

PHYTOGEOGRAPHY AND BOTANY

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Vegetation formations in the Sudan are principally a function of the rainfall gradient (and hence of latitude), from the desert in the north to the humid zones of the south. Two additional factors, however, have an influence on the vegetation.

The first is the effect of altitude. The major hill masses cause more rain to fall than would be normally expected for a given latitude. Temperatures are also lower at altitude and further assist in reducing evaporative stress. Some species, notably *Themeda triandra* of the grasses and *Olea africana* among woody plants, only occur at altitude. Steep gradients cause a concentration of water along valleys, where woody vegetation may develop even along the desert edge, or close to rocky outcrops and run on areas totally devoid of any vegetation. At the higher altitudes there are some perennial grasslands.

Soil texture, through its influence on moisture availability, is the second major factor affecting vegetative composition. Water is more readily available to plants on sandy than on clay soils. Plants that habitually grow on sandy soils have root networks that penetrate deeper and extend over wider areas than do plants of clay soils. The gum arabic tree, *Acacia senegal* usually has roots longer than 20 metres and the root system of *Panicum turgidum*, a grass of arid sandy areas, is very well developed. Species richness is normally greater on sand than on clay soils and the use of soil water is more effective. Dominant species on clays are less dependent on the climate than those on sand and their active growth phase is shorter. Woody species are also more important on fine-textured clays than on coarser sands but they extend less far north than do those on sands. A similar phenomenon is seen with regard to cultivation, which is practised on sands where rainfall is as low as 350 mm but rainfed cropping does not go north of the 400 mm isohyet on the Nile clays.

THE VEGETATION OF THE SUDAN

The classification of the Sudan's vegetation by Harrison and Jackson (1958) - which is based on rainfall, altitude and soil type - is still the most detailed one available and remains the most widely used. The boundary between the semi-desert and the arid and semi-arid zones is put at 400 mm, to the north of which fine-leaved *Acacia* species and the small and hard-leaved species such as *Maerua crassifolia* and *Balanites aegyptiaca* dominate. South of the 400 mm line it is the large-leaved species such as the *Combretaceae* which predominate. Each phytogeographic region is further divided on the basis of major soil types and as a function of altitude.

Desert

Vegetation is largely absent in the desert with the exception of some oases in fossil valleys, where the Date Palm *Phoenix dactylifera* is the dominant species. Although many of the oases are gradually being covered by sand there are some surviving remnants, yet further endangered by the recent droughts, of riverine vegetation including *Acacia raddiana* and *A. tortilis*. The rare and unpredictable rainfall occasionally allows the growth of some small grasses including *Aristida papposa*, *A. plumosa* and *Triraphis pumilio*, as well as a few short-cycle dicotyledons.

In Northern Darfur, following some as yet imperfectly understood combinations of rainfall and temperature, an ephemeral vegetation type, known as "gizu", appears sporadically (Wilson, 1978). The principal plants of the "gizu" are *Tridigofera bracteolata*, *L. arenaria* and *Neurada procumbens*; in addition there are some *Zygophyllaceae* (including *Tribulus longipetalus* and *Fagonia cretica*), *Crotalaria thebaica* and some *Aristida* species. Formations identical to the "gizu" are also found in the south of the Libyan desert where, as in Sudan, they result from the influence of the Mediterranean climate and combinations of rain and the cool humid air masses moving southwards. The "gizu" is an excellent feed resource, especially for camels, and nomadic tribes from Sudan and Chad travel long distances in search of it. The plants of the formation do contain large quantities of moisture and animals are able to feed on it, sometimes for months on end, without the need to drink. In a good "gizu" year many thousands of animals flock to and produce in areas that are otherwise devoid of life. It is also an invaluable element in the long distance caravan trade. This spectacular vegetative formation has always impressed travellers and explorers, many of whom really credited it with too much importance, as its appearance is always irregular and limited in time and space. The "gizu" is not found in Kordofan except occasionally in very small areas between Jebel Tageru and Jebel El Eiq, in proximity to the *Aristida* and *Panicum* grasslands.

Semi-desert

Five formations have been described (**Harrison and Jackson, 1958**), two of which are grasslands related to soil type and three being scrubs related to geographical position.

Semi-desert grassland on clay

These grasslands are found in a triangle bounded on the south by a line from Ed Dueim to Kassala, by the line Na'aima-Abu Deleig, and by the Atbara River: they are most usually known as the Butana. The woody species, mainly *Acacia mellifera* and *A. nubica*, are found only in shallow valleys and slight depressions. The main field layer species are *Schoenefeldia gracilis*, *Sehima ischaemoides*, *Aristida* spp. and *Ipomoea* spp. This very flat area is only used during the rainy season.

Semi-desert grassland on sand

This formation is actually a shrub-grassland which is more or less continuous from Darfur to the Nile. The field layer is mainly composed of *Aristida* spp. (especially *A. plumosa*), *Panicum turgidum*, *Blepharis linariifolia*, *Trianthema pentandra*, some *Cyperaceae* and *Eragrostis tremula*. The most common shrubs are *Acacia raddiana*, *Leptadenia pyrotechnica*, *Boscia senegalensis* and *Acacia mellifera*. There are few perennial water sources and its main season of use, and principally by camels and goats, is during the wet season.

***Acacia tortilis* and *Maerua crassifolia* scrub**

Found on both sides of the Nile, this formation occurs on various soil types in a transition area between the semi-desert clays and the desert proper. Principal shrubs and small trees, in addition to the classificatory ones, include *Leptadenia pyrotechnica*, *Acacia mellifera*, *Capparis decidua*, *Balanites aegyptiaca* and *Salvadora persica*. *Aristida* is the dominant grass genus, with *Schoenefeldia gracilis* on clays. Most of this type of vegetation is concentrated in shallow depressions.

***Acacia mellifera* and *Commiphora* scrub**

This formation is discontinuous and occupies the less sandy and more variable areas in the west of Sudan. In addition to the nominate species there are *Maerua crassifolia* and *Boscia senegalensis* among the shrubs and *Schoenefeldia gracilis*, *Aristida plumosa* and *Panicum turgidum* in the field layer. Stony soils are characterized by *Lasiurus hirtus*, *Tetrapogon spathaceus* and *Chrysopogon aucheri*.

***Acacia glaucophylla* and *Acacia etbaica* scrub**

Found only on the eastern fringe of the semi-desert, this very distinctive formation occurs on the slopes of the Red Sea Hills. It is influenced to a considerable extent by the presence of the nearby Ethiopian highlands. In addition to the type species, *Acacia tortilis* and *Moringa aptera* are found, with *Phoenix reclinata* and several *Euphorbia* in the numerous valleys.

Low-rainfall savanna

Six vegetation communities occur north of 12°N but two are principally influenced by altitude and will be dealt with later. The first two of the remaining four units are on clay to the east of the country, the last two on sand in the west.

***Acacia mellifera* grassland on cracking clays**

This formation is found on the extensive clay plains in a rainfall area of between 400 mm and 570 mm per year. *Acacia mellifera* is accompanied by *Cadaba glandulosa*, *C. rotundifolia* and *Dicrostachys glomerata*. The grasses include *Cymbopogon nervatus*, *Sorghum purpureosericeum*, *Dichrostachys glomerata*, *Schoenefeldia gracilis*, *Setaria verticillata* and *Hyparrhenia pseudocymbaria*.

Acacia seyal/Balanites aegyptiaca savanna

Located to the south of the preceding formation these savannas are in a slightly better rainfall area. The two principal species are found with other acacias, including *A. mellifera*, *A. campylacantha* and *A. drepanolobium*. The field layer comprises various grasses, often fairly tall, and includes *Beckeropsis uniseta*, *Rottboellia exaltata*, *Ischaemum sp.*, *Brachiaria obtusifolia*, *Pennisetum ramosum* and *Setaria incrassata*. *Cymbogon nervatus*, *Rhyncosia memnonia* and *Heteropogon contortus* are also found in this formation.

Acacia senegal savanna

The gum belt occupies the sandy plateaux and the dunes of red sand. The woody layer is quite varied and representative of a typical sahelian habitat. *Acacia senegal*, *A. raddiana* and *Acacia nubica* occupy the dunes and the interdune hollows. Degraded areas are invaded by *Leptadenia pyrotechnica*, *Maerua crassifolia*, *Adansonia digitata* and *Calotropis procera*. The field layer, composed of *Aristida* species (especially *A. pallida* and *A. stipoides*), *Blepharis linariifolia* and *Crotalaria microphylla* is gradually transformed to a simple *Cenchrus biflorus/Eragrostis tremula* pasture under the influence of grazing. These areas are grazed during the rains by cattle and then during the dry season by the animals of the northern pastoral tribes. Cultivation in this zone is expanding and occupying more and more of the area.

Combretum savannas

In areas where rainfall exceeds 400 mm, between 11° and 13°N, this formation is predominant. Where not been subject to heavy cultivation there is a considerable cover of woody vegetation, including *Adansonia digitata*, *Acacia senegal*, *A. nubica* and *Boscia senegalensis*. Among taller broad-leaved trees are *Combretum glutinosum*, *Dalbergia melanoxylon*, *Albizia sericocephala*, *Terminalia laxiflora*, *T. brownii* and *Guiera senegalensis*. The field layer on sand includes *Cenchrus biflorus*, *Eragrostis tremula* and *Aristida pallida*. Capped areas and wetter soils have a field layer with *Brachiaria xantholeuca*, *Zornia glochidiata*, *Andropogon gayanus* and *Monechma hispidum*. Bare over-grazed soils are subject to severe erosion and are invaded by *Zornia glochidiata* and *Cassia tora*. This is an area that is simultaneously subject to very heavy grazing pressure - from both sedentary herds and commercial herds on their way to market - and to intense cultivation. The installation of water points everywhere has resulted in year-round use by all kinds of domestic stock.

Formations at altitude

Three formations are influenced by altitude to varying extents, although **Harrison and Jackson** (1958) classed the first two of them as semi-arid formations on clay. They are, however, clearly separable from the great clay plains of the Nile basin by their lack of monotony, more varied relief and different soil types.

Acacia mellifera and Commiphora africana on hill soils

This savanna formation occurs on the hills to the north of Jebel Marra and along its eastern slopes. Rainfall is low, about 300-500 mm per year, but vegetation is more abundant than in the arid zone and the husbandry system is not so nomadic. The commonest shrubs, occasionally in dense stands, are *Acacia mellifera*, *Commiphora africana* and *Boscia senegalensis*. Grasses include *Schoenefeldia gracilis*, *Aristida mutabilis*, *Brachiaria lata*, *Pennisetum pedicellatum* and *Setaria pallidifusca*: most of these are of excellent nutritional value.

Anogeissus leiocarpus/Combretum hartmannium savanna

This formation is found on the eastern subhumid hills which form the frontier area with Ethiopia. Rainfall is usually in excess of 800 mm per year. The soils are shallow, but fertile if formed on basalt, and the woody cover is sometimes quite dense. Woody species, in addition to those named in the formation title, include *Acacia seyal*, *Balanites aegyptiaca* and *Sterculia setigera*. The field layer is largely of *Hyparrhenia* (especially *H. pseudocymbaria*), *Andropogon gayanus*, *Schoenefeldia gracilis* and *Setaria incrassata*. Water is in plentiful supply at shallow depths and these pastures are an important dry season feed resource. The Dinder National Park occupies a large proportion of this formation.

Hill catena

Jebel Marra and its south-eastern extensions receive good rainfall and have a well developed surface and subsurface water network. They are ideal areas for livestock productivity and only a minimum of seasonal movement is required. The woody vegetation includes *Boswellia papyrifera*, *Combretum hartmannium*, *Sterculia setigera*, *Sclerocarya birrea*, *Adansonia digitata*, *Acacia nubica*, *Stereospermum kunthianum*, *Dicrostachys glomerata* and *Adenium honghel*. *Hyparrhenia* spp., *Beckeropsis nubica*, *Andropogon gayanus*, *Cymbopogon nervatus*, *Pennisetum pedicellatum* and *Schoenefeldia gracilis* are among the major grass species. The complex floristic composition results from the varied environment including the substrate of volcanic or Basement Complex origin and the changes that occur with altitude. The numerous valleys add another dimension to the vegetation of this area: *Acacia albida*, *A. sieberiana*, *Ficus* spp., *Tamarindus indica*, *Cordia abyssinica*, *Celtis integrifolia* and *Ziziphus mucronata* are the common trees while *Cynodon dactylon*, *Chloris pilosa* and *Sorghum lanceolatum* are conspicuous in the field layer.

Phytoecological classification

Some convergence in the descriptions of the vegetation communities that have just been described is evident. The overall environment has more influence on the vegetative composition than the simple factor of rainfall. The pseudo-steppes on the sandy soils and the *Acacia senegal* savanna thus have many components in common. The major differences occur on the different dune types: on recent dunes the pioneer species are *Leptadenia pyrotechnica* and *Panicum turgidum*, these being quickly succeeded by *Aristida pallida*, *A. plumosa* and *A. funiculata*; on older worn dunes *Acacia senegal* and *A. raddiana* occupy the summits. *Balanites aegyptiaca* is found on deeper clays, *Acacia nubica* in the loamy hollows and *Acacia mellifera* on shallow clays with the *Capparidaceae* (*Maerua crassifolia*, *Cadaba glandulosa* and *Capparis decidua*) being ubiquitous.

In a similar manner several species of the Sudan savanna, including *Salvadora persica*, the *Combretaceae* and the *Tiliaceae*, and even *Strychnos inocua*, are present on the edges of rocky areas in the Sahel zone. Here, also, the valleys are occupied by a more hydrophilous vegetation than the surrounding areas.

Geographical distribution

There is a tendency towards homogeneity in the vegetative formations independently of the climatic zones and, for example, trees such as *Balanites aegyptiaca* or *Acacia mellifera* can be locally dominant from the north to the south of the dry savanna area. The distribution of woody species in Kordofan illustrates this clearly (Table 1) and shows that many of them occur over a wide geographical area. Some environments are especially varied but the scale used for the map of necessity leads to some simplification in presentation and to a reduction in the number of communities classed. At the smallest scale it is usual to name communities after the so-called dominant and commonest species but which in themselves indicate only vaguely the type of environment in which they occur: at larger scales these plants are replaced in the community descriptions by species that are more characteristic of the environment.

Vegetation communities are usually complex. In 13 sample areas in the "Acacia tortilis/Maerua crassifolia desert scrub" the nominate species were only found in seven (Baumer, 1958). Areas with most woody vegetation were composed of *Acacia nubica*, *A. raddiana*, *Balanites aegyptiaca* and *Ziziphus spinachristi*. The field layer is dominated by *Tragus berteronianus* but *Eragrostis cilianensis*, *Schoenefeldia gracilis*, six species of *Aristida*, *Enneapogon brachystachyus*, *Heliotropium strigosum* and *Boehrvia repens* are also frequent species.

Other samples from *Acacia senegal* savanna showed the common occurrence of *Combretum glutinosum* and *Commiphora africana* with 10 other less frequent species. At most sites some 10 grasses are found, the commonest being *Aristida mutabilis*.

Samples in 23 subdesert valleys showed the regular and widespread occurrence of about 30 plant species, including seven *Acacia*, *Cyperus conglomeratus*, *Tephrosia nubica*, *Cymbopogon*

proximus, *C. nervatus*, *Chrozophora brocchiana*, *Indigofera semitrijuga*, *Aristida mutabilis*, *A. pallida* and *A. funiculata*, all of which are generally only found far to the south. This association, which usually also includes *Panicum turgidum* and *Neurada procumbens* on sandy-loam and gravelly soils, has been described previously (Queval, 1958).

Man-made degradation is leading to a certain uniformity in vegetation communities. The formation of *Tephrosia nubica*/*Aristida funiculata*, for example, is being transformed in areas where rainfall exceeds 500 mm per year to an open savanna grassland of *Cenchrus biflorus* and *Eragrostis tremula* which is similar to the long-term fallows of the area in which only a few *Adansonia digitata* and *Acacia albida* trees remain standing. The increasing appearance of species such as *Acacia nubica*, *Calotropis procera*, *Cenchrus biflorus* and some *Cassia* species is usually consequent on continuous overgrazing: it is well-known, for example, that the germination of *Blepharis linariifolia* is greatly assisted by the partial digestion process in the ruminant stomach and the subsequent evacuation in the faeces. Other examples of plants that appear when competition for plant feed resources and other requirements is reduced due to overgrazing and that are not there in response to natural conditions, are *Tribulus terrestris*, *Trianthema crystallina*, *Zygophyllum simplex* and *Z. coccineum*.

Table 1 -The ecological distribution of woody species in Kordofan

Characteristic trees and shrubs	ECOCLIMATIC ZONE AND SPECIES PRESENCE																
	Sahelo-saharan				Northern Sahel				Southern Sahel			Sahelo-sudanian					
	Recent dunes	Undulating sands	Sandy pediments	Loamy valleys	Stabilized dunes	Sandy pediplains	Rocky areas	Lacustrine limestone	Loam/clay deposits	Sandy pediplains	Shallow sands	Rocks laterite	Drainage lines	Sandy plateaux	Rock outcrops	Fertisols laterite	Clayey lowlands
<i>Leptadenia pyrotechnica</i>	1																
<i>Cabada glandulosa</i>		3															
<i>Capparis decidua</i>	2					1											
<i>Salvadora persica</i>	1		1			1											
<i>Euphorbia balsamifera</i>	2					1	2										
<i>Hyphaene thebaica</i>				3				3									
<i>Phoenix dactylifera</i>				2		2				2							
<i>Lonchocarpus laxiflorus</i>					1	3				1							
<i>Boscia senegalensis</i>						3											
<i>ziziphus mauritanicus</i>						1				3							
<i>Combretum glutinosum</i>						1	1	1	1	3							
<i>Acacia laeta</i>						1											
<i>Commiphora africana</i>						3				3	3						
<i>Acacia ehrenbergiana</i>			2					2				2					
<i>Acacia raddiana</i>	1			1			3				3	2				2	
<i>Balanites aegyptiaca</i>				2				4					3				
<i>Pterocarpus lucens</i>										2							
<i>Combretum aculeatum</i>										1	2						
<i>Grewia spp.</i>							1					1					
<i>Acacia nubica</i>								2		1	3	1	1				
<i>Faidherbia albida</i>									2				3				
<i>Maerua crassifolia</i>		3														1	
<i>Acacia tortilis</i>		1	1	3		1	1		1	1				3			
<i>Guiera senegalensis</i>						4				3		1	1	1			
<i>Calotropis procera</i>						2				2				2			
<i>Adansonia digitata</i>							1				1		3	1			
<i>Acacia mellifera</i>				1				2					3			2	
<i>Sclerocarya birrea</i>						1	1	1	1			1			1		
<i>Acacia senegal</i>						1							1				
<i>Acacia seyal</i>									1	3	2		3				
<i>Piliostigma reticulatum</i>														1			1
<i>Boscia angustifolia</i>										2				4			4
<i>Sterculia setigera</i>										1						1	
<i>Anogeissus leiocarpus</i>										3				3		3	
<i>Terminalia brownii</i>																	
<i>Feretia podanthera</i>												2					
<i>Dalbergia melanoxylon</i>											1			1			
<i>Strychnos inocua</i>												2			2		
<i>Bauhinia rufescens</i>											1				1	1	
<i>Lannea africana</i>														3			
<i>Cordia abyssinica</i>														2			
<i>Kigelia africana</i>															1		2
<i>Albizzia spp.</i>																2	
<i>Terminalia avicennoides</i>																3	
<i>Acacia sieberiana</i>																	2

Key : 1 = sparse occurrence; 2 = local occurrence; 3 = frequent; 4 = very frequent. (source.: Michel Baumer, pers. comm.)

Species composition and physiognomy

Vegetation community descriptions can be expressed in various ways, depending on the way the information has been collected and the type of output desired. Some of the information available for the vegetation of the Sudan provides an opportunity to look at complementary classifications. This is the case for the complex associations of Jebel Marra and its southwestern extensions (Table 2), which have been described earlier in this section as the Hill Catena. The first description is botanical in concept and attempts to differentiate among characteristic local vegetation communities (it is important here to note the importance of *Anogeissus leiocarpus* - which is not even mentioned by **Harrison and Jackson** (1958) - and of *Acacia mellifera* on less favourable soils, whether these are of volcanic or Precambrian origin).

Table 2a - Vegetation units in the Jebel Marra area

Location	Soil type	Vegetation units
Jebel Marra massif	Volcanic formation	Upland grasslands and meadows
Jebel Marra slopes	Eastern volcanics Ash piedmont	<i>Acacia mellifera</i> shrubland <i>Combretum glutinosum</i> and <i>Terminalia laxiflora</i> or <i>Acacia albida</i> open savanna
Major valleys	Alluvial soils	<i>Acacia albida</i> and <i>Balanites aegyptiaca</i> riverine woodlands
Western hills	Basement complex	<i>Anogeissus leiocarpus</i> and <i>Boswellia papyrifera</i>
Lower slopes	Basement complex	<i>Anogeissus leiocarpus</i> savannas or <i>Acacia seyal</i> and <i>Anogeissus leiocarpus</i> mosaic
Drier areas	Basement complex	<i>Acacia mellifera</i> and <i>Anogeissus leiocarpus</i> or <i>Acacia mellifera</i> savannas
	Indurated soils	<i>Acacia mellifera</i> and <i>Commiphora africana</i>
	Aeolian sands	<i>Acacia senegal</i> and <i>Combretum glutinosum</i>
Western plateau	Clay soils	<i>Acacia seyal</i> and <i>Balanites aegyptiaca</i>
	Sandstone	<i>Combretum glutinosum</i> and <i>Guiera senegalensis</i>

Source: Wickens 1976

Table 2b - Environmental units in Darfur

Topography and geomorphology	Soil type	Vegetation
Volcanic steep mountain cover	Deep dark soils	Open woody and medium grass
Basement hills	Shallow grey or pink	Dense woody cover in the southern part, scattered <i>Acacia</i> and <i>Commiphora</i> in the north
Jebbel Mara slopes	Volcanic soils with outcrops and stones	Dense vegetation
Lower slopes	Basement complex with red soils	Dense woody cover; <i>Acacia</i> woodland and bush associations with <i>Acacia mellifera</i>
Valleys	Dark brown soils and black alluviums	Thorn thickets or medium woody and tall grass
Valleys (southern)	Black and grey alluviums	Riverine grassland, medium cover of <i>Acacia</i> , <i>Combretum</i> , <i>Balanites</i> and <i>Acacia seyal</i> thickets
Drier areas, Basement	Pink and red soils, sometimes eroded	Sparse grassland and scattered to dense <i>Acacia</i> and <i>Commiphora</i> cover
Western plains	Black and grey clays	Tall grassland with <i>Acacia</i> , <i>Balanites</i> trees and thorn thickets

Source: Hunting Technical service 1968

The most detailed descriptions are those relating to the higher altitudes on volcanic soils, where five clearly differentiated types are found. In the same work all the valley communities are classed as a single unity.

In the second type of description the environment is defined on the basis of aerial photographs and more emphasis is placed on cover density. The whole of the volcanic mountainous area appears as an area that is well covered with grass with rather dense woody vegetation on the slopes but very open on the summits. The valleys are classified as those on the northern slopes, which are mainly of *Acacia*, and the more variable ones of the southern slopes. The lower hills of the Basement Complex appear as fairly uniform savannas of *Acacia* and *Commiphora*, except close to Jebel Marra, but with some differences related to latitude.

A comparison of these two types of description emphasises the need to take into account local influences such as the underlying geology, type and colour of soil, topographic position, relief, and the steepness of the slopes. The factors mentioned are also closely related to land use and to the

nutritional value of the feed resources. This information is essential if a simple description that only takes into account climatic factors and botanical composition is to be modified and made useful in the estimation of its pastoral value. The ecological description is also a permanent and stable factor that is independent of climatic fluctuation and changes in the vegetation.

The value of an ecological description can be shown by a study of the *Acacia mellifera*/*Schoenefeldia gracilis* formation on fine structured soils in the Sahelian and Sudano-Sahelian zones. This formation, in the north, is found in clayey depressions, in which it is very dense and difficult to penetrate and where it is surrounded by *Acacia nubica*. In the south it is found, for example, on the foot slopes of the Nuba Mountains in association with a variety of woody species including *Commiphora africana*, *Combretum aculeatum*, *C. kordofanum*, *Guiera senegalensis* and *Terminalia brownii* and field layer species including *Beckeropsis nubica*, *Cyperus rotundus* and *Setaria verticillata*. A vegetation census in the El Ain Forest Reserve near El Obeid (Baumer, 1968) showed a total of 600 trees and shrubs per hectare of which 160 were *Cadaba glandulosa*, 160 *Grewia granosum*, 60 *Acacia mellifera*, 95 *Combretum aculeatum* and 80 *Dicrostachys glomerata*, all rising above a dense field layer of *Schoenefeldia gracilis*, *Cymbopogon gracilis* and *Aristida adscensionis*. This kind of formation is subject to intense use for charcoal making, particularly the *Acacia mellifera*, and heavy grazing which favours the development of fine-leaved grasses such as *Eragrostis pilosa*, *E. tremula*, *E. ciliaris*, *Chloris prieurii*, *C. ciliata* and *C. gayana*. The last stage is now much more in evidence around El Obeid than the original formation. A knowledge of the soil type and the topography, however, provides a better indication of what the land would be capable of than can be gleaned from the current vegetation cover.

The pastoral map

A pastoral map must indicate the grazing value of the different areas and is therefore neither a vegetation map nor a simple physiographic one. The map takes account of such factors as the livestock production system. Within that system the degree of mobility or sedentarization, the species of animals and their levels of production, the degree of common or complementary use with adjacent areas, and the kind of association that the livestock system has with the cropping system need to be taken into account. A pastoral map is thus also an indicator of land use potential and indicates the likely primary production that can be used by livestock, the area in which it is available, and its ability to withstand grazing. In particular the map should indicate the best grazing areas.

Livestock feed resources

Certain areas make an important, indeed an essential, contribution to the value of a zone in its role as a pastoral area: these include the valleys and all the areas that have a favourable moisture status. The classifications presented above have mainly taken account of the dominant vegetation types with little consideration for the great variation which is found within these large units and without which most areas would be of little value for pastoral production.

There are several ways of classing an area (Table 3). For part of Kassala Province, for example, it is possible to compare the original classification (Harrison and Jackson, 1958) with two later ones, one (FAO, 1978) of which is also based on vegetation types, the other (Gibb, 1968) on soil units. In the most detailed description of the vegetation, grasslands as such have disappeared from the classification in favour of a description that includes trees and shrubs and a field layer that increases in species richness from north to south. The subdivision of *Acacia mellifera* on clay soils into two units is an indication that the *Acacia seyal*/*Balanites aegyptiaca* formation on clay is not strictly confined to the southerly areas: riverine formations as well as those in slight depressions are also given some importance and the total number of vegetative units is doubled.

The classification based on soils provides 18 different units and demarcates five clay plain types in addition to the drainage lines. The fact that one of these is susceptible to erosion or to capping indicates that moisture status varies and that there are differences in the growth periods of the vegetation. The undulating plains are more varied and for the most part are occupied by *Acacia mellifera*: they are complemented by alluvial depressions which allow the whole area to be grazed over a longer season. While the vegetation itself is not affected by this classification, the distinction is important for grazing management.

The Atbara River valley is subdivided into a flood plain and the degraded and fragile areas on the lower and upper terraces, which separate the river valley from the clay plains. The subdesert

pastures to the north include some depressions and drainage lines, the vegetation of cannot be classified as a result solely due to sandy and rocky areas which cover most of it and on the basis of which its value as a feed resource would be much lower.

Table 3 - Environment and vegetation in Kassala Province

Harrison and Jackson 1958	Source	
	FAO 1978	Gibb 1968
<i>Acacia tortilis</i> - <i>Maerua crassifolia</i> desert scrub	North-western semi-desert and bare areas, <i>Acacia raddiana</i> and <i>A. ehrenbergiana</i> , <i>Aristida</i> spp.	Desert pediplain, <i>Aristida</i> spp <i>Wadi alluvium (grass)</i> Closed clay plain Dunes and sandsheets, <i>Capparis decidua</i> and <i>A. raddiana</i> Gash depression Sand sheets, dunes and interdunal bare flats
Semi-desert grassland on clay	Semi-desert on sand, <i>A. raddiana</i> and <i>A. tortilis</i> , <i>Leptadenia</i> , <i>Maerua crassifolia</i> , <i>Capparis</i> , <i>Panicum turgidum</i> Semi-desert on clay <i>A. nubica</i> and <i>A. mellifera</i> , <i>Schoenefeldia</i> , <i>Blepharis</i> khasm-el-Girba and Gash schemes Riverine vegetation, <i>Capparis</i> , <i>Calotropis</i> , <i>Hyphaene</i> , <i>Acacia</i> spp.	Aggradational north central clays plain, grass and herbs <i>Wadi alluvium</i> Semi-desert aggradational clay plain; semi-desert degradational clay plain; gently undulating degradational clay plains (<i>Acacia mellifera</i>) Aggradational south-central clay plain (<i>A. seyal</i> and <i>A. nilotica</i>) Isolated hills
<i>Acacia mellifera</i> on cracking clay, alternating with grass areas	<i>Acacia mellifera</i> thornland, with <i>Acacia nubica</i> , <i>Balanites</i> , <i>Cadaba rotundifolia</i> , <i>Cymbopogon</i> , <i>Sorghum</i> , <i>Sporobolus helvolus</i> <i>Acacia savanna</i> (<i>A. seyal</i> , <i>A. senegal</i> , <i>A. mellifera</i> , <i>A. nubica</i> , <i>Balanites</i> , <i>Cymbopogon nervratus</i> , <i>Sorghum</i> spp. <i>Hyparrhenia</i>)	Degradational clay plain (<i>A. mellifera</i>) Lower and Upper "Kerrib" (<i>A. seyal</i> , <i>A. raddiana</i> , <i>A. ehrenbergiana</i> , <i>Capparis</i> , <i>Calotropis</i>) Atbara flood plain (<i>Hyphaene</i> , <i>A. ehrenbergiana</i> , <i>Capparis</i>)

When mapped at a scale that is useful for pasture management purposes it can be seen that these areas are more complex than would be indicated by a purely botanical description. The valleys in the semi-desert are in fact very useful pasture areas (Baumer, 1968) and include *Acacia raddiana* and *A. tortilis* in the browse layer and *Cymbopogon proximus*, *Panicum turgidum*, *Tragus berteronianus*, *Aerva javanica*, *Eragrostis cilianensis* and *Schoenefeldia gracilis* in the field layer: in the more sandy valleys *Demostachya bipinnata*, *Aristida* spp. *Indigofera arenaria*, *I. hochstetteri*, *Tephrosia vicioides*, *Schmidia pappophonoides* and *Ischaemum afrum* are also found. There are also small depressions with *Sorghum sudanense*, which can grow as tall as 2 metres on a rainfall of as little as 150 mm, and even though these areas are very small their contribution to livestock nutrition is very important, particularly in view of the fact that this grass is high in salt content and is a favourite animal feed.

A practical pastoral classification

The classification decided upon for the 1:500 000 map is based to some extent on climatic factors but also includes a large number of those just discussed. The division between the hyper-arid and the arid (or Sahelian *stricto sensu*) zones falls at about the 200 mm isohyet. This is not because the vegetative composition changes at this limit but because of the implication that there are small areas of useful pasture to the north of the line whereas south of it there are much larger contiguous areas of good grazing. The other major climatic distinction is put at 350 mm on sands and 400 mm on clays because these are the limits of rainfed cultivation as seen on the satellite images. In the western mountainous areas (where geology, topography and substrate are much more important than rainfall) the use of rainfall isohyets has been discarded in favour of a more general description. The small area of the Nuba Mountains included on the map and the wetter hills of the south-east have not been classed separately from the areas around them as they form of continuum with these and are much less influenced by the altitudinal effects than are the mountainous areas in Darfur. To the north of the 12th parallel of latitude **seven major grouping** have been distinguished:

- D:** The desert and the Red Sea Hills. The desert in the strict sense has been restricted to those vast areas where there is no vegetation at all except in the few valleys and at the bases of hills (and these can be seen clearly on the images where it has previously been considered that there was absolutely nothing). Included in the desert are the inhospitable hills in the extreme north-east of the country, again with vegetation only in the valleys, and which are almost totally unused. It needs to be noted, however, that the valley vegetation in the north-east, mainly *Acacia glaucophylla* and *Aristida acutiflora*, differs from that in the rest of the desert area.
- X:** The very arid or Saharo-Sahelian zone. Feed resources are irregularly scattered in the almost totally bare sand and rock desert areas and are almost confined to the more favoured valley sites. The zone is grazed only during the rainy season by camels and small ruminants: these travel long distances, mainly along the wadi beds, from their dry season bases that are perhaps several hundred kilometres to the south. The main woody species are *Acacia raddiana* and *A. tortilis* with an understorey of *Panicum turgidum* and *Aristida plumosa*.
- A:** The arid or Sahel zone. As for the previous zone, this is essentially a wet season grazing area but is also used by cattle. Areas with capped soils and those shallowly covered with blown sand are the only ones that are devoid of vegetative cover. The whole zone is mainly sandy dunes in various stages of development and with a vegetation that changes from year to year. The main plant species are *Acacia senegal*, *Commiphora africana*, *Aristida mutabilis* and *Cenchrus biflorus*.
- L:** The arid clay plains. The growing season is usually shorter than that of the previous zone, and the whole area presents a monotonous uniformity except around its edges. Pastoral use is often opportunistic, without any regular pattern, and adapted to a feed resource that varies greatly from one year to the next. *Acacia mellifera*, *A. nubica*, *Cymbogon nervatus* and *Aristida adscensionis* are the dominant plant species.
- S:** The semi-arid or Sudano-Sahelian zone. This is the classic pastoral area in which cattle predominate and where they are often sedentary. There are also some camels which are present more by historical accident than because this is a zone that is favourable to them. Once well-wooded, the zone is now very much degraded with many poor quality grasses in the pastoral areas and on old fallows. The typical woody plants are *Combretum* and *Albizzia* with *Schoenefeldia gracilis* and *Eragrostis tremula* in the understorey.
- C:** Semi-arid clay plains. Modern cultivation techniques have turned this semi-arid to subhumid zone into one in which very few grazing areas remain. Rainfall on the southern border is as much as 800 mm per year. Except for areas on basalt or at higher altitudes the vegetative cover is not as dense as in 'S' and *Acacia seyal* and *Balanites aegyptiaca* are associated with *Sorghum* and *Hyparrhenia species*.
- M:** The high altitude zone. This is a major livestock production area where, because of the varied soil types and the numerous valleys, short distance movements prevail. Changes in vegetation are more in response to altitude than to latitude. The most common plants are *Anogeissus leiocarpus*, *Acacia albida*, *Aristida funiculata* and *Setaria* spp.

Within each of the above zones it is possible to group the various vegetation associations as a function of the major landscape units which are themselves usually identified as having a specific physiognomy or relief. The map legend includes pastures of type 'R' which are found on the

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summits, slopes and foothills of the hills and mountains (whether volcanic, Pre-cambrian or of sandstone) and also on the rocky peneplains, stony desert and sometimes on shallow sands. The 'S' units are on sandy plains and plateaux and here a directional mark indicates the alignment of the dunes. A letter 'C' in second position indicates fine textured loam or clay soils on flat land or barely distinguishable slopes with compact or capped soils of very poor drainage capacity: the direction of valleys and depressions is indicated by a 'V' and the major vegetation forms are retained.

The species of vegetation used to characterize the various units, whether they be woody or herbaceous plants, represent a compromise between the dominant plants (which would probably be found in most of the units in the same area) and those that are truly characteristic but not necessarily very frequent, and which may also disappear under the influence of man and his animals. The mapped units reflect the need to distinguish a number of pastoral units at a small scale within a geographically- defined vegetation association: it is necessary, when using the map, not to dissociate the plant species used as indicators from those which are dominant in the same area.

Acknowledgements

The Editors are grateful to all who helped to make this pastoral map possible, and especially to **Michel Baumer** who allowed the use of his many personal papers on the Sudan savannas.



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