
Manmade Forest	240	430	+190	+ 80
Indigenous Forest (e)	100	0	-100	-100
Temporary Fallow	230	90	-140	- 60
Unimproved Pasture (f)	3,080	2,250	-830	- 30
TOTAL	4,300	4,300	0	0

NOTES:
(a) For fuller details see Tables 7 to 10
(b) Between about 1985 and 2030
(c) To the nearest 10
(d) Including improved pasture
(e) Any remnants in column Y are incorporated into Unimproved Pasture
(f) With Class FM. Although grasses unimproved, soil will probably have had fertilizer, legumes may have been introduced etc., by Potential stage.

the total farm families will in fact be farmhands' families on continuing or new estates and plantations, mostly ITH but some (Sihoya style) on CNL. When timber reaches the 430,000 acres set under head (d) of page 285 there will probably be some 7,000 forest families.

The IFB, the pine and gum woods and alternative (i) in the Periphery for dryland agriculture together involve, at 7 per family, nearly 390,000 farm and forest dwellers or, using the 70% Development Plan factor, a rural community of 550,000.

At present nucleated settlement is growing at a rate of perhaps 6% annually. Should this increase be maintained until 1987 the towns, villages and hamlets will have 250,000 residents, and the national population of 800,000 (mean density 120 per square mile) will agree broadly with the constant-fertility population projection of Jones (1968) for that year – 760,000 Africans. There could well be 30,000 Europeans and Coloureds by then.

Will the whole quarter-million acres of IFB be developed by 1987? It seems likely that they cannot be because of the magnitude of the task – the finance to be found and the administrative machinery to be established, as well as soil and agronomic implications. If this is so, then there will continue to be low incomes per rural family and severe population pressure on farmland locally, as is now building up (see the references on page 62 to the most crowded 1966 Enumeration Areas, with less than 15 acres per family).

But the longer intensive farming projects on a big scale are delayed, the more menacingly will land hunger and poverty stalk the kingdom. This will be true even if the immediate tenurial inequalities are alleviated, so that unused and underused ITH is tacked on the CNL. Swaziland simply cannot afford to postpone the agrarian intensification for which the soils of Classes AS and BS are ready.

CONCLUSION:

The principal soil survey contribution to a fuller understanding of land capability in Swaziland has been to demonstrate that progressively enhanced returns can be got by farming on soils of successively better ratings, E to A. Yields and profits increase as Land Class improves.

Moreover, one can now predict *how much* better good soil will be than poor soil at a given proficiency of management (rather above the present average) for four important crops, using quantitative results which Figure 35 synthesizes. The perennials sugarcane and pine show less variation in yield than the annuals maize and cotton, from best to worst land, for two main reasons: (a) the effect of poor seasons is smoothed out to some extent and (b) they are grown in areas of optimum climate, whether natural or, as in the case of irrigated cane, manmade.

These findings, coupled with the 1:125,000 soil set and slope mapping, lead to an unequivocal answer to the question posed on page 54 regarding the choice of steps that Swaziland should take towards agroforestal progress. The answer dictated by the soil pattern is that concentration of near-future development on Classes AS and BS, the better arable, will undoubtedly be advisable. This recommendation is reinforced by the spatial conjunction, partly due to deliberate acts of preference by populations in the past, of the main zones of economic activity, the Cores, with tracts of good soil.

Development of the Cores, their fringes and the belts of country linking them will prove to be the best means of ultimately spreading material benefits to the residual Periphery.

The essence of the solution is easy enough to propound. Its implementation – the priorities and the precise changes in farming systems and rural mores that should be fostered – will be facilitated if several novel concepts are embraced. Three of the more fundamental and pervasive will be as follows:

(1) Regional planning on a co-ordinated basis is the key to the selection of the first areas that are to become Intensive Farming Blocks, out of the 5% or 6% of the country that appears to lend itself to sustained highly productive crop-growing. The existing national planning authorities, rather than any District or other subnational organization, would be best qualified to turn their attention to regional analysis. On the side of physical planning, a soil and water use feasibility study covering the whole country will be the logical consequence to the UNDP Usutu Basin project. Other catchments are too small and interconnected to warrant separate individual surveys.

(2) Once initial IFB have been chosen, special treatment in many spheres will have to be accorded them. In particular land tenure changes and, on IFB that are already populous, any necessary rearrangement of homesteads, fields and grazing grounds should be enabled to proceed untrammelled in each area concerned — and without there having to be a simultaneous national revision of tenurial rights. By proclamation each IFB could be given a particular status taking it out of the CNL-ITH duality, and for different IFB there could be different provisions according to how the schemes there will be best run.

(3) As more than 100,000 acres of irrigated crops, over and above those already in the ground, are envisaged — mainly in IFB — there is a need for the training of farmers in irrigation techniques and help to new irrigators on their land. At present no government officer is stationed on CNL anywhere with this service as his duty.

These new departures, and others they will set in motion, must involve a complete volte-face by some traditionalists. But the King and Parliament are on the side of steady progress. Their persuasiveness and the voices of the younger generation will be decisive in attempts to avoid discord on the nation's development aims.

Thus recognition of parcels of good soil is but one preliminary job among many in the initiation of an intensive agricultural project. Unless all or most other factors besides soil are propitious too, more advanced farming will not automatically follow on. Several excellent texts enumerate the factors whose integrated interpretation results in a strategy of development Papanek (1960), Elkan (1961), Yudelman (1964), Boudeville (1966), De Wilde (1967), other authors quoted by Fair, Murdoch and Jones (1969) etc.

Communications, markets and the crops to grow are three of those factors, apart from land resources per se, and the Swaziland Government is well aware of their importance. Detailed inferences regarding the first two are outside the scope of this thesis. A direct rail link to Johannesburg and more tarring of roads, especially in the North-East and East-Central Cores are among the objectives which it is hoped to attain in the 1970s: for longterm proposals, highly generalized, see Map 24.

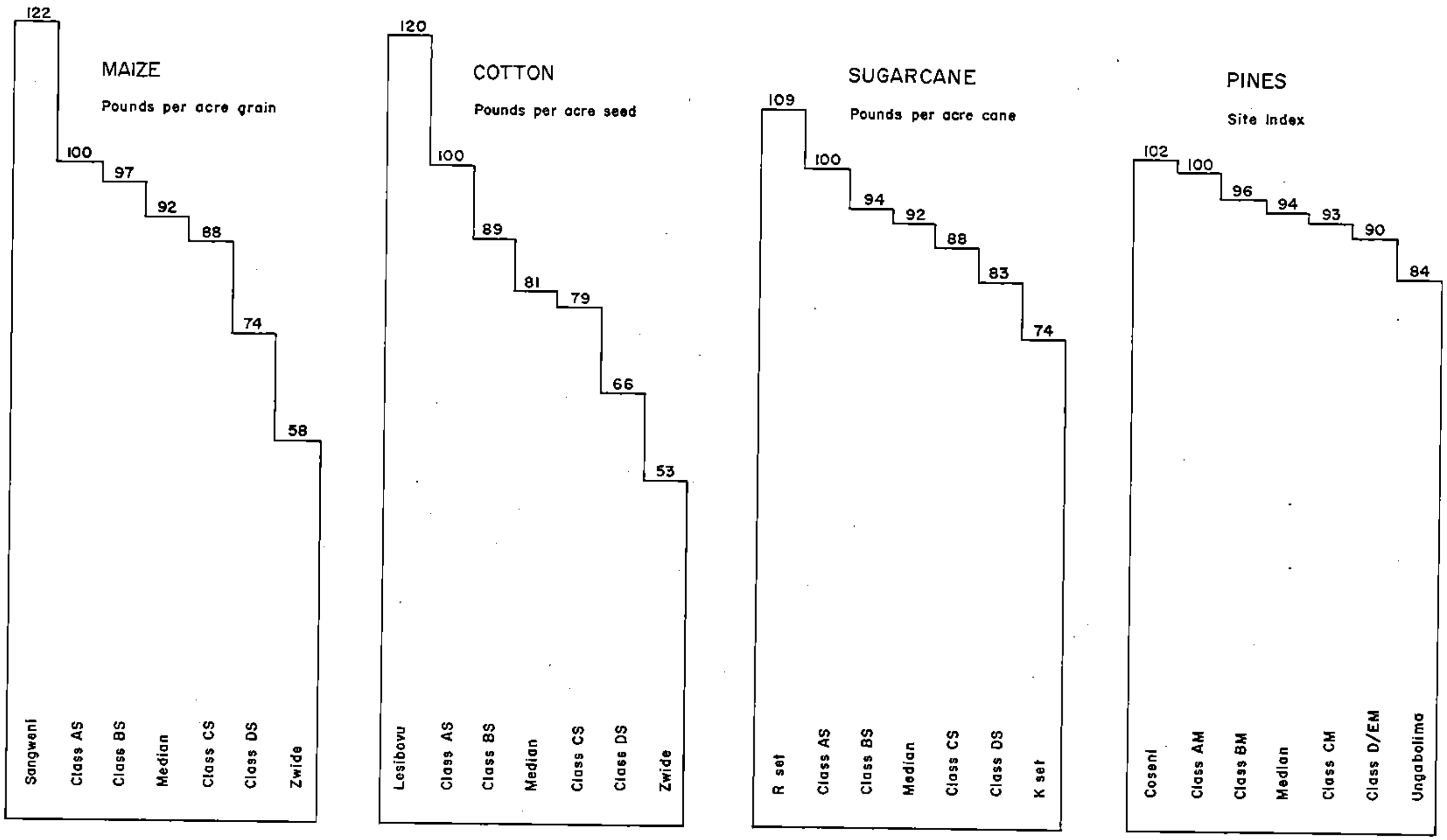
Markets for produce, nearer home than the two main buyers at present (Britain and Japan) are being actively sought. Trade with Zambia and Kenya has blossomed since 1966 and the prospects for more exports to the Republic of South Africa are fairly bright. Moreover Swaziland consumers will themselves generate secondary and tertiary industries as they increase in numbers and in wealth.

The crops to grow in IFB clearly matter tremendously. A wide range of commercial plants is agronomically possible and economics will be the arbiter of exactly which are selected. A very rough order of preference for 1968 plantings under irrigation on appropriate Classes AS and BS would read: cotton, rice (until the claims upon water are too great, or the price falls), various vegetables, cereals other than rice, pasture, citrus, sugarcane (very restricted quotas awarded).

FIGURE 35

Yield-Soil Correlation Summary

Numbers capping colums are percentages of Class AS or AM mean yields: best and worst series or sets are featured: maize from Table 60, cotton from Table 67, sugercane from Table 48 and pine trees from Table 70.



Of dryland crops on the better arable soils cotton is also perhaps the most rewarding over fairly large areas, between the 25 and 40 inches isohyets. Potatoes at and above the 50 inches isohyet can be recommended, and the less profitable maize, beans and other raingrown crops come some way behind. Pineapples will rally, assuredly, once their processing is rationalized. Afforestation is proceeding in the Highveld and Cool Middleveld, with more gums than conifers currently being put in.

It would be foolhardy to try to specify the order in which all thirteen IFB of Map 24 should be brought into being, but at least those from which the country would gain most by an early start to projects can be short-listed. Acreages refer to Classes AS and BS minus nucleated settlement, from Table 75.

(a) The Central Middleveld heartland (39,000 acres). Diversification possibilities great, infrastructure already effective, best internal market and good external communications, national prestige value as royal capitals are embedded. But much resettlement, as distinct from new settlement, will be involved as population densities are already high.

(b) Irrigation settlement schemes proper, in sparsely peopled or uninhabited areas. The main outer-Core and Core-fringe candidates for this kind of development are two northern IFB and the Usutu riverain downstream from Sipofaneni. South of the North-East Core 16,000 acres in the Lower Umbeluzi basin await irrigation. The Lower Komati IFB has 13,000 acres (excluding already irrigated land, Sihoya to Bordergate). The Lower Usutu, outside the East-Central Core, could provide 18,000 acres. From the viewpoint of improving connectivity between Cores the strategically sited Lower Komati and Lower Usutu ribbons of potential development stand out as very desirable nuclei-cum-routeways.

(c) The prospective South-West Core (21,000 acres). Agroforestal investment in the environs of Goedgegun would balance the national disposition of advanced nodes, and would stimulate further enterprises along the new road north to Manzini.

Concurrently with the generation of IFB, there is no reason why the remaining Periphery should not also be uplifted agriculturally in a much less intensive manner, notably by additional fertilizer consumption and feeder road construction. These and other simple agricultural extension levers will, however, best be directed not necessarily to all parts of the Periphery at once, but in the first instance to the most promising areas as depicted on the Land Capability Map. Minor growth points (e.g. Mahlangatshe RDA or Engcina RDA) would then be groomed to act as route junctions, settlement foci and centres of advancement generally, once the whittling away of the Periphery gains momentum.

Sites for new towns and villages and for the various other non-agricultural land uses which will loom large in the future, from industrial complexes to touristic and recreational amenities, could well be influenced by the Land Capability Map. Consulting it once the general vicinity for the new feature has been decided will at least supplement the topographic surveys that are usually carried out on such occasions. Near towns and villages land suitable for market gardening could be reserved after reference to the Land Classes of the neighbourhood, accompanied by more detailed soil surveys where necessary.

In the end success will depend on the people who are prepared to till the soil, whether of Intensive Farming Blocks or of the far Periphery, and their fellow-citizens in other walks of life with whom they will be interdependent. The Swazi are a proud and close-knit nation. Socially and politically they are hampered by far fewer restraints and indignities and shibboleths than many another community of half a million in the world. A latent entrepreneurial skill and will to succeed is being revealed. What a few are accomplishing now in the economic sphere, many should be achieving in the next generation.

The post-independence barometer is thus set fair. Further awareness of the implications of the regional geography of the country and of the patchwork and potentialities of its soils cannot but assist the nation's decision-makers in their endeavours to maintain a course that is stable and not beset by alarums, and yet evolutionary.

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INDEX OF AUTHORS

And of Other Personal Names

SUBJECT INDEX

Excluding most soil profile characteristics (depth, colour, texture etc.) listed on pages 105 to 126 -- the Index of Sets and Series. Including abbreviations.

APPENDIX A

CONTINUING SOIL SURVEY PROGRAMME

Supplementing this memoir, and the achievements to date of the Swaziland Soil Survey, with additional work is strongly recommended. This will entail ventures into spheres of applied and pure pedology so far scarcely touched.

More than 18 man-years of soil survey have been devoted to the whole of Swaziland – about 4,600 acres per week per soil surveyor. During at least 12 years detailed and semidetailed surveying was done on 900,000 acres – at most 1,500 acres per week. Both rates include map production, report compilation, holidays etc. as well as fieldwork: the latter has indeed occupied only 2 to 3 days in the average week.

Costs per man-year, including all hidden charges, have not exceeded R 10,000 and total soil survey expenditure has thus been less than R 180,000 or 4c per acre. In another 30 man-years it would be possible to complete detailed or semidetailed mapping of the entire country, save U set.

Continuation of the Soil Survey as an agricultural extension, not research, activity seems to be warranted, since the detailed surveys most urgently needed relate to CNL irrigation schemes, new or expanded Rural Development Areas, and some developing ITH farms. Detailed soil maps of those Intensive Farming Blocks which have not yet been surveyed at 1:50,000 or larger scales should be given high priority, starting with the Lower Komati riverain.

Land capability investigations for specific farming systems are also called for – perhaps tea, irrigated vegetables, gum trees, in addition to further study of several already being rated. Yield-soil correlation for citrus, possibly pineapples, and eventually gum trees will be worth embarking upon. Armitage (1968)[1] points out the poor agreement between maize yields from several plots on each of 4 soil sets (particularly M but also CH, L, SH) in his comments on 1967-1968 countrywide experiments. Work should continue so that the scatter and patterns of yields from each important soil become better known. Soil ratings in Table 40 should be thoroughly revised by at latest 1973. Other topics within applied pedology that await attention include market gardening soils, more work on siting and construction of roads in relation to kinds of soil, and an examination of population distribution according to soil sets at 1:125,000.

For each important established soil series it will be well to accumulate data about soil water (infiltration rates, hydraulic conductivities, available water holding capacities etc.) and aeration of soil (bulk density, porosity) as a complement to chemical determinations already made. These themselves need augmenting, especially in the direction of pure pedology – the reason why black Vertisols occur on certain fairly steep slopes in the Lowveld, the cause of the yellow colour in some Ferralitic Soils on the Highveld, the Ferralitic status of CH set, and the fitting of soils generally with greater precision into the classifications of D'Hoore and Dudal, and into other relevant systems. A revision of the 1:1,000,000 map of soil groups would be one result.

Further detailed profile descriptions are necessary. Soil temperatures and hyperthermicity should be investigated, as a longterm project. And finally, the numerical taxonomy of soil series – after e.g. Rayner (1966)[2] – will be worth pursuing, using Table 17 and some of the morphological features from pages 104 to 126 as "classes", whereof the required 30 or so could easily be found.

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APPENDIX B

GAZETTEER

Of Placenames on the Accompanying 1:125,000 Maps

Orthography is that commonly used 1955-1967 while soil mapping was proceeding. Some later official changes of placenames, e.g. from Bunya to Bhunya, are indicated by crossreferences.

RIVERS – grid reference is to source or point of entry into Swaziland.

Assegai W2
Black Umbeluzi G2
Cotshane Z6
Dingindlovu K9
Dudusi P1
Entshanini W6
Fulangwenya = Ingwenya
Gongola R6
Great Usutu N1
Gwengwane V2
Hlambenyatsi L2
Hlambenyoni K5
Hlezane V4
Ihlelo S1
Ingwavuma U5
Ingwenya U9
Komati E3
Kukwane S3
Kumbane K9
Lambongwenya D4
Little Usutu J1
Lomati B4
Lubhuku L7
Malolotsha G3
Mantambi Z5
Manziwayo Y6
Matimatima X3
Mbabane J3
Metulo L1
Mhlatuzane S5
Mhlatuze V5
Mkondvo = Assegai
Mlawula L9
Mnyame L9
Motjane H2
Mozane R3
Mozane Y3
Mpofu C5
Mponono N1
Msuzwane Y8
Mtombe Y5
Muweni U4
Mzimnene C5
Mzimnene L5
Mzimnene N7
Mzimpofu M6
Ndlozane S1 and T1
Ndumbi R6
Ngwedzi Y5
Ngwempisane P1
Ngwempisi R1
Nhloya W7
Nkalishane D9
Nkomozane C3
Nkomozane G3
Nyetane M9
Nyomane W3
Nyonyane H5
Palati N0
Pongolwane V6
Poponyane D3
Popota U5
Poyeni K5
Riet Z7
Salugazi M5
Sibowe U5
Sidvokodvo K6
Sidvokodvo M5
Simonyet F7
Sitilo Y6
Songweni W3
Sulotane L7
Tibe P0
Tibolati N0
Towela S2
Tsambokulu E9
Tungolubi S2
Ulembo P1
Umbeluzi G2 or G9
Umhlamanti M6
Umhlangotane B6
Umhlatane B6
Umpelusi L1
Umtilane K4
Umtindzekwa L8
Usushwane = Little Usutu
Usutu N1 or P5
White Umbeluzi L5
Yaningo X8
Zibe X9

OTHER PLACENAMES

Abbeyleix U8
Abercorn S0
Abundance U4
Adamsrest X9
Aelybrown J0
Bestview F5
Bethal V2
Bethal Y6
Bethany M4
Bethany T6
Bulunga P6
Bulungapoort Q6
BUNYA N2
Busaleni S4
Bushlands H7

Umkiwa J6
Umkwakweni Z6
Umkwelintaba M3
Umlindazwe L9
Umlindazwe M1
Umlindazwe U2
Umlindazwe Y8
Umlokotwa Y5
Umlotshwa W6
Umnandi S3
Umoquba L2
Umpondla D5
Umshange M3
Umshinande C5
Umsinsi C5
Umswazis Garden M4
Umtongwane M1
Umziluse C7
Undobandoba U9
Unie U2
Urquhart M6
Usushwane M4
Usutu Orchard M3
Usutu Pulp = Bunya
Usutupoort S0
Utontela W8
Uzamane R3

Vandersand T8
Vanyane N5
Velabantu V6
Velakubi T4
Velapi T6
Velazizweni Q3
Vembila A5
Vemvane N3
Vendi W3
Verdun S5
Vergelegen F5
Vermaak X6
Vermelles W9
Vezi X6
Vikesijula P7
Vilekazi P2
Vilekazi W3
Vimbe R0
Vimy Z8
Vineyard L9
Vlakhoek Y4
Vlugkraal S2
Volinde E8
Vondo R9
Voorspoed X8
Vredisdal X3
Vroegveld Q2

Vukela U2
Vulenkonzo F3
Vundla Q9
Vusweni C5
Vusweni K4
Vusweni W3
Vuvulane F9
Vygeboom X6

Wagner P8
Wandlovu F3
Ward K2
Warren V4
Warrenwood H7
Waspageni S0
Waterberry C4
Waterfall G3
Waterford J3
Watersmeet N5
Waverley K1
Waweni K8
Waweni R1
Webani V5
Welgelegen S2
Weltevreden P2
Weltevreden S1
Weltevreden Y6
West Ranching F7
Westridge K3
Wimabe C4
Wisselrode T9
Wisteria U8
Witbank N4
Womkupulangwenya K7
Wonderboom X7
Wosheni A5
Wubeni P0
Wyldsdale B4
Wyndham L2

Xapo S2
Xoba L1
Xulweni M6
Xulweni S7

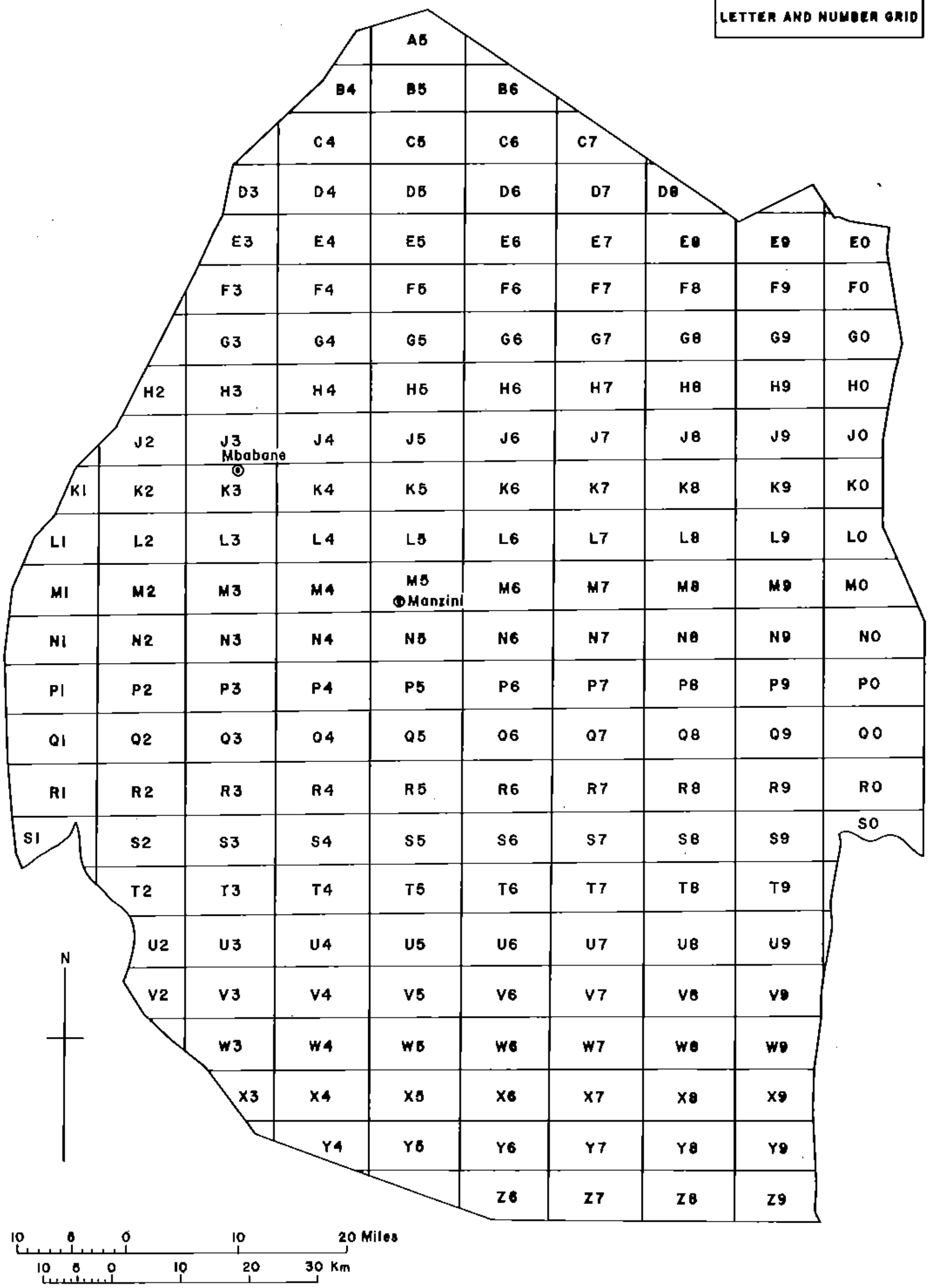
Yabayaba V5
Yandeni Z6
Yaningo W8
Yezimbali N4
Yihomu B5
Yokane G4
Yonga G6
Yorkdale W4
Yoxwane M0
Yudomane J4

Yulane E0

Zabeni J4
Zabeni L4
Zabeni X7
Zakhe W9
Zakheli M5
Zambane X9
Zameni W3
Zameni X4
Zandnek V2
Zandondo G6
Zandspruit H3
Zanzane K5
Zaquel N0
Zawi X3
Zed Seven Q8
Zeeman J2
Zelweni Q4
Zenga R3
Zenumba G0
Zenzeli U7
Zibanyoni P4
Zibondeni X5
Zigojela T3
Zikane S7
Zikhoteni Y5
Zimu M6
Ziya S8
Ziyahle L9
Zogudwini Y6
Zombiswe U9
Zombode L4
Zonderwater L8
Zondwako N2
Zondwako N0
Zongumane V3
Zulangi J4
Zulangi V7
Zulu Z8
Zwakela T8
Zwartkop P2
Zwide E7

APPENDIX C

LETTER AND NUMBER GRID



For use pending delivery of 1:125,000 maps

Obtain frontier squares by extrapolating