The regional landscape: Nylsvley in perspective

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A report of the Committee for Terrestrial Ecosystems
National Programme for Ecosystem Research

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

133

1987

Issued by

Foundation for Research Development
Council for Scientific and Industrial Research
P O Box 395
PRETORIA
0001

from whom copies of reports in this series are available on request

Printed in the Republic of South Africa in 1987

ISBN 0 7988 3827 2

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PREFACE

The Savanna Ecosystem Project of the National Programme for Ecosystem Research is one of several national scientific programmes administered by the CSIR's Foundation for Research Development. The National Programme is a cooperative undertaking of scientists and scientific institutions in South Africa concerned with research related to environmental problems. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE (Scientific Committee on Problems of the Environment), the body set up in 1970 by ICSU (International Council of Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field.

More recently, the International Union for Biological Sciences (IUBS) has launched major projects on the Responses of Savannas to Stress and Disturbance, and on Tropical Soil Biology of Fertility within the Decade of the Tropics programme. The Savanna Ecosystem Project will provide the basis for an important southern African input to this international activity.

The Savanna Ecosystem Project being carried out at Nylsvley Provincial Nature Reserve in the northern Transvaal is a joint undertaking of more than fifty scientists from the Department of Agriculture and Water Supply, the Transvaal Provincial Administration, the CSIR, the Transvaal Museum and eight universities. As far as possible, participating laboratories finance their own research within the project. The shared facilities at the study area and the research of participating universities and museums are financed from a central fund administered by the National Committee for Ecosystem Research and contributed largely by the Department of Environment Affairs.

The research results of the project have been published in over 100 papers in the open literature, while descriptions of the study site, soils, vegetation, plant and animal taxonomic checklists and similar specific syntheses have been published in this report series. A general account of the relationships between the environmental components at the Nylsvley Study Site and regional phenomena is not available, however, and this synthesis provides this perspective.

ABSTRACT

This report deals with the South African Savanna Ecosystem Project study site at the Nylsvley Provincial Nature Reserve, northern Transvaal. In particular, a description of the environmental features and ecological processes active in the area is provided so that these processes may be seen in their regional perspective. Little has previously been published on the position of the study area in the regional landscape, yet the ecological patterns and processes being researched at Nylsvley are largely determined or influenced by phenomena occurring at a regional scale. This report attempts to fill this gap.

SAMEVATTING

Hierdie verslag handel oor die studiegebied van die Suid-Afrikaanse Savanne-ekosisteemprojek te Nylsvleyse Provinsiale Natuurreservaat in Noord-Transvaal. Dit bied in die besonder 'n beskrywing van die omgewingskenmerke en ekologiese prosesse wat werksaam in die gebied is, sodat hierdie prosesse in streeksperspektief gesien kan word. Weinig is voorheen oor die posisie van die studiegebied in die streekslandskap gepubliseer, howewel die ekologiese patrone en prosesse wat op Nylsvley nagevors word, in 'n groot mate deur verskynsels op streekskaal bepaal of beïnvloed word. Met hierdie verslag word gepoog om die leemte te vul.

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INTRODUCTION

The dimensions, structure and aspects of the functioning of an ecosystem are strongly influenced by the position of that system in the regional landscape. Climate, geology, hydrology, and soils, together with their interactions and changes in space and time, produce the environmental template through which is etched the plant and animal communities of that system and the processes that pattern and sustain them. An analysis of these environmental features is therefore important in understanding ecosystem structure and functioning (Tinley 1977). Although detailed descriptions of the South African Savanna Ecosystem Project (SASEP) study site have been given previously by a number of authors (Hirst 1975; Coetzee et al 1976; Huntley and Morris 1978, 1982) few of these have made more than a passing reference to the position of the study site in the regional landscape. The aim of this report is therefore to provide that description so that the features and processes of the area being studied can be seen in their regional perspective.

The SASEP study area is located on a 745 ha portion of the Nylsvley Provincial Nature Reserve (24°39'S, 28°42'E), situated 10 km SSE of the town Naboomspruit in the north-central Transvaal. The 3 120 ha reserve lies on the western edge of the Springbok Flats, where these abut foot-hills of the Waterberg Plateau. The reserve lies in gently undulating to flat countryside, ranging in altitude from 1 080 m above sea level along the Nyl River, which bisects the reserve, to 1 155 m on the hill, Maroela-kop, in the centre of the study area. To the west, the Waterberg hills rise abruptly to over 1 700 m; to the east, the plains of the Springbok Flats drop gradually to below 900 m in the Olifants River valley. Much of the surrounding area is intensively farmed; maize, sunflower, wheat, millet and groundnuts are the main crops, while cattle ranching is the main form of livestock production. Prior to its proclamation as a provincial nature reserve in 1974, Nylsvley was a cattle ranch. Much of the original vegetation remains intact, with only a few areas, principally in the bottomlands, having been cultivated for fodder or other crops.

CLIMATE

Details of the climate of the SASEP study area and the Nylsvley Nature Reserve have been given by Huntley and Morris (1978, 1982) and Coetzee et al (1976) respectively. In the Köppen classification the region is classed as hot, dry steppe with a winter dry period (BShw) (Schulze 1947). For Nylsvley, the long-term average July-June rainfall over the period 1917/18-1985/6 is 620 mm (Weather Bureau 1965 and unpublished records; G Whitehouse personal records; Transvaal Division of Nature Conservation records). Mean annual temperature is 18,6°C (Figure 1). The annual atmospheric demand, calculated from limited 'A' pan evaporation data, is about 1 250 mm or about twice the mean annual rainfall.

Three distinct seasons occur. From May to July it is dry with warm, usually cloudless, days and nights. Mean daily maximum and minimum temperatures for this period are 22,3°C and 2,6°C respectively. Ground frosts occur regularly, particularly along the Nyl River valley and other low lying areas. The prevailing winds are predominantly light westerly to

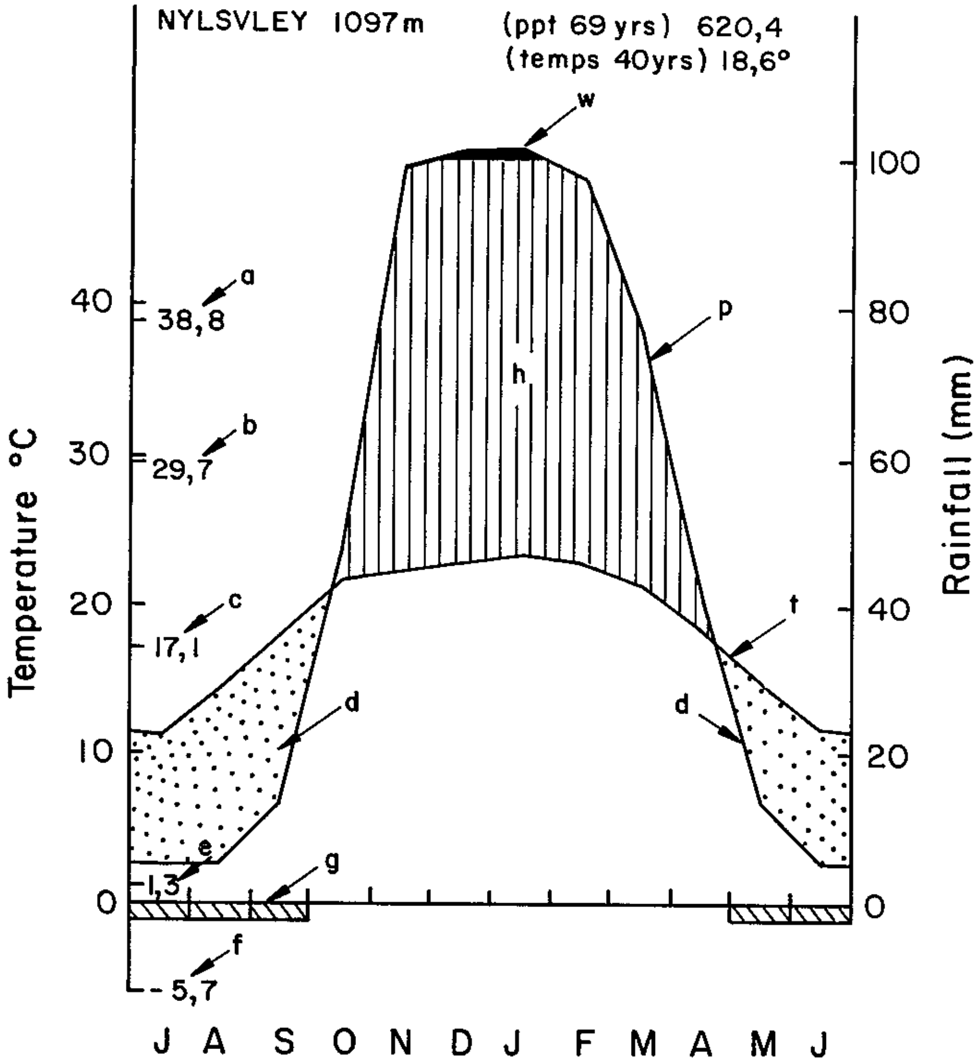

FIGURE 1. Climate diagram for the Nylsvley Nature Reserve: a = absolute maximum temperature, b = mean daily maximum temperature of hottest month, c = mean daily temperature range, d = arid period, e = mean daily minimum temperature of coldest month, f = absolute minimum temperature, g = months in which frost is recorded, h = humid period, p = mean monthly rainfall, w = per-humid period (scale reduced ten times).

north-westerly. From August to October daily temperatures begin to rise, accompanied by strong, predominantly north-easterly winds. While the days are generally hot the nights still tend to be cool, with mean daily maximum and minimum temperatures of 27,6°C and 8,6°C respectively. Although remaining dry, occasional thundershowers develop, mainly in October.

The annual wet season extends from November to April, a hot period with mean daily maximum and minimum temperatures of 29,2°C and 14,5°C respectively. About 85 per cent of the annual rainfall occurs during these months. Most of the rain falls in the form of heavy thundershowers which develop during the middle of the day over the highveld to the south-west and proceed northwards in a regular fashion against the prevailing north-easterly surface winds, usually reaching Nylsvley and the surrounding areas late in the afternoon and evening. These storms, which are frequently accompanied by strong winds, are formed by the convergence of a rising stream of warm, moist air being advected in from the north-east, and a mass of cooler subsiding air from the upper, predominantly south-westerly, air stream (Jackson and Tyson 1971). The resulting storms vary widely in extent and large differences can be measured over short distances in the amount of rain falling during any particular storm. Although the long-term rainfall records from a number of stations in the region show the same annual trends (Tarboton in preparation), small but consistent differences in the spatial distribution do occur. The average annual rainfall is highest on the Waterberg Plateau, particularly along its southern margin, declining gradually with decreasing elevation and distance from the plateau.

Annual variations in the amount of rainfall are high; the annual coefficient of variation for the past 69 years is 24 per cent. Some of this variation has been due to normal year-to-year fluctuations in rainfall but some of it reflects alternating periods of above and below average rainfall (Figure 2). Rainfall was generally low in the 1920's and early 1930's, when the area was subjected to a particularly severe drought, and in the mid 1960's and early 1980's. It was well above average in the early 1940's, early to mid 1950's and in the mid 1970's. Intraseasonal variations in rainfall are also high, the coefficients of variation for the main wet months ranging from 48 per cent in November to 75 per cent in February. In more than half the years a summer drought occurs (defined here as one or more months during the period December to February receiving less than 50 mm of rain).

Evidence for long-term changes in climate come from an analysis of pollen spectra in cores taken from peat deposits surrounding a thermal spring, "Wonderkrater", 10 km north of Naboomspruit (Scott 1982). Conditions about 35 000 years ago appear to have been much cooler and moister than the present. These conditions soon gave way to a drier period which lasted until about 25 000 yr BP when cold, moist conditions again developed. Temperatures during this period were probably about five to six degrees centigrade cooler than the present, though a gradual amelioration took place towards about 11 000 yr BP. It also became much drier, semi-arid conditions persisting from about 11 000 to 6 000 yr BP. From about 9 500 to 4 000 yr BP temperatures were apparently similar to those of the present, while during the latter part of this period (6 000 to 4 000 yr BP) it gradually became wetter, giving rise to a moisture regime which is thought to have been broadly comparable with current conditions. The climate continued to become more mesic, the period from about 4 000 to 2 000 yr BP probably being cooler and moister than now, followed by a return about 1 000 years ago to a warmer, drier climate that has persisted through to the present time (Scott 1982).

The interpretation of past climates from pollen spectra is dependent on the assumption that the observed changes in these spectra represent climate-related changes in the floras from which the pollen originated. Moreover, within the various cores from the "Wonderkrater" there are discrepancies in the radio-carbon dates of the different strata, which have required some assumptions to be made about the exact chronology of these assemblages. Despite these though, the analyses clearly indicate the existence of large-scale changes in the composition of the flora of the north-central Transvaal in the recent past, the most probable explanation of which is that they were induced by changes in both the temperature and moisture regimes of the region.

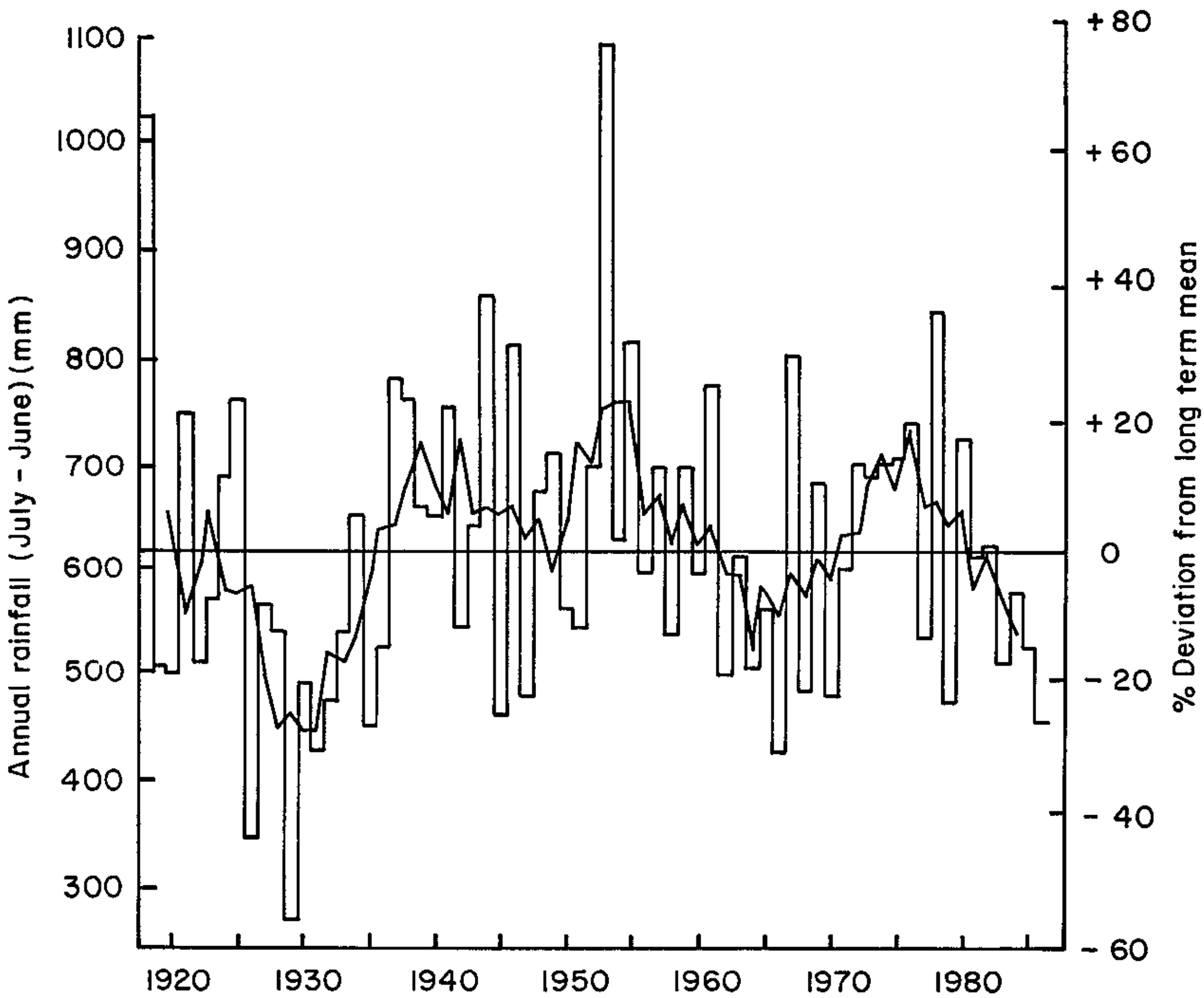

FIGURE 2. Annual (July-June) rainfall for the Nylsvley Nature Reserve for the period July 1917 to June 1986, together with five-year running mean of annual rainfall total.

GEOLOGY

There are three dominant physiographic features of the region: the Waterberg Plateau and its foothills, lying to the west and north-west of Nylsvley and rising up some 500 to 700 m above the surrounding countryside to a height of over 1 700 m; the plains of the Springbok Flats lying to the north-east, east and south of the reserve; and the Nyl River valley which leaves the Waterberg foothills on Nylsvley and sweeps northwards in a broad, shallow basin that cuts across the western edge of the Springbok Flats. Most of the area forms part of the dicyclic Post-African Planation Surface, though the top of the Waterberg Plateau corresponds to the older African Planation Surface (King 1967).

The geology of the region is complex, comprising a variety of igneous, sedimentary and metamorphic rocks of very different ages (Figure 3). The youngest rocks (125 to 205 My) are those of the Karoo Sequence which rest in a downwarped basin made up of the much older rocks of the Pretoria and Rooiberg Groups, the Bushveld Complex and, in the extreme west, the Waterberg Group (South African Geological Survey 1978). As a result of folding and denudation the rocks within this basin have been shaped into two shallow, elongate flexures filled with amygdaloidal basalts and separated by a slight north-east to south-west orientated anticline comprised of Karoo sandstones. The basalts have been reduced to fairly level plains, the Springbok Flats, made up of deep, clay-rich soils, while the intervening region is slightly elevated and overlain by shallow sands.

The Waterberg Plateau and its foothills, west of the Sprinkbok Flats, consist of sedimentary rocks, principally medium to coarse-grained sandstones but including pebble, feldspathic and micaceous sandstones, graywracke, siltstones and mudstones, all belonging to the Waterberg Group. These rocks are laid down unconformably in two overlapping basins formed from intermediate and acid lavas of the Rooiberg Group and granites of the Bushveld Complex (South African Geological Survey 1978). The precise age of these Waterberg sandstones is not known, but they are estimated to be about 1 850 My old, based on an age of 1 790 My for a granitic intrusion within the Waterberg system and the ages of the rocks of the Bushveld Complex and Rooiberg Group, which predate those of the Waterberg Group, and are therefore older than 1 960 My (van Eerden 1972).

The Rooiberg Group lavas, together with the medium and coarse-grained granites of the Bushveld Igneous Complex, lie exposed along the eastern and southern edges of the Waterberg Plateau. They are extensively faulted, the majority of the faults resulting from the deposition of the Karoo beds to the east, although many of them arose along old fracture lines (van Eerden 1972). As a result of long exposure to uplift, folding, intensive faulting and denudation, the rocks of this area interdigitate extensively with one another, giving rise to sharp changes in underlying geology over very short distances. A number of prominent synclines and anticlines occur, among which are the Nylstroom syncline formed mainly within sedimentary rocks of the Waterberg Group, and the adjacent Swaershoek anticline formed from the Rooiberg lavas. Both reach their easternmost exposed limit on the Nylsvley Nature Reserve. The felsitic and rhyolitic lavas of the Rooiberg Group underlie the northern half of the reserve, while the southern half, including the whole of the SASEP study area, is comprised of basal conglomerates, medium to coarse-grained sandstones, shales, siltstones and tuffaceous graywrackes of the Waterberg Group.

DRAINAGE

Geology, landform, and climate are key determinants of regional drainage patterns. Rivers and streams, by altering the conformation of the landscape through erosion and deposition, in turn influence the dynamics of the biotic communities established on these substrates. In addition to modifying the landscape, these geomorphological processes also play a

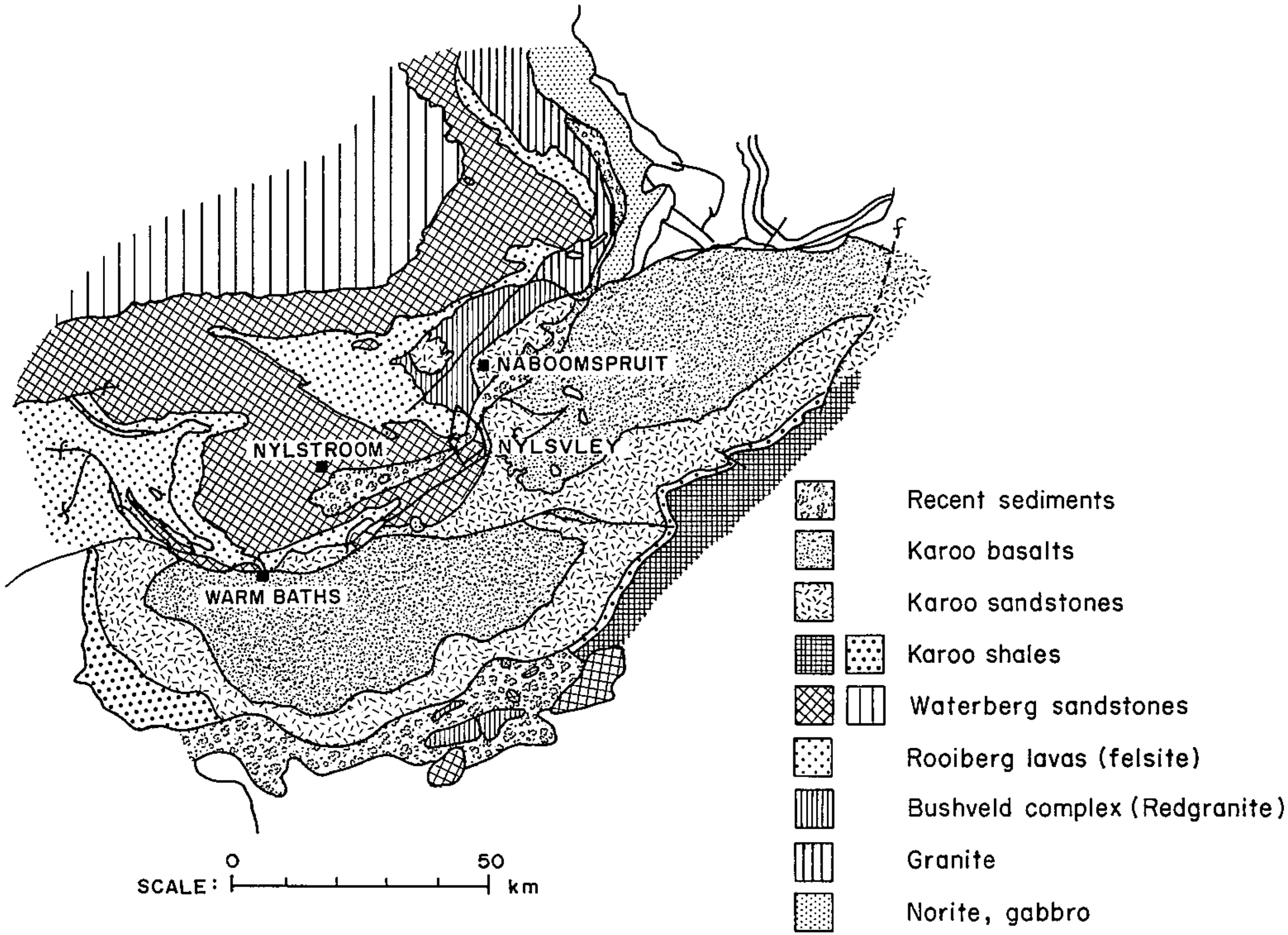

FIGURE 3. Geology of the area surrounding the Nylsvley Nature Reserve. Information derived from South African Geological Survey 1:250 000 Geological Series Map 2428 Nylstroom.

fundamental role in the release and redistribution of minerals through mobilization, transport and sedimentation of particulate and dissolved matter. In so doing they serve to link often widely separated systems and their dynamics.

All the major river systems in the north-central Transvaal form part of the Limpopo drainage basin. Those rivers originating in the Waterberg and surrounding areas flow northwards to join the Limpopo River in its upper reaches, while those arising south and east of the Springbok Flats flow eastwards, only joining the Limpopo lower down in Moçambique. Only three rivers of any consequence drain the eastern half of the Waterberg Plateau and its foothills: the Mogalakwena River and its main tributary, the Sterk River, drain the north-eastern foothills and eastern escarpment respectively, while the Nyl River and its tributaries drain the south-eastern and eastern foothills. The only other major rivers in the region, the Olifants and a tributary, the Elands, occur to the east and south of the Springbok Flats and do not significantly influence local drainage patterns. With the exception of the Nyl River, the flats are devoid of perennial rivers and streams, the existing watercourses only containing flowing water for short periods after rain and then generally draining internally on the flats.

The Nyl River arises from the confluence of the Groot and Klein Nyl Rivers which drain the hills forming the western end of the Nylstroom synclinal basin. Initially the Nyl flows accordantly with the underlying geological structure, being confined to the synclinal basin until its eastern end is reached on Nylsvley. At this point the river cuts through the rim of the basin and the adjacent felsite beds on the northern half of the reserve, and swings northwards across the western edge of the Springbok Flats. Because of the lack of relief in this area the river channel broadens considerably and becomes diffuse, forming a floodplain vlei (Noble and Hemens 1978). This extends as far north as Vaalkop, 25 km north-east of Naboomspruit, where the Nyl has been subjected to river capture by the Mogalakwena River.

The tributaries feeding the Nyl flow exclusively from the Waterberg foothills, there being no significant flow off the Springbok Flats. Those tributaries draining areas underlain by Waterberg sandstones have tended to erode out the weaker sediment and along fault lines to form broad, shallow valleys filled with alluvium. In contrast, in those areas underlain by the more resistant Rooiberg lavas, erosion by the tributaries has tended to proceed vertically rather than headwards, principally along faults and joints, leading to the formation of deep, steep-sided valleys. In some areas these have linked up with the older drainage lines traversing the uplands, thereby altering the drainage patterns in these areas. Unlike those tributaries which drain areas of Waterberg sandstone, these streams carry relatively light sediment loads, made up mainly of fine material, which are flushed out of the valleys and deposited in the lower reaches of the tributaries and in the Nyl valley.

The rocky nature and generally steep inclination of the valleys in the Nyl River catchment promote a rapid runoff of rainwater. Relatively little storage occurs, and this coupled with the variable and localized nature of much of the rainfall, leads to an erratic and highly seasonal input of water to the Nyl. In seasons of above-average rainfall, particularly when there has been a carry-over of water in the Nyl from the previous wet season, some 9 000 to 16 000 ha of the Nyl valley become inundated. These floodwaters may persist for some months into the dry season and even occasionally into the following wet season, though more frequently the waters gradually recede until only the deeper parts of the main channel retain water. Extensive flooding of this nature has occurred in nine of the past 20 years. In the remainder, during years in which the rainfall was below average and little or no water remained on the floodplain from the previous wet season, there was either only brief, unsustained flooding or no flooding at all (Tarboton in preparation).

The form of the Nyl valley, and the directions taken by some of the drainage lines leading into it, suggest that prior to the capture of the Nyl by the Mogalakwena River the area was probably a large internal drainage basin (Tinley 1981). The basin was probably formed by the subsidence of the Karoo beds relative to the surrounding area. At an earlier stage, water draining off the south-eastern foothills of the Waterberg Plateau probably flowed eastwards across the Springbok Flats to join up with the Olifants River. Although direct evidence for this is scanty, a number of broad, shallow drainage lines, which currently only carry water for short periods after exceptionally heavy rains, can be traced across the Springbok Flats. These drainage lines, which are orientated in a general west-east direction, and which in some cases link up with the Olifants drainage system, are underlain by beds of coarse gravel, indicating that at one time they carried much greater amounts of water (Wagner 1927). While water volumes would have been greater during the wetter conditions of the past, it is possible that at least some of these drainage lines owe their origin to flow off the Waterberg foothills, and that processes such as faulting, increased deposition of sediments during arid periods, and the pinching off of stream flow by laterally invading alluvial fans, acted subsequently to cut off this drainage to the east (Tinley 1981).

Not all the surface waters in the region are free-draining. Large areas occur where surface drainage is restricted by the presence of an impermeable subsurface horizon, leading to the development of seasonally waterlogged soils and thereby to dambo and other high water table grasslands. Such sites occur in both upland situations, where the soils overlie shallow, flatly-bedded rock strata, and in the lowlands, where laterite, calcrete or claypan horizons impede drainage. Laterites occur mainly on the pediments of the foothills, particularly in soils derived from weathered felsite. Calcrete, on the other hand is confined locally to the clayey soils of the Springbok Flats, in some areas reaching considerable thickness (Wagner 1927). The claypan horizons are best developed in the soils of the Nyl River valley and floodplain, and on alluvial fans formed by rivers and streams as they leave the foothills. They appear to be more prone to develop on those alluvial fans composed of sediments derived from weathered felsite, principally because of the higher clay content of these soils.

SOILS

At the regional level, three soil mapping units have been recognized, each based on a characteristic association of the most commonly occurring soil groups (van der Merwe 1962; Harmse 1978). In their distribution, these units correspond closely to the positions of three of the main geological formations of the area, namely the two basalt-filled basins of the Springbok Flats, the intervening ridge and areas peripheral to these basins, composed mainly of Karoo sandstones, and the complex of igneous, sedimentary and metamorphic rocks that make up the Waterberg Plateau and its foothills.

The most fertile soils are the black and red montmorillonitic clays (locally called 'turf' soils) derived from weathered amygdaloidal basalt of the Karoo Group rocks. These clays fill the two major basins of the Springbok Flats. There are no significant structural differences between the two groups of soil but they differ chemically in that the red clays contain less calcium carbonate, have a lower amount of available phosphorus and a higher combined percentage of iron and aluminium oxides. They are also occasionally acid, whereas the black clays are always basic (Galpin 1926). Generally, the black clays are confined to shallow, poorly drained depressions while the red clays predominate in the better drained raised areas. Because of their high fertility and good moisture holding properties, these are prime agricultural soils and have been extensively cultivated.

In contrast to the soils of these two basins, the soils occurring to the south and east of them, and in the intervening area, comprise mainly red, yellow and grey fersiallitic sands and loams (Harmse 1978). Lithosols are also prominent but are restricted to the scattered sandstone outcrops and ridges of the area. The sands and loams are derived from the weathering of the underlying fine-grained Karoo sandstones and are porous, generally acid and infertile, being particularly low in available phosphorus (Galpin 1926). Their overall agricultural potential is low.

The soils on the Waterberg Plateau and foothills are mostly yellow and grey fersiallitic sands and loams derived from weathered sandstones and conglomerates (Harmse 1978). In general the sands are best developed in certain upland situations and on the mid to lower slopes of the hills, while the loams are confined largely to the valley bottoms. Along the crests and scarps of the hills lithosols are dominant, particularly in areas underlain by acid, igneous rocks. Despite the differences in geological origin, these sands and loams closely resemble those derived from the younger Karoo sandstones, being porous, acid, and having a generally low cation exchange capacity. Their agricultural potential is low and they have only been cultivated extensively in the valleys.

Descriptions of the major soil groups at a regional level do not adequately portray the structural and chemical diversity that exists within these soils. On the Nylsvley Nature Reserve alone 17 soil forms (classified according to the South African National Soil Classification System [McVicar et al 1977] on the basis of unique vertical sequences of the diagnostic horizons) and, within them, 34 soil series (differentiated in terms of texture, colour, clay content, base status, and degree of calcareousness) have been identified and mapped. Although the individual features used to distinguish these soils are not discrete variables, when taken together they reveal much about the complex processes involved in soil development and the evolution of the soil-landscape system.

The nature of the parent material, topography and drainage appear to have been major factors in the process of soil development on Nylsvley. The soils originate from four main sources. North of the Nyl River they are derived mainly from the fine-grained felsitic lavas of the Rooiberg Group. South of the river, the weathering of sandstones and other sedimentary rocks of the Waterberg Group has produced the sandy soils of the upland areas, while the intervening Nyl River valley is filled with water-borne sediments derived from both sandstone and felsite. In addition, lying between the sandstone ridge on the southern boundary of the reserve and the Nyl River is a shallow depression filled with montmorillonitic clays derived from weathered Karoo basalts.

Litholitic soils

Shallow lithosols with a poorly developed or non existent structure are widely distributed throughout the upland areas of Nylsvley (Figure 4). They are derived principally from the weathering of the underlying sandstone and felsite. Because of the slope most of the soil so produced does not accumulate in situ, but is washed off onto the lower slopes. Lithosols also occur on the pediments of the felsite uplands where a shallow mantle of soil overlies sheets of laterite. Here, in contrast to the process of soil removal that characterizes the presence of lithosols in the uplands, the soil is slowly accumulating on top of a previously eroded surface. Texture and chemical composition of these lithosols varies considerably due to the nature of the parent material. The soil derived from the coarse-grained sandstones on the southern half of the reserve is more sandy and has a lower base status and cation exchange capacity than that originating from the fine-grained felsitic lavas occurring north of the Nyl River (Tables 1 and 2).

Well drained, noncalcareous soils on elevated sites

The soils derived from weathered felsite are easily transported. Consequently, there are few areas on the felsite uplands where soil of any depth accumulates. In contrast much of the upland area south of the Nyl River is covered with residual latosols (ferralsols) derived from deep weathering of the underlying sandstone (Figure 4). These latosols, are acid, sandy, well drained, noncalcareous and generally dystrophic to mesotrophic (Tables 1 and 2). They are classed as Hutton form soils in terms of the South African National Soils Classification System (McVicar et al 1977), being weakly structured with a five to 30 cm deep orthic A-horizon and a 30 to 130 cm deep, red apedal B-horizon that grades into a saprolytic layer immediately above bedrock. Since these soils comprise the dominant soils of the SASEP study area (Harmse 1977) they will be discussed in some detail.

Soil depth is variable and unrelated to surface topography, the bedrock being at or close to the surface in some areas and as deep as 4,5 m in others. The average depth of soil recorded in two four-hectare sites situated in the main part of the study area is 1,05 ± 0,6 m (± s.d.; n=877). The surface of the bedrock of these sites is broken and very uneven (Figure 5), a feature which has broad implications for the patterns of soil moisture retention and subsurface drainage.

The soils are porous and well-drained and hold relatively little water, the volumetric soil water content of a Hutton soil at field capacity (-0,3 bar) is only six to 10 per cent (van Rooyen 1978). This declines to two to three per cent at wilting point (-15 bar), so that the amount of water available to plants is limited to between four per cent and seven per cent on a volumetric basis. Since the rainwater percolates rapidly through to the lower layers of the soil, saturated conditions (more than 10 per cent volumetric soil water) occur only in the upper 60 cm of the soil profile and then only for brief periods after rain. As a result, lateral drainage

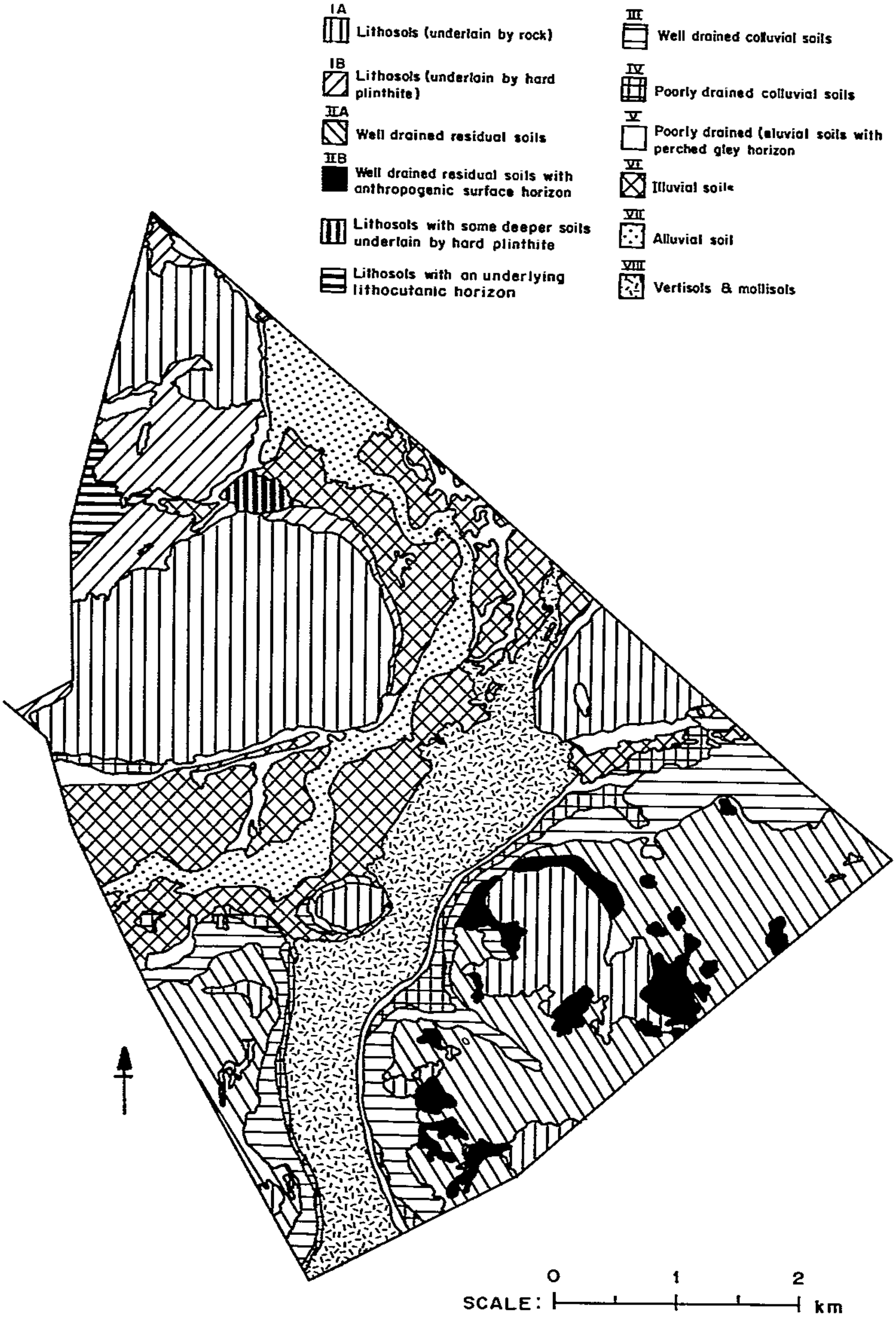

FIGURE 4. Soils of the Nylsvley Nature Reserve (adapted from data in Harmse 1977).

TABLE 1. Summary of distinguishing features and physical characteristics of Nylsvley soils (data from Harmse (1977) and Ferrar (1982))

FORM Series	Internal drainage	Hori-zon	PARTICLE SIZE DISTRIBUTION (%) Coarse sand	Medium sand	Fine sand	Silt	Clay	Bulk density
MISPAH								
Mispah	Poor	A1	17,1	41,7	31,0	3,0	7,2	1,55
Klipfontein	Poor	A1	2,6	20,6	34,8	8,0	34,0	
HUTTON								
Chester	Good	A1	15,9	46,5	27,8	5,1	4,7	1,50
		B21	16,8	34,2	41,5	2,0	5,0	1,54
Kyalami	Good	B21	18,9	35,3	36,3	3,0	6,5	
Middleburg	Good	A1	17,1	37,5	31,3	8,2	7,3	1,53
		B21	7,4	41,8	31,7	9,4	10,3	1,55
Bontberg	Good	A1	17,0	37,6	31,7	8,0	5,6	1,61
		B21	19,0	34,4	31,2	5,9	9,5	1,40
Portsmouth	Good	A1	19,8	36,3	32,6	7,2	4,2	1,61
CLOVELLY								
Mossdale	Moderate	A1	8,9	37,5	43,7	4,0	6,0	1,54
		B21	8,9	37,2	37,0	5,5	11,5	1,52
Springfield	Moderate	A1	11,6	37,7	40,5	5,2	6,0	1,52
		B21	10,0	39,8	36,5	6,4	7,3	1,50
Sebakwe	Moderate	A1	29,0	40,0	28,0	1,0	2,0	1,73
		B21	26,0	37,1	30,9	2,0	4,0	1,58
Gutu	Moderate	A1	20,8	31,9	38,8	3,5	5,0	1,60
		B21	20,5	34,7	33,8	3,5	7,5	1,50
FERNWOOD								
Maputa	Poor	A1	3,3	30,6	41,6	5,5	19,0	
		C	1,2	11,5	73,3	6,5	7,5	
AVALON								
Leksand	Moderate	A1	8,0	81,9	5,6	0,5	4,0	
		B21	1,4	42,1	45,6	4,6	7,0	
GLENCOE								
Glencoe	Moderate	A1	2,0	26,3	47,2	3,5	21,0	
		B2	1,5	20,5	52,0	3,0	23,0	

TABLE 1 (continued)

FORM Series	Internal drainage	Hori-zon	PARTICLE SIZE DISTRIBUTION (%) Coarse sand	Medium sand	Fine sand	Silt	Clay	Bulk density
LONGLANDS								
Waldens	Moderate -Poor	A1	11,1	34,7	45,2	6,0	3,0	
		E	3,2	27,5	45,3	4,5	19,5	
		soft pliathite	2,1	27,8	52,1	5,5	12,5	
Albany	Moderate -Poor	A1	3,4	33,9	22,7	9,0	31,0	
		E	2,7	29,4	42,9	6,0	19,0	
		soft pliathite	3,3	33,3	4,4	6,0	16,0	
WASBANK								
Kromvlei	Poor	A1	1,1	16,6	70,3	7,0	5,0	
		E	1,6	18,6	64,3	6,5	9,0	
VALSRIVIER								
Lindley	Poor	A1	2,8	27,9	34,3	7,0	28,0	
		B21	2,3	23,3	30,9	8,0	35,5	
STERKSPRUIT								
Sterkspruit	Very Poor	A1	2,6	22,7	38,2	10,5	26,0	
		B21	2,0	17,4	26,6	6,5	47,5	
OAKLEAF								
Levubu	Moderate	A1	2,7	33,7	38,1	4,5	21,0	
		B21	2,8	40,3	43,9	3,0	10,0	
Limpopo	Moderate	A1	2,6	24,9	47,5	5,5	9,5	
		B21	2,5	33,2	41,3	6,0	17,0	
INHOEK								
Cromley	Moderate	A	0,8	14,4	35,3	11,0	38,5	
		C1	1,2	47,0	45,3	2,5	4,0	
DUNDEE								
(Kleierig)	Moderate	A1	6,5	58,6	12,9	4,0	18,0	
		C1	1,2	75,8	20,0	2,0	1,0	
ARCADIA								
Gelykvlakte	Poor	A1	1,3	4,5	35,2	4,0	55,0	
		C	1,9	7,2	34,9	6,5	49,5	
BONHEIM								
Weenen	Poor	A1	1,2	20,7	56,1	4,0	18,0	
		B21	1,7	31,1	53,2	3,0	19,0	

TABLE 2. Some chemical characteristics of Nylsvley soils (data from Harmse (1977))

FORM Series	Hori-zon	pH (H_2O)	TOTAL EXCHANGEABLE CATIONS (me/100g) Ca	Mg	K	Na	S-value	CEC	% base saturation	MEAN NUTRIENT STATUS (ppm) P	K	Mg	Ca	Na	%N in A1 horizon
MISPAH															
Mispah	A1	4,8	0,32	0,07	0,06	0,08	0,53	2,63	20,2	6	25	8	63	19	0,043
Klipfontein	A1	5,5	1,80	0,88	0,33	0,38	3,39	5,00	67,8	5	130	107	360	88	
HUTTON															
Chester	B21	4,9	0,25	0,04	0,06	0,07	0,42	2,10	20,0	2	5	5	50	17	0,024
Kyalami	B21	4,9	0,25	0,04	0,03	0,05	0,37	2,20	16,8	4	10	5	50	22	0,040
Middleburg	B21	4,8	0,15	0,05	0,04	0,04	0,28	2,58	10,9	13	15	6	30	9	0,025
Bontberg (B)	B21	4,9	0,20	0,04	0,04	0,08	0,36	2,30	15,7	4	15	5	40	18	0,042
(A)	B21	5,2	0,40	0,34	0,05	0,09	0,88	2,71	32,5	2	20	41	80	21	0,047
Portsmouth	B21	6,1	1,00	0,27	0,16	0,06	1,49	2,51	59,4	23	62	33	200	14	0,042
CLOVELLY															
Mossdale	B21	5,0	0,23	0,13	0,06	0,10	0,58	2,02	25,7	2	25	16	45	22	0,031
Springfield	B21	4,9	0,30	0,08	0,07	0,09	0,54	2,63	20,5	2	25	9	60	20	0,036
Sebakwe	B21	4,7	0,20	0,04	0,04	0,06	0,34	2,04	16,7	2	15	5	40	13	0,027
Gutu	B21	5,0	0,40	0,04	0,13	0,07	0,64	2,40	26,7	10	70	10	100	30	
FERNWOOD															
Maputa	C	5,1	0,45	0,12	0,04	0,07	0,68	1,90	35,8	2	15	15	90	16	
AVALON															
Leksand	B21	5,2	0,40	0,31	0,17	0,09	0,97	2,60	37,3	4	65	38	80	21	
GLENCLOE															
Glencoe	B2	5,3	2,55	0,19	0,12	0,10	2,96	4,60	64,3	8	45	23	510	23	

TABLE 2 (continued)

LONGLANDS														
Waldens	A1	5,6	1,10	0,58	0,33	0,13	2,14	3,80	56,3	2	130	71	220	29
	E	5,5	0,35	0,12	0,04	0,09	0,60	1,10	54,6	2	15	15	70	21
Albany	A1	5,6	3,40	1,51	0,22	0,13	5,26	9,20	57,2	7	85	184	680	31
WASBANK														
Kromvlei	A1	5,7	0,75	0,38	0,47	0,17	1,77	2,90	61,0	10	185	46	150	3
	E	5,1	0,40	0,07	0,24	0,13	0,84	3,10	27,1	7	95	8	80	30
VALSRIVIER														
Lindley	B21	9,1	2,80	2,11	0,35	1,62	6,88	11,80	58,2	13	135	256	560	373
STERKSPRUIT														
Sterkspruit	B21	7,7	2,94	2,47	0,14	1,55	7,10	15,20	46,7	7	55	300	590	365
OAKLEAF														
Levubu	A1	5,8	2,50	1,27	1,27	0,21	5,25	6,80	77,2	12	495	154	500	48
	B21	6,7	0,75	0,37	0,06	0,07	1,25	1,70	73,5	3	25	45	150	16
Limpopo	A1	5,4	1,70	1,02	0,26	0,20	3,18	5,30	60,0	13	100	124	340	45
	B21	7,5	4,84	2,24	0,13	0,57	7,78	10,20	76,3	10	50	272	970	132
INHOEK														
Cromley	A	6,0	8,50	2,72	0,23	0,34	11,79	19,80	59,5	10	90	330	1700	78
	C1	6,6	1,30	0,49	0,05	0,11	1,95	5,10	38,2	5	20	60	260	26
DUNDEE														
(Kleierig)	A1	5,4	3,34	1,45	0,14	0,17	5,10	9,20	55,4	12	55	176	670	40
	C1	5,8	0,75	0,29	0,06	0,08	1,18	1,90	62,1	5	25	35	150	18
ARCADIA														
Gelykvlakte	A1	8,3	14,97	4,53	0,61	2,48	22,59	41,40	54,6	17	240	550	3000	570
	C	8,0	15,47	4,61	0,87	2,33	23,28	39,90	58,4	18	340	560	3100	535
BONHEIM														
Weenen	A1	8,2	7,73	2,67	0,24	1,72	12,36	22,60	54,7	6	95	325	1550	396
	B21	7,7	4,24	3,25	0,15	2,01	9,65	16,80	57,4	7	60	395	850	462

and subsurface runoff are likely to be important only in the shallower soils (Moore 1982).

Although the deeper soils do not get as wet as the surface soils, they do not dry out as thoroughly either. The water content of the soil below 60 to 90 cm generally exceeds three per cent throughout the dry season whereas the surface soils, under the same conditions can contain as little as one per cent soil moisture (Moore 1982). Thus the mosaic of deep and shallow soils creates a patchwork of relatively moist and dry sites within what superficially appears to be a uniform landscape.

Considerable diversity exists within the study area latosols. Differences in texture, amount of clay and base status (S-value per 100 g clay: McVicar et al 1977) of the soil in the B2-horizon, are used to distinguish the six locally occurring soil series in the Hutton soil form. In their distribution they form a mosaic that reflects poorly understood, complex relationships between topography, drainage and proximity to the hill Maroelakop, which is situated in the centre of the study area, and other rocky outcrops.

The dystrophic soil series, principally Middleburg, and Kyalami, generally occur furtherest from Maroelakop. The medium-textured Middleburg soils are confined to relatively shallow ground at the top of the ridge while the coarse-textured Kyalami soils occur on both the outer pediment at the base of Maroelakop and along what appears to be an ancient drainage line running off the sandstone ridge. In contrast, the mesotrophic soil series are located closer to the hill. The commonest series, Chester, consisting of usually shallow, well drained soils with a low clay content, occurs off the pediment of Maroelakop, whereas the soils of the slightly heavier Bontberg series occur primarily in sloping terrain on the pediment. Finally, situated on generally level ground on the pediments of Maroelakop and some of the smaller rocky outcrops, are the eutrophic Portsmouth series soils. In addition to their high base status (Table 2), these soils are more compacted, have a higher water retention capacity and are slightly richer in N, P and K than the other soils of the Hutton form (Huntley and Morris 1978, 1982).

Paralleling the differences in soil texture and chemistry are differences in the type of vegetation that these soils support. The soils with a relatively poor base status support a deciduous broad-leafed savanna that physiognomically and floristically is typical of a moist savanna (Huntley 1982). In contrast the eutrophic Portsmouth series soils, as well as some of the mesotrophic Bontberg soils (eg Bontberg (A) in Table 2), support well established stands of microphyllous savanna which are allied to the arid savannas of Africa (Huntley 1982). That the boundaries of these patches coincide closely with the limits of these high base status soils demonstrates clearly that even though the soils are derived from the same parent material, subtle differences in soil texture and chemistry markedly affect the type of vegetation occurring on a site (Huntley and Morris 1978, 1982).

There are two hypotheses about the origin of these differences. One of them draws on the observation that these sites were, until quite recently, occupied by pastoralists, giving rise to the suggestion that the input of nutrients in the form of charcoal, bones and cattle dung, associated with this prolonged human occupation, could have raised the nutrient status of the soil.

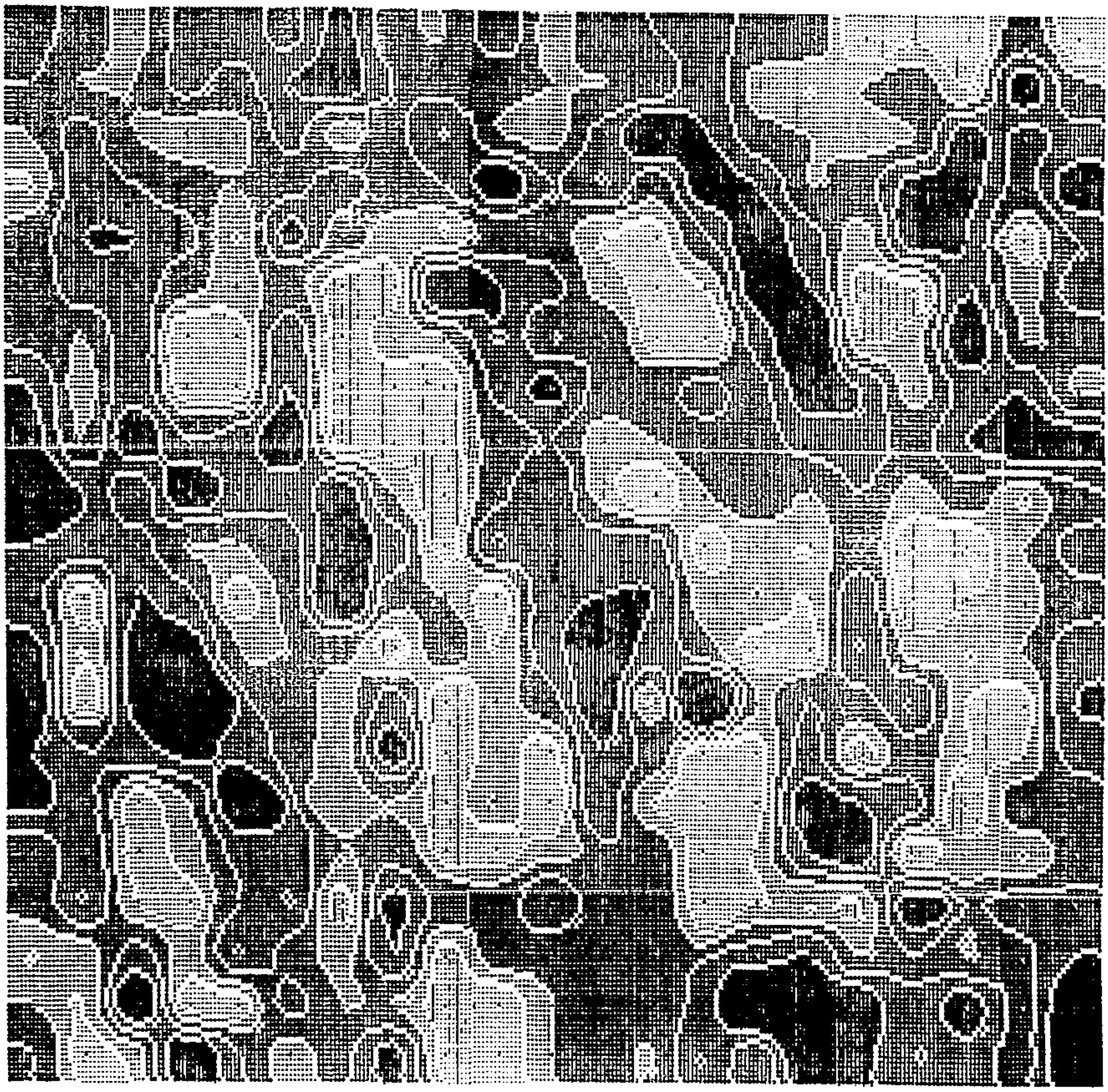

FIGURE 5. SYMAP of soil depth in *Burkea* savanna. Profile of a 200 x 200 m area of the main SASEP study site. The profiles were drawn using a 6th order polynomial fit to 10 x 10 m grid of soil depth sampling points. Dark shading indicates deep soil and light shading, shallow soil. Shading classes are given in 20 cm intervals. Mean soil depth = 70,5 cm (s.d. = 34,1 cm, n=436). Data from Morris (unpublished).

The other hypothesis is that these patches have been formed and are maintained by talus wash derived from the weathering of mudstones and other fine-grained sedimentary rocks present in the Waterberg sandstones (Tinely 1981). In terms of this hypothesis, the fine material so produced is being washed off the source areas (principally the rocky outcrops) and deposited as a superficial layer on the soils derived in situ from deep weathering of the underlying sandstone. The question as to which hypothesis is best supported by the available data, and the implications of the two hypotheses for current management, are currently unresolved.

Situated immediately below the Hutton soils on the catena is another group of sandy latosols. These belong to the Clovelly form and are largely colluvial in origin, though the material towards the base of the profile is probably residual. Like the Hutton soils they are noncalcareous and have a generally low base status (Table 2). Although they are well drained, the yellow-brown colour of the B-horizon soil indicates a generally wetter soil-moisture regime than that experienced by the Hutton form latosols, as might be expected from their position on the lower slopes of the sandstone ridge. They fall into two groups: medium-textured soils occurring on relatively level sites and coarse-textured soils on shallow slopes and along drainage lines.

<u>Poorly drained colluvial soils</u>

Lying along the footslopes of the sandstone and felsite uplands is a narrow strip of poorly drained, acid, sandy colluvial soils (Figure 4; Tables 1 and 2). The most widely distributed of these are medium to fine-textured regosols of the Fernwood form, situated in areas where colluvium from adjacent sandstone ridges has been deposited at the lower ends of drainage lines. Although the internal drainage of these soils is poor, their depth and relatively large pore space tend to prevent excessive water-logging, although subsurface runoff from neighbouring soils occasionally saturates the base of the profile.

In sites where the subsurface soil is subjected to a fluctuating water table, iron and manganese oxides and hydrates accumulate in the better aerated parts of the profile. The resulting mottles and concretions may remain dispersed as soft plinthite or, over time, coalesce to form ferricrete (hard plinthite). At Nylsvley, soft plinthite develops in those acid, sandy soils lying in shallow depressions filled with colluvium derived from Waterberg sandstone, whereas hard plinthite is formed only in poorly drained sites at the base of, and on, the felsite uplands. The difference seems to be a consequence of the nature of the parent material rather than of the relative ages of the soils, the fine textured soils originating from felsite apparently being more conducive to the rapid formation of hard plinthite.

<u>Poorly drained soils with a perched gley horizon</u>

These soils have developed in situations where the vertical drainage of water is impeded by a relatively impermeable subsurface layer, such as a clay pan or a plinthic horizon, resulting in prolonged water-logging and gleying of the overlying soil. Where the water is able to drain laterally, nutrients, other minerals and occasionally clay particles are washed out of the saturated soil, so creating an albic or eluvial (E) horizon. Situations where this occurs include areas of mixed colluvium at the interface of the predominantly sandy upland soils and the clay-rich soils of the bottomlands; along ill-defined, intermittent drainage channels in the bottomlands, and in poorly drained sites on both the pediments and uplands of the felsite ridge (Figure 4; Harmse 1977).

Eluvial horizons are also present in some of the clay-rich soils of the bottomlands, such as on the edges of depressions and drainage channels alongside the Nyl River. In these soils, vertical drainage is impeded by the presence of a cutanic B-horizon formed by the illuviation of clay particles from the upper profile and their deposition on the surfaces of the underlying material. These bottomland soils are particularly prone to erosion when exposed because sodium ions tend to accumulate at the cation exchange sites in the B-horizon, thereby causing the clay particles to deflocculate when wetted.

Illuvial soils of the bottomlands

Illuviation is the main process involved in the consolidation of the sediments occurring in the Nyl River valley. These sediments are derived partly from colluvium washed in from surrounding areas and partly from alluvium deposited during periodic floods. Scouring, sorting and the redistribution of this material during subsequent floods has created a mosaic of different-textured substrates on these bottomlands, with the coarser sediments generally being found along the river banks and the finer fractions occurring in slack water zones away from the river.

The youngest soils occur on and adjacent to the river levées and are comprised mainly of sandy alluvium. Structurally, they are poorly developed, the neocutanic B-horizon showing only slight signs of illuviation. In contrast, the cutanic character of the other soils occurring on the alluvial flats is well developed. These soils are clay-rich, alkaline and have a high base status (Table 1 and 2). They occupy a variety of sites, from old point bars on bends in the river to low-lying, poorly-drained depressions on the outermost fringes of the alluvial plain where they are subject to regular and prolonged water-logging during the wet season (Figure 4).

Floodplain soils

The floodplain of the Nyl River is filled with alluvium deposited during regular floods (Figure 4). The structural development of these soils has been minimal though incipient O- and A-horizons are visible where the alluvium has been stabilized by the vegetation for some time. The underlying sediments are distinctly stratified, comprising alternating bands of clay-rich and sandy material. These indicate changes through time in the types of loads carried by the floodwaters and so probably reflect long-term shifts in climate. The cation exchange capacity and base status of these soils is high, particularly when measured relative to their clay content (Table 2). This suggests the presence of a considerable amount of colloidal material in the alluvium.

Vlei soils

The sandstone uplands situated along the southern boundary of the reserve are separated from the Nyl River by a broad, seasonally inundated depression or vlei. This is filled with calcareous, montmorillonitic clays originating from weathered basalt and derived, in the recent past, as alluvium brought in from the neighbouring Springbok Flats (Figure 4). Although the depression is linked to the Nyl River by a number of poorly-defined drainage channels, it receives most of its water from the Eersebewoondspruit, draining the western edge of the Springbok Flats and surrounding uplands.

The soils occupying the central part of the depression are strongly crusting vertisols with an unconsolidated calcareous subsoil. They are highly expansive when wet and contractile when dry, producing a pronounced hummocked or gilgai microrelief. They are replaced in the slightly better drained sites of the periphery of the depression by mollisols, distinguished by a melanic A-horizon with a well-developed crumb structure superimposed on a pedocutanic B-horizon. These soils are less clayey than the vertisols, though both are calcareous, fertile and have a high cation exchange capacity (Tables 1 and 2).

In concluding, it is worth noting that the geological and topographic diversity found at Nylvley and in the surrounding areas has favoured the development on a small scale of a soil-landscape system that represents a pattern which is repeated over much wider areas: acid, nutrient-poor, sandy lithosols and latosols occurring in upland situations; and alkaline, base-rich clayey soils developing in the bottomlands. While this juxtaposition within such a small area of such a variety of soil types helps to highlight the differences between them, it also serves to emphasize their connectedness through the processes of drainage, and mineral and sediment transport.

VEGETATION

The vegetation of the north-central Transvaal is placed in the Zambezian Domain of the Sudano-Zambezian phytochorological region (Werger 1978; Werger and Coetzee 1978). However, Huntley (1982) has suggested that the southern African savannas should be separated into a Zambezian Domain, consisting of moist savanna elements, principally deciduous micro- and mesophyllous taxa such as *Brachystegia*, *Julbernardia* and *Burkea*, and an "Austral" Domain, comprising arid savanna elements dominated by spinescent and succulent micro-, nano and leptophyllous taxa such as *Acacia*, *Commiphora*, *Colophospermum* and *Adansonia*. In this scheme the north-central Transvaal occupies a tension zone between the two botanical domains since the vegetation consists of a mosaic of both arid and moist savanna communities.

The vegetation of the region has been described by Galpin (1926) and summarized by Acocks (1953) and Werger and Coetzee (1978). Most of the vegetation falls into Acocks' (1953) Tropical Bush and Savanna Types (Bushveld), though elements of the Inland Tropical Forests (the Afromontane forest belt of White (1978)), in the form of North-eastern Mountain Sourveld (Acocks 1953), occur in sheltered kloofs and on well-drained, moist talus slopes on the Waterberg Plateau and neighbouring mountainous areas (Figure 6). These forest elements were more extensively distributed during the cooler, moister periods of the past (Scott 1982).

The savanna vegetation types can be divided into those communities occurring on the Waterberg Plateau and foothills, and on the sandstone outcrops and ridges of the Springbok Flats, and those occurring on the clay-rich soils of the Springbok Flats and the Nyl River valley. The summits of the plateau and foothills are covered with an open tree savanna interspersed with extensive hydromorphic grasslands (Figure 6). These Sour Bushveld

(Acocks 1953) or Upland (Temperate) Subhumid Mountain Bushveld communities (Werger and Coetzee 1978) occur principally on shallow but reasonably well-drained acid soils and are dominated by species such as *Faurea saligna*, *Acacia caffra*, *Protea caffra* and *Combretum molle*. *Bequaretiodendron magalismontanum*, *Croton gratissimus* and *Kirkia wilmsii* are common on rocky outcrops and broken rocky soil. The hydromorphic grasslands are best developed along fossil drainage lines and in areas where unfractured bedrock lies close to the surface, such as along the crest of the Swaershoek anticline. A large number of grass species occur, among which *Schizachyrium jeffreysii*, *S sanguineum*, *Elyonurus muticus*, *Loudetia simplex*, *Diheteropogon amplectens*, *Themeda triandra* and *Hyperthelia dissoluta* are common (Acocks 1953). *Protea welwitschii* is the main shrub. The nutritional value of the grasses during the winter months is very low.

Dispersed throughout these grasslands are termitaria which provide better drained conditions and so facilitate the establishment of woody species. Most of the species occurring in these bushclumps are characteristic of the Sourish Mixed Bushveld communities of lower altitudes. Species such as *Dombeya rotundifolia*, *Acacia robusta*, *Combretum molle*, *C zeyheri*, *Dovyalis zeyheri*, *Berchemia zeyheri*, *Rhus pyroides*, *Euclea crispa*, *Maytenus heterophylla* and *M polyacantha* are common. Elements of Sour Bushveld, especially *Faurea saligna*, *Acacia caffra* and *Protea welwitschii* in turn extend down the valleys and onto the pediments of the foothills, along drainage lines and dambos, wherever the soils are acid and reasonably moist.

Sourish Mixed Bushveld (Acocks 1953) is confined largely to shallow rocky soils on the upper and middle slopes of the Waterberg foothills (Figure 6). The main species are *Acacia caffra*, *A robusta*, *Peltophorum africanum*, *Dombeya rotundifolia*, *Combretum zeyheri* and *C apiculatum* among the trees, and *Cymbopogon plurinodis*, *Themeda triandra*, *Elyonorus muticus*, *Loudetia flavida* and *Heteropogon contortus* among the grasses. Again, most of the grasses are coarse and of very low nutritional value during the dry season.

Sourish Mixed Bushveld and Mixed Bushveld, which occurs on the relatively deep, acid sands and low rocky ridges at the base of the Waterberg Plateau and foothills and on that part of the Springbok Flats overlying Karoo sandstone (Figure 6), are classed as Broad Orthophyll Plains Bushveld by Werger and Coetzee (1978). The two veld types share many species, though the dominant species of Mixed Bushveld are mainly those of the deeper soils. These species show strong affinities to the moist savannas of central Africa. Most of the vegetation of the uplands on the Nylsvley Nature Reserve is classed as Mixed Bushveld (Coetzee et al 1976).

The dominant trees on the sandy areas are *Burkea africana*, *Terminalia sericea*, *Ochna pulchra*, *Combretum molle*, *C zeyheri*, *Securidaca longepedunculata*, *Strychnos cocculoides* and *S pungens*, with *Grewia flavescens* the dominant shrub. Most of the grasses are coarse and of low nutritional value. *Eragrostis pallens*, *Digitaria eriantha*, *Aristida argentea*, *Perotis patens* and *Diheteropogon amplectens* are common in the open areas, *Panicum maximum* is dominant under the trees, and *Trachypogon spicatus*, *Schizachyrium jeffreysii* and *Setaria perennis* are common in the wetter soils along drainage lines.

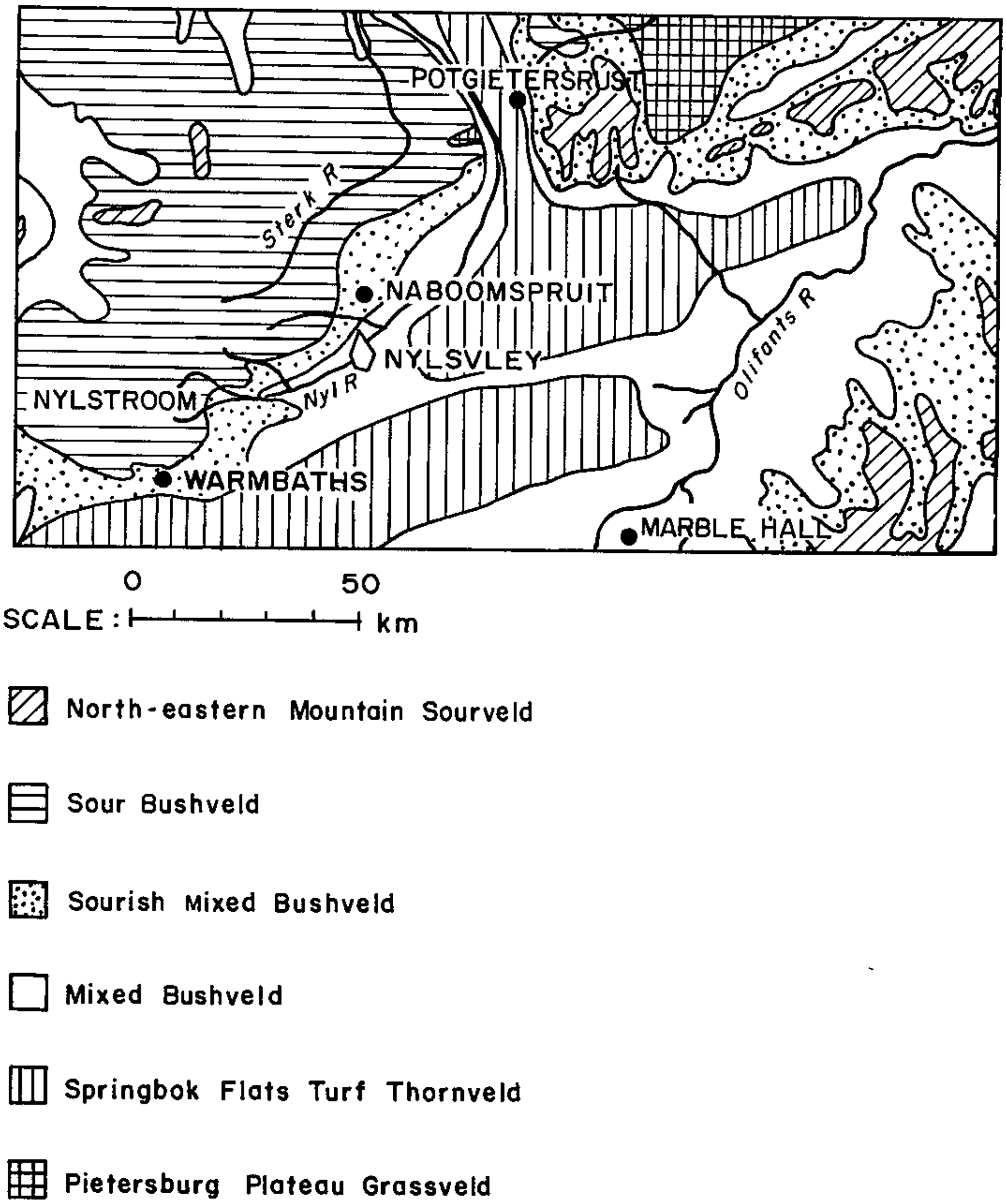

FIGURE 6. Regional distribution of vegetation types across the northern Springbok Flats and adjacent Waterberg Plateau (from Acocks 1953).

The vegetation of the Springbok Flats has been described in general terms by Galpin (1926) who recognizes two associations among the thorntree and grass savanna types: the Black Turf Association (Black Turfveld Variation of Acocks' (1953) Springbok Flats Turf Thornveld), occurring on the black montmorillonitic clay soils, and the Basaltic Loam Association (Red Turfveld Variation of the Springbok Flats Turf Thornveld (Acocks 1953)), occurring on the red loamy clays (Figure 6). Originally both vegetation types occurred as an intricate mosaic reflecting changes over small distances in the two predominant soil types, but because of the prime agricultural value of these soils much of the original vegetation has since been replaced by cultivated lands.

The Black Turf Association consists largely of pure grassland, the waterlogged soils during summer preventing the deeper rooted trees from becoming established. *Ischaemum afrum*, *Sehima galpinii* (which is unique to the Springbok Flats), *Setaria sphacelata*, *Themeda triandra* and *Elyonurus muticus* are some of the dominant grasses. Small clumps of *Acacia tenuispina* and *A karroo* are scattered throughout these grasslands, while on the drier edges *Acacia tortilis*, *A nilotica* and *A gerrardii* also occur, together with various *Rhus* species, *Ziziphus mucronata*, *Diospyros lycioides* and *Maytenus heterophylla*.

The Basaltic Loam Association was originally also an almost pure grassland with scattered *Acacia* trees. Most of the woody vegetation was confined to termite mounds where the drainage is better. Among the dominant grasses, *Themeda triandra*, *Cymbopogon plurinodis*, *Bothriochloa insculpta*, *Eragrostis superba*, *Brachiaria nigropedata* and *Heteropogon contortus* are particularly common. At the time of Galpin's survey (1926) acacias, particularly *Acacia tortilis* and *A karroo*, were gradually invading these grasslands, but today they are confined to the uncultivated fringes and drainage lines. Other *Acacia* species, such as *A robusta*, *A gerradii* and *A luderitzii*, which are much less common, were apparently always more locally distributed.

As with the soils, this broad description of the vegetation does not portray the subtle variations that exist within an area, as related to soil type, slope, aspect and elevation. The only detailed information available comes from the study of the vegetation of the Nylsvley Nature Reserve by Coetzee et al (1976). Using the Braun-Blanquet method of vegetation survey they identified four floristically distinct plant community groups and, within each, a number of variations and subvariations (Figure 7).

<u>Communities of the elevated sandstone and felsite areas</u>

These communities, grouped together as *Rhynchelytrum villosum-Schizachyrium jeffreysii* tree savannas and grasslands, consist of broad-leafed tree savannas occurring on the uplands, where the soils are well-drained and frost is relatively mild, and grasslands, occurring on the lower slopes in sites with impeded drainage and which are subject to regular frosts during the winter months. Three subdivisions are apparent, each with a clear topographic and soil type preference.

Eragrostis pallens - Burkea tree savanna

This community occurs on the moderately shallow to deep, well-drained, acid, dystrophic sandy soils of the sandstone uplands and comprise the main vegetation type of the SASEP study area. Constant differential species in the tree and shrub layer are *Grewia flavescens*, *Strychnos pungens*, *S cocculoides*, *Lannea discolor* and *Securidaca longepedunculata*. In the field layer, *Eragrostis pallens*, *Aristida argentea* and *A stipitata* are dominant among the grasses, and *Vernonia poskeana*, *Limeum viscosum*, *Cleome maculata*, *C rubella* and *Dichapetalum cymbosum* are among the herbs. The community consists of three variations correlated with soil and microclimatic gradients associated with slope and elevation. The *Eragrostis pallens-Dombeya rotundifolia* variation is the most extensive and occupies well-drained soils on the upper and middle slopes of the sandstone ridge. The *Eragrostis pallens-Setaria perennis* variation occurs on the lower sandstone areas on medium-textured, dystrophic sands, while the *Eragrostis pallens-Trachypogon spicatus* variation is confined to coarse-textured, mesotrophic soils along drainage lines (Coetzee et al 1976).

Barleria bremekampii-Diplorhynchus tree savanna

This community is confined to the litholitic soils of the rocky sandstone hills and ridges and consists predominantly of broad-leafed trees. Grass cover is sparse or absent. Tree cover varies considerably, being most dense on uneven, rocky areas and least dense on the flatter, more even terrain. Common differential species include the tree *Diplorhynchus condylocarpon*, the shrub *Barleria bremekampii* and the forbs *Tephrosia longipes*, *Rhynchosia totta*, *Corchorus kirkii*, *Indigofera comosa*, *Asparagus saundersiae* and *Euphorbia neopolycnemoides*. The graminoid *Xerophyta retinervis* (Velloziaceae) is a conspicuous feature of very shallow soils and rocky outcrops. The distributions of the three community variations are correlated primarily with the rockiness of the substrate (Coetzee et al 1976).

Eragrostis racemosa-Schizachyrium jeffreysii tree savanna and grassland

This community occurs on all the felsite uplands and on the footslopes of the sandstone ridge in areas of gently sloping to virtually level topography. On shallow well-drained soils on the upper slopes the vegetation is predominantly a broad-leafed tree savanna (*Eragrostis racemosa-Combretum apiculatum* tree savanna: Coetzee et al 1976) in which *Combretum apiculatum* and *Vitex rehmannii* are the common trees, together with the shrub *Lippia javanica* and the forbs *Ruellia patula* and *Crabbea angustifolia*. This vegetation is replaced by grassland on the poorly drained soils along the lower slopes. Winter frosts are also much more severe at these lower elevations. Among the common grasses that characterize this community are *Elionurus muticus*, *Trachypogon spicatus*, *Setaria perennis*, *Brachiaria serrata*, *Eragrostis racemosa*, *E gummiflua* and *Digitaria monodactyla*.

Communities of flat bottomlands and of termitaria

These communities, classed as *Panicum maximum-Acacia tortilis* tree savannas and termitaria thickets (Coetzee et al 1976), occupy the alluvial and illuvial bottomland soils other than the self-mulching vertisols. The vegetation consists of a microphyllous thorntree savanna in which *Acacia tortilis* in the tree and shrub layer, and *Panicum maximum*, *Aloe* species and *Chloris virgata* in the field layer, are the common differential species. Also included in this group are those communities occurring on the termitaria thickets which occur throughout the reserve other than on the sandstone ridges. Differences in soil texture and brackishness appear to determine the distribution of the two communities in this group.

Sporobolus iocládus-Acacia tortilis tree savanna

This community, which is differentiated by *Sporobolus iocladus* and *Ocimum canum*, occurs on the very heavy, compacted illuvial soils of the bottomlands. These soils are often inundated during the wet season and the vegetation is heavily grazed at all times. In addition to *Acacia tortilis* a number of other *Acacia* species, such as *A mellifera*, *A luderitzii* and *A hebeclada*, also occur.

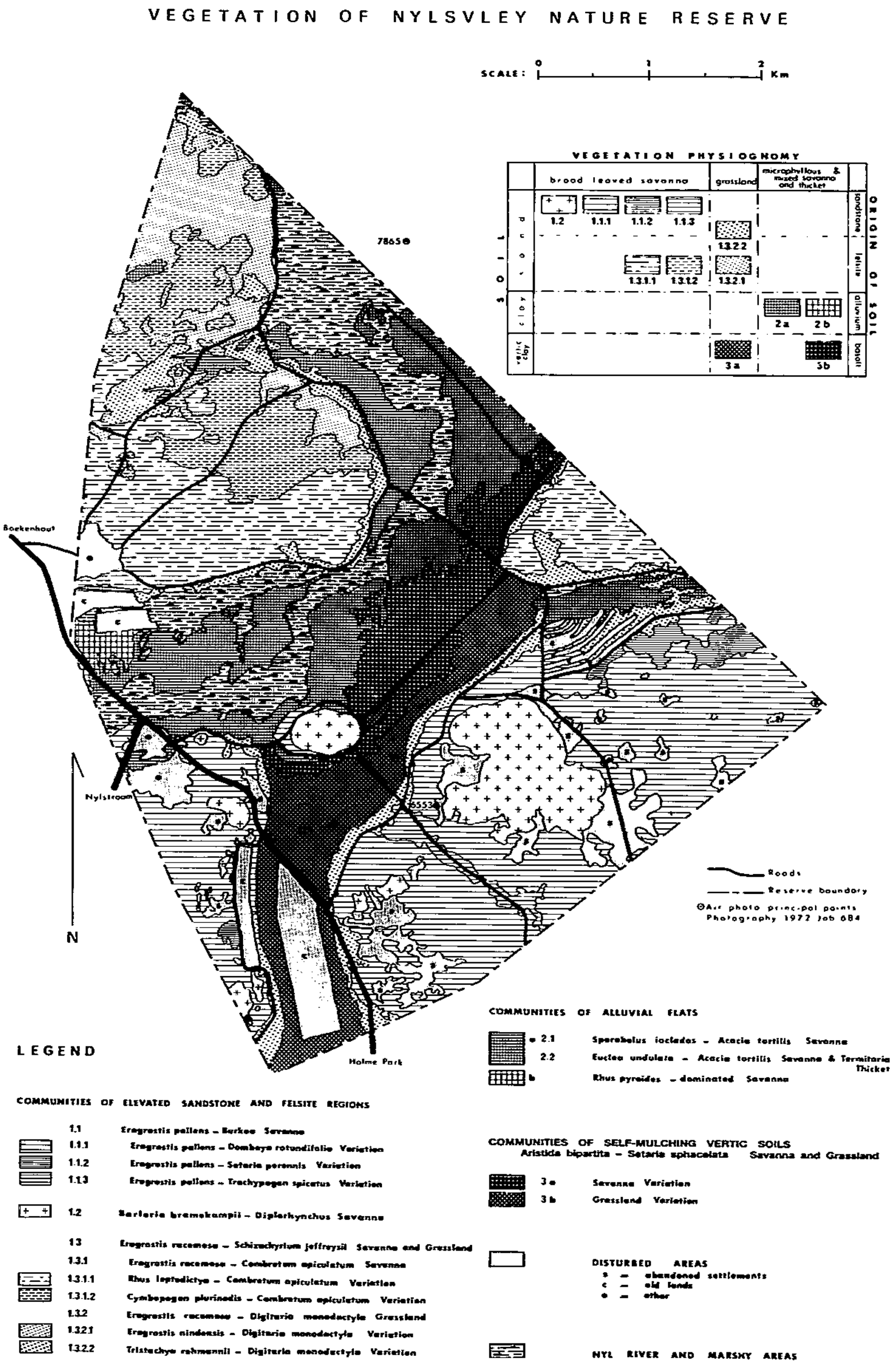

FIGURE 7. Vegetation of the Nylsvley Nature Reserve (from Coetzee et al 1976).

Euclea undulata-Acacia tortilis tree savanna and termitaria thickets

This community occurs on the lighter, less compacted and less brackish soils and on the termitaria. The vegetation on the termitaria forms dense, often impenetrable thickets with *Euclea undulata*, *Ziziphus mucronata*, *Pappea capensis* and *Carissa bispinosa* the most common species. *Kalanchoe lanceolata*, *Plectranthus cylindraceus* and *P neochilus* are typical differential species of the field layer. The vegetation on alluvium is dominated by *Acacia tortilis*, with *Carissa bispinosa* dominant in the shrub layer, and *Panicum maximum* and *Eragrostis lehmanniana* dominant in the field layer. A considerable number of other woody plants occur on the better drained soils along the levees of the floodplain, including *Cassine transvaalensis*, *Combretum erythrophloeum* and *Acacia robusta*.

Communities of self-mulching vertisols

These communities, classed as *Aristida bipartita-Setaria sphacelata* tree savanna and grassland, are closely related to the Black Turf Associations (Galpin 1926) of the Springbok Flats and occur on the same heavy, swelling calcareous clays. The vegetation consists mainly of grasses and forbs, with *Setaria sphacelata*, *Dichanthium papillosum*, *Scirpus dregeanus* and *Aristida bipartita* being the dominant species. Very few woody species occur. *Acacia karroo* and to a lesser extent *Ziziphus mucronata* are the most common of the species that are present but are confined largely to the drier sites on the edge of the vlei and on the crests of the gilgai mounds. The absence of woody elements reflects the seasonally high water table of these soils which tend to drown any woody seedlings.

Communities of abandoned settlements

Reference has previously been made to the plant communities occupying the eutrophic sandy soils situated on the pediments of Maroelakop and other rocky outcrops along the sandstone ridge. These open thorntree and grassland communities are differentiated by the grass *Eragrostis lehmanniana* and the forbs *Solanum delagoense* and *Crotolaria pisicarpa*. Among the trees, *Acacia tortilis*, *A nilotica*, *Dichrostachys cinerea* and *Sclerocarya caffra* are common. Despite the sandy nature of the soil, these communities show greatest affiliation with the communities of the clay-rich bottomlands and termitaria thickets, indicating the importance of soil nutrient status rather than soil texture in determining which plants will establish and maintain themselves on a given site.

The sharp difference seen at Nylsvley in particular and in the surrounding countryside in general, between those plant communities growing on acid, dystrophic or mesotrophic, noncalcareous sands and those occurring on alkaline, calcareous or eutrophic noncalcareous clays and loams, supports the distinction made by Huntley (1982) between the arid, eutrophic savanna formation on the one hand, and the moist, dystrophic savanna formation on the other. The differences extend also to the faunal communities and to the functional attributes of these systems (Huntley 1982; Huntley and Morris 1982). That these differences occur, at Nylsvley, within a single soil-landscape system, does not alter the validity of Huntley's argument. Instead, it serves to emphasize the importance of soil characteristics, particularly soil nutrients, in influencing the structure of the ecological communities that establish themselves on these different substrates, and their modes of functioning.

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