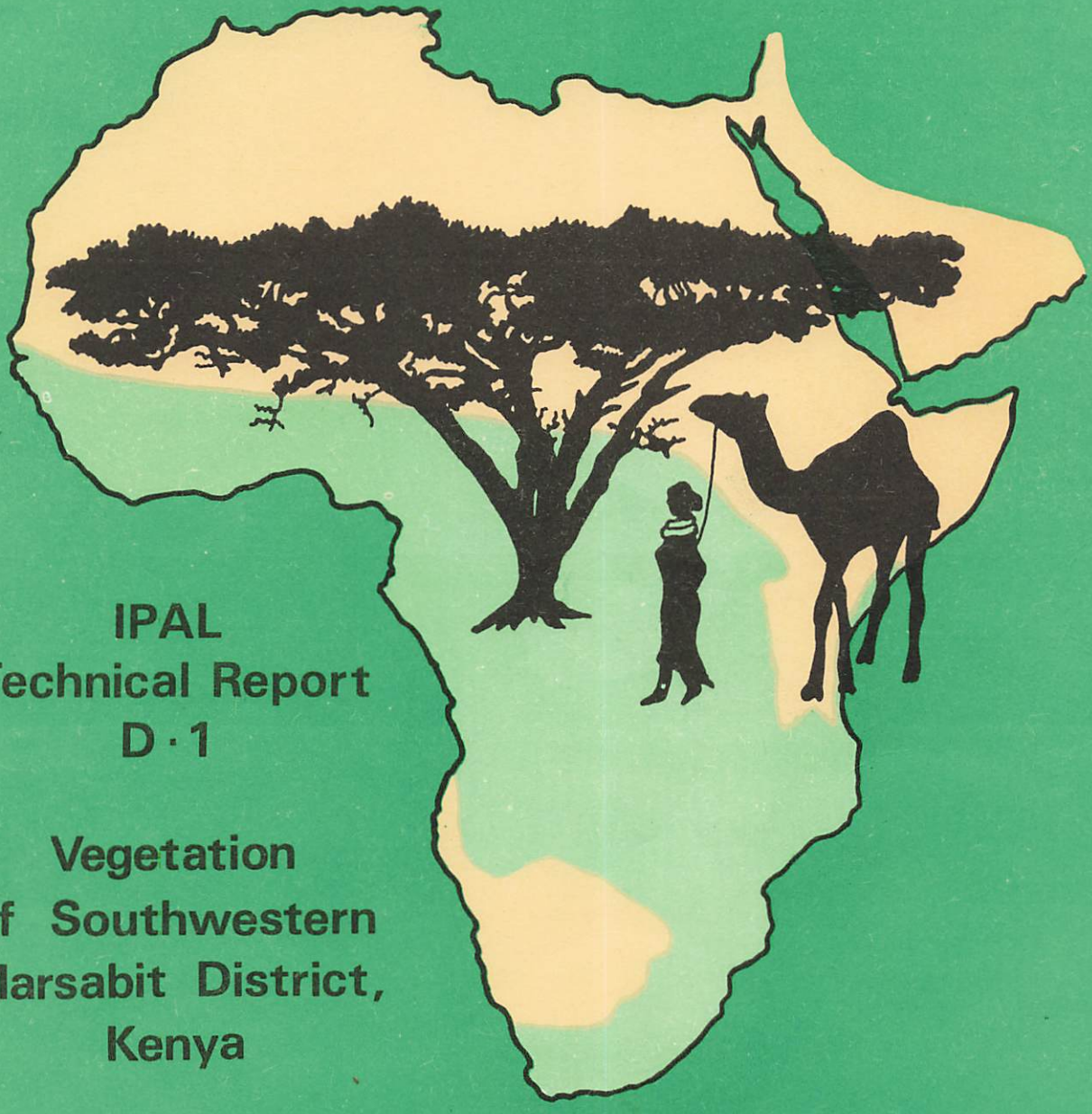
Unesco Programme on Man and the Biosphere (MAB)

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Integrated Project in Arid Lands (IPAL)



IPAL Technical Report D·1

Vegetation of Southwestern Marsabit District, Kenya

MAN AND THE BIOSPHERE PROGRAMME

Project 3: Impact of Human Activities and Land Use Practices on Grazing Lands

IPAL Technical Report Number D - 1

VEGETATION OF SOUTHWESTERN MARSABIT DISTRICT, KENYA

by

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UNEP - MAB Integrated Project in Arid Lands

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Summary Introduction to IPAL and the Technical Report Series

The Integrated Project in Arid Lands (IPAL) was established jointly by UNEP and UNESCO in 1976 with the aim of finding direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. It forms part of the operations under MAB Project 3, the Secretariat of which is jointly held by UNESCO and FAO, and also those of UNEP's Desertification Unit, established in response to the plan of Action adopted by the United Nations Conference on Desertification. It is an example of the type of pilot activity that UNEP and UNESCO, together with other organisations and a number of governments, are trying to promote to provide the scientific basis for the rehabilitation and rational development of arid and semi-arid zone ecosystems, through integrated programmes of research (including survey, observation and experimentation), training and demonstration.

During the early operational work of IPAL, a co-ordination unit was established in Nairobi and the initial field-work started in the arid zone of northern Kenya, where a field station has been constructed on the lower slopes of Mount Kulal and a working area demarcated between Lake Turkana and Marsabit Mountain. Work was started on several aspects of the ecology and experimental management, centred upon the interaction of pastoralists and their livestock with the soils and vegetation of the environment.

During the next two or three years (1979 - 1982), the investigations in progress will be extended and intensified. Initially, new activities within the IPAL project will be started in Tunisia, to be followed by other areas in the arid zone of Africa and the Near and Middle East.

This report is one of a series published by IPAL describing technical findings of the project and, where appropriate, giving management recommendations relating to the central problems of ecological and sociological degradation in the arid zone. The reports are divided into the following categories distinguished by the base colours of their covers:

A. general, introductory and historical: white

B. climate and hydrology: blue.

C. geology, geomorphology and soils: brown.

D. vegetation: green.

E. livestock and other animal life: red.

F. social and anthropological: yellow.

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VEGETATION OF SOUTHWESTERN MARSABIT DISTRICT, KENYA

1. Introduction

In order to provide a scientific basis for rehabilitation and rational development of arid and semi-arid ecosystems it is necessary to first collect information on their basic ecological attributes.

Vegetation is a particularly important ecosystem component because of its value in soil stabilization and primary production. It is the major support of the grazing/browsing systems which are adapted to arid and semi-arid areas.

Baseline information is required on the following vegetational attributes: type, location, extent, abundance, quality and dynamics.

The first three attributes when combined give an adequate first approximation of the nature and importance of an area's vegetation. Knowledge of vegetation type allows application of management and research experience elsewhere within this type to the present situation. Further, as vegetation integrates all environmental factors acting on a site, knowledge of vegetation type may be used to make inferences about prevailing environmental patterns. Location of a vegetation type or stand obviously affects its importance relative to present or planned management and research activities. Topographical position or situation along some other kind of environmental gradient affects the basic ecological status of vegetation. Extent is an indication of abundance.

The three vegetational attributes; type, location and extent are best expressed in combination as a vegetation map. The map delineates land units of relative ecological homogenity and provides the basic stratification of a major ecosystem component required for planning of further managment and/or research.

Thus, the preparation of a vegetation map is one of the most important initial steps in the establishment of a program of research and management in arid/semi-arid ecosystem.

2. Environmental factors

2. 1 Climate

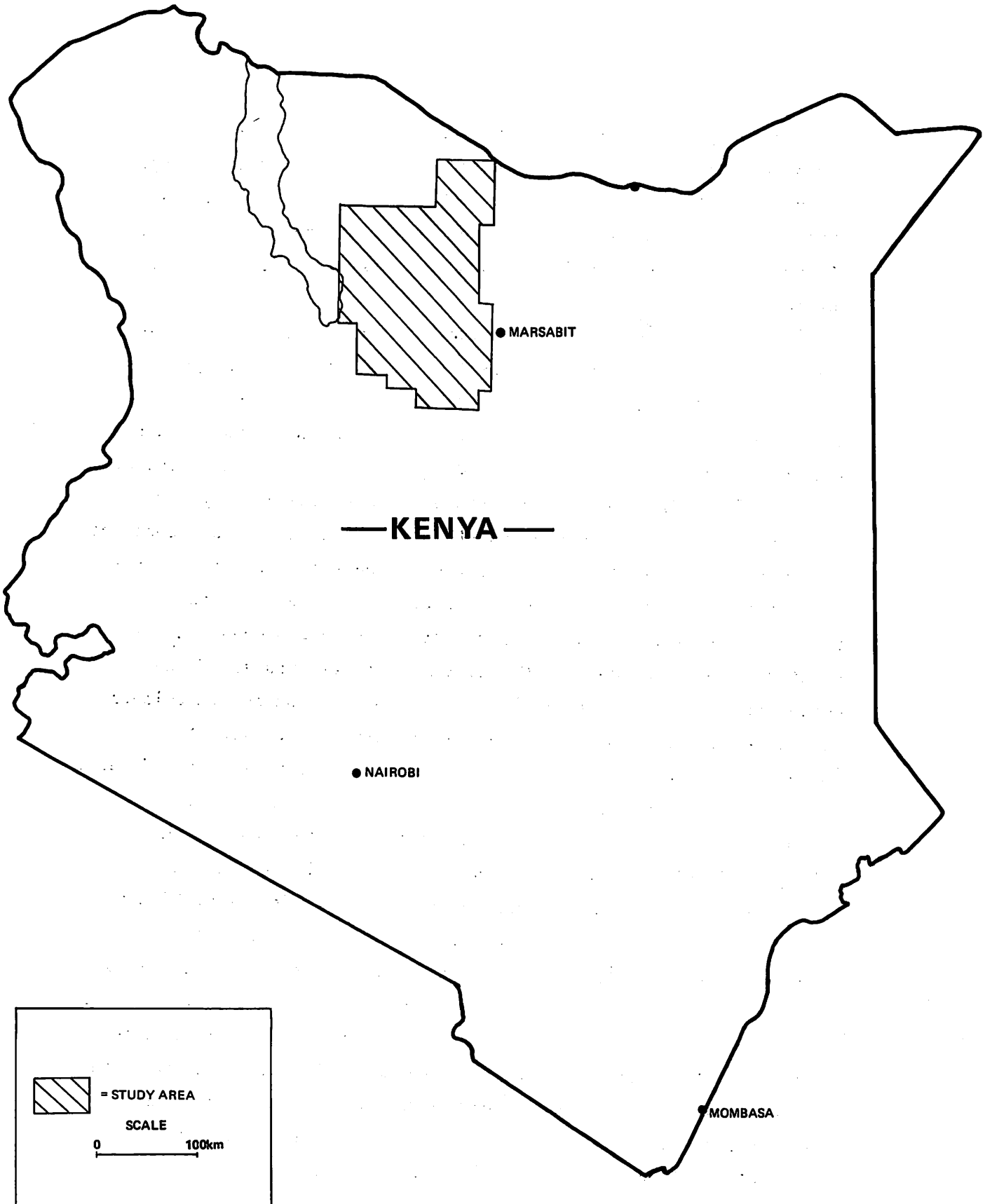
The study area (Figure 1) lies within a large climatic region — the most arid in East Africa — affecting Somalia, northern Kenya and eastern Ethiopia (Griffiths, 1969; Nieuwolt, 1977). It is characterized by large scale divergences of air masses belonging to the northeast and southeast monsoonal systems (Nieuwolt, 1977; Edwards, et al, 1979).

The northeast monsoon originates over Arabia and passes over Somalia before reaching the study area from December through March. This typically divergent stable flow of hot, dry, air masses results in little rain (Nieuwolt, 1977) except for a short season of relatively low rainfall during October — November (Edwards, et al, 1979). The flow of one branch of this monsoonal system westwards between the Kenyan and Ethiopian highlands causes constant and, often, high winds within the study area (Edwards, et al, 1979)

Rainfall is most apt to occur under the influence of the southeast monsoon, which originates over the Indian Ocean and is relatively cool and moist. Convergence with air masses of the northeast monsoon, or orographic lifting of its own moisture-laden air masses by large mountains within the study area, lead to instability, cooling, and subsequent rainfall. However, considerable divergence of air masses occurs during this period as well because of the strong influence of climatic factors as far away as the Ethiopian Highlands and India. Hence, even during the greatest influence of the southeast monsoon, rainfall is often low, highly variable, and of short duration (Nieuwolt, 1977) — occurring primarily during April within the study area (Edwards, et al, 1979).

Most moisture laden air arrives from the southeast so orographic rainfall is concentrated on the southeastern flanks of mountains, especially at higher elevations. Subsequent air flow over mountain summits results in descending, divergent, warming and drying air masses which create rain shadows on the mountains' west and northwestern flanks (Nieuwolt, 1977; Edwards, et al, 1979).

Fig. 1 LOCATION OF STUDY AREA



Rainfall within the study area, particularly at lower elevations, is typically low (Figure 2). For instance, North Horr, the only station below 1,333m elevation with long term rainfall records, has a mean annual rainfall of 150mm (1961 - 1967) (Edwards, et al, 1979).

Potential evaporation, however, is high, exceeding 2600mm annually over most of the study area (Woodhead, 1968; Dagg, 1969). Plant-exploitable mean precipitation is less than 10 percent of potential evaporation (Woodhead, 1970). Thus, the water that does not run off is soon returned to the atmosphere through evapotranspiration.

With increasing elevation rainfall amount and duration increases while variability decreases. This reflects associated trends of decreasing temperature and increasing cloudiness, which also result in decreasing potential evaporation (Griffiths, 1969; Edwards, et al, 1979). For instance, rainfall on Marsabit Mountain (1965m elevation) averages 944mm annually (1918 - 1977) (Edwards, et al, 1979), while potential evaporation is 1800 - 2200mm annually (Woodhead, 1968) and plant-exploitable mean precipitation is 40 - 50 percent of potential evaporation (Woodhead, 1970).

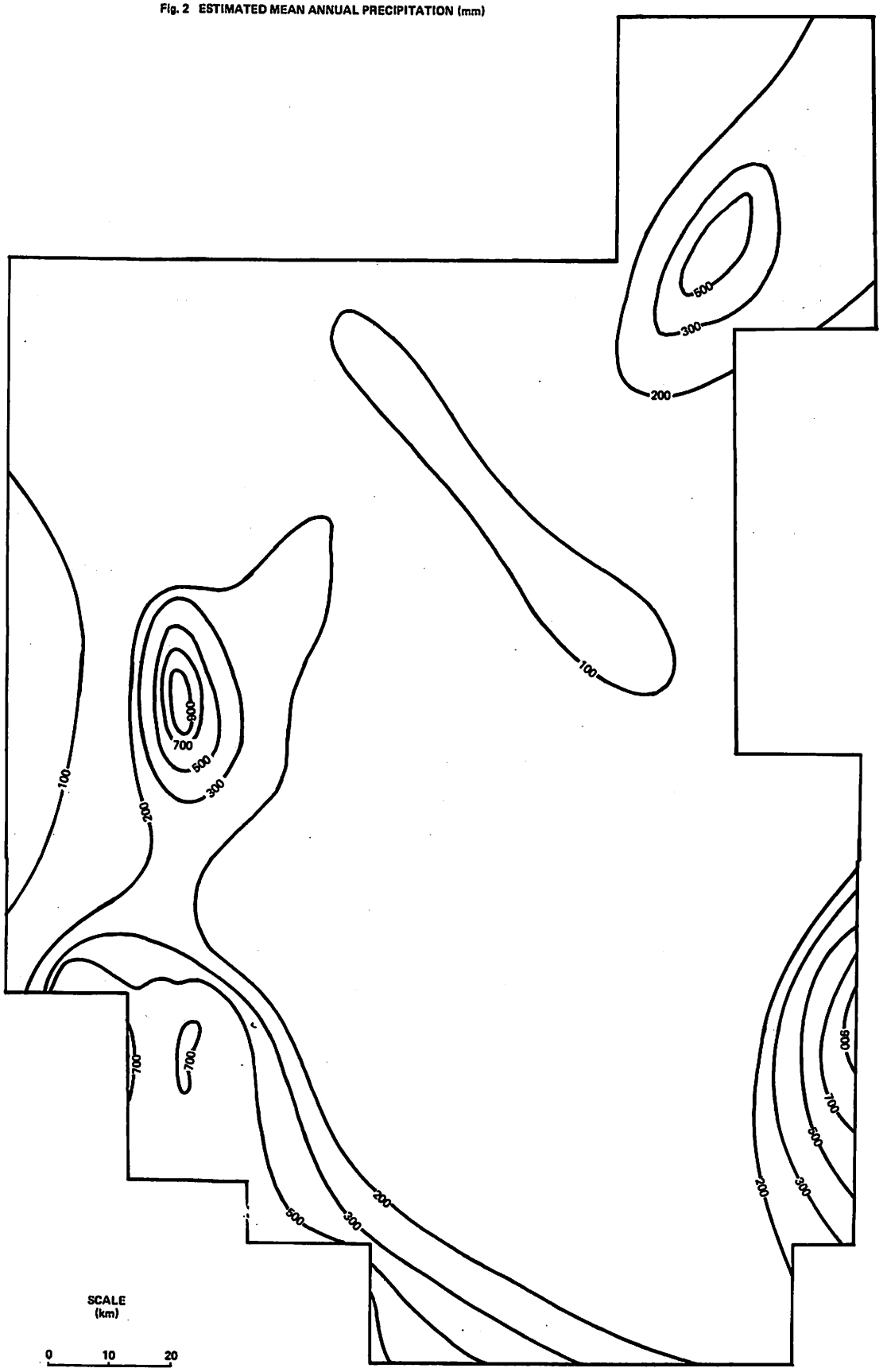
Rainfall is typically variable and often of high intensity (Edwards,et al, 1979). Thus, surface runoff and soil erosion rates are probably high.

Thus, most of the study area has been classified as being within the semi-desert eco-climatic zone (Pratt and Gwynne, 1977). On the major mountains the climate becomes moister with increasing altitude, culminating in the very small areas on mountain summits which lie within the montane forest eco-climatic zone (Pratt and Gwynne, 1977).

2. 2 Geology

Only a small percentage (11%) of the study area has undergone a geological survey and that has been along the southern boundary (Baker, 1963; Dodson, 1963; Randel, 1970). A further geological survey of the east Rudolf area (Vondra and Bowen, 1976) was close enough to the study area boundaries to allow extrapolation of some of its information into the northwestern portion of the study area.

Fig. 2 ESTIMATED MEAN ANNUAL PRECIPITATION (mm)



Two major geological formations occur within the study area; pleistocene basaltic lavas and quaternary sedimets (Saggerson,1969) (Figure 3).

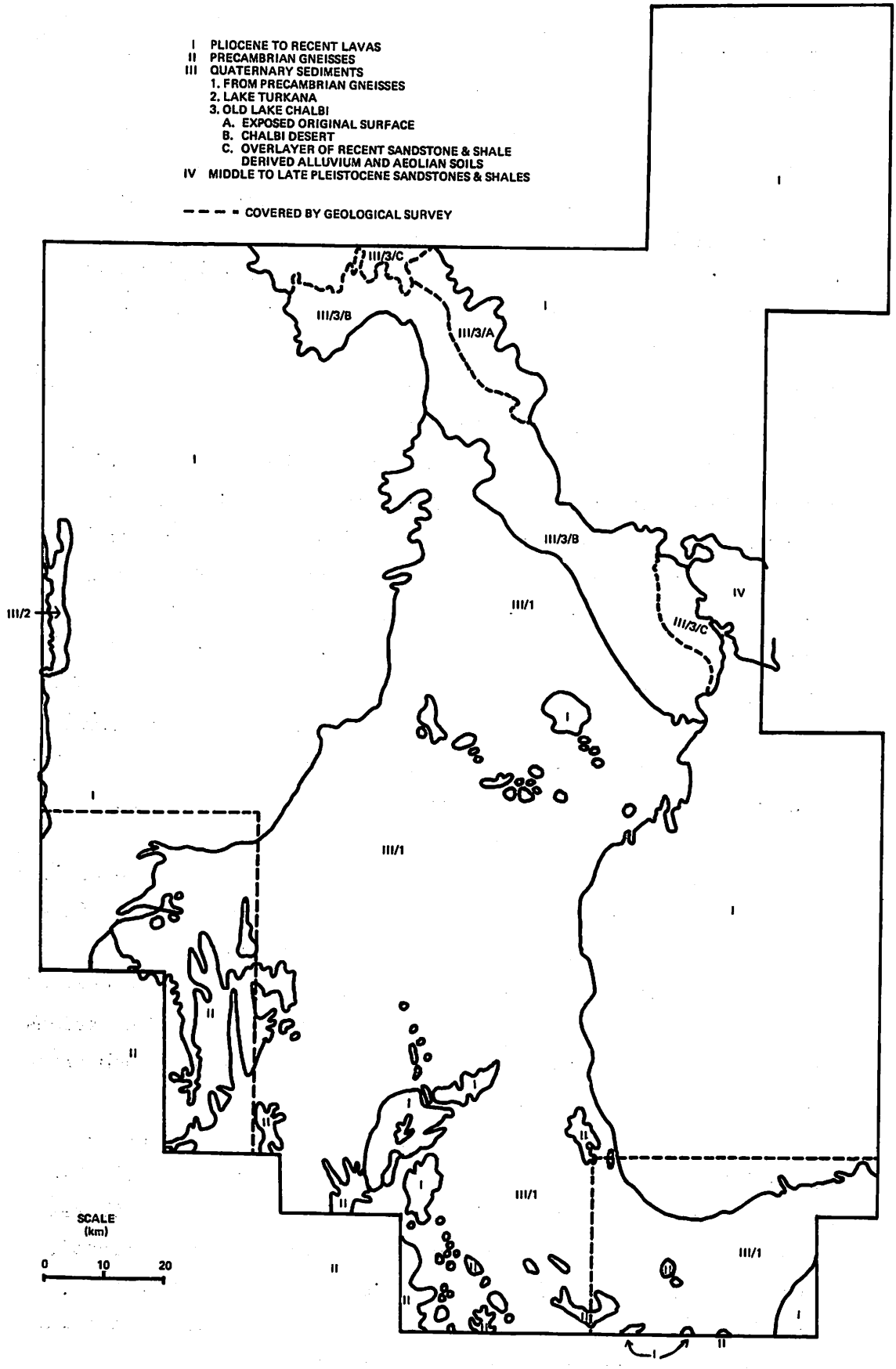
Pleistocene basaltic lavas, often thick and waterbearing at depth (FAO, 1971), occupy 13,000km^2 or 57% of the study area, primarily centred on Mt. Kulal, Marsabit Mtn. and the Hurri Hills.

Quaternary sediments occupy 8,982km^2 or 39% of the study area. These are of four types: those derived from Precambrian gneissic rocks of Nyiru, Ol Doinyo Mara and the Ndoto Mtns comprise the largest area. This includes the Koroli, Hedad, and Kaisut areas. Other geological formations are associated with the old lake beds of Lake Turkana and Lake Chalbi. The old Lake Chalbi is further divided into: (1) the exposed original surface (between Kalacha and the Lugga Balal); (2) saline/alkaline alluvial materials overlying the old lake bed, which constitute the desert itself and; (3) recent alluvial and aeolian materials overlying the eastern and northwestern edges of the desert. Most of this consists of low, stabilized sand dunes, at least some of which probably originated as alluvium from middle to late pleistocene sandstones and shales just southeast of Maikona. An extensive area of such sand dunes also occurs along the southern and western edge of the Chalbi Desert. These may have originated from alluvium derived from Precambrian gneisses.

Two major wind streams blow off the western end of the Chalbi Desert in a northwesterly direction (mean bearing 305°) on either side of North Horr. The thin layer of sand which has been deposited by these wind systems overlies the local topography and can be clearly seen from the air. The effect of the wind streams is visible on Landsat satellite imagery for up to 40 - 50km from the western edge of the Chalbi Desert.

Several large barchan sand dunes occur in line within the northern-most windstream which passes over Dabendabli Hill 4km north of North Horr. The occurrence of barchan dunes indicates that the wind streams remain primarily unidirectional (Bagnold, 1941). The effect of wind currents is again apparent in the occurrence of a long seif dune just south of Kalacha in the centre of the Chalbi Desert and parallel to its main axis.

Fig. 3 MAJOR GEOLOGICAL FORMATIONS



According to Bagnold (1941) seif dunes are formed when strong winds also blow from a quarter other than that from which the prevalent winds, responsible for the general sand drift, arrive.

A small area of another geological formation; middle to late pleistocene sandstones and shales (FAO, 1971) lies southeast of Maikona between the lava and the Chalbi Desert. This covers 175km^2 or a bit less than 1% of the study area.

A fourth geological formation; Precambrian gneisses (Saggerson, 1969; FAO, 1971) occurs over a relatively small area along the southwestern edge of the study area (643km^2 or 3% of the study area). Although small in area it is an extremely important formation because it is the source of most of the quaternary sediments within the study area. An isolated low outlier of this formation forms the low hills of Korr.

2. 3 Topography

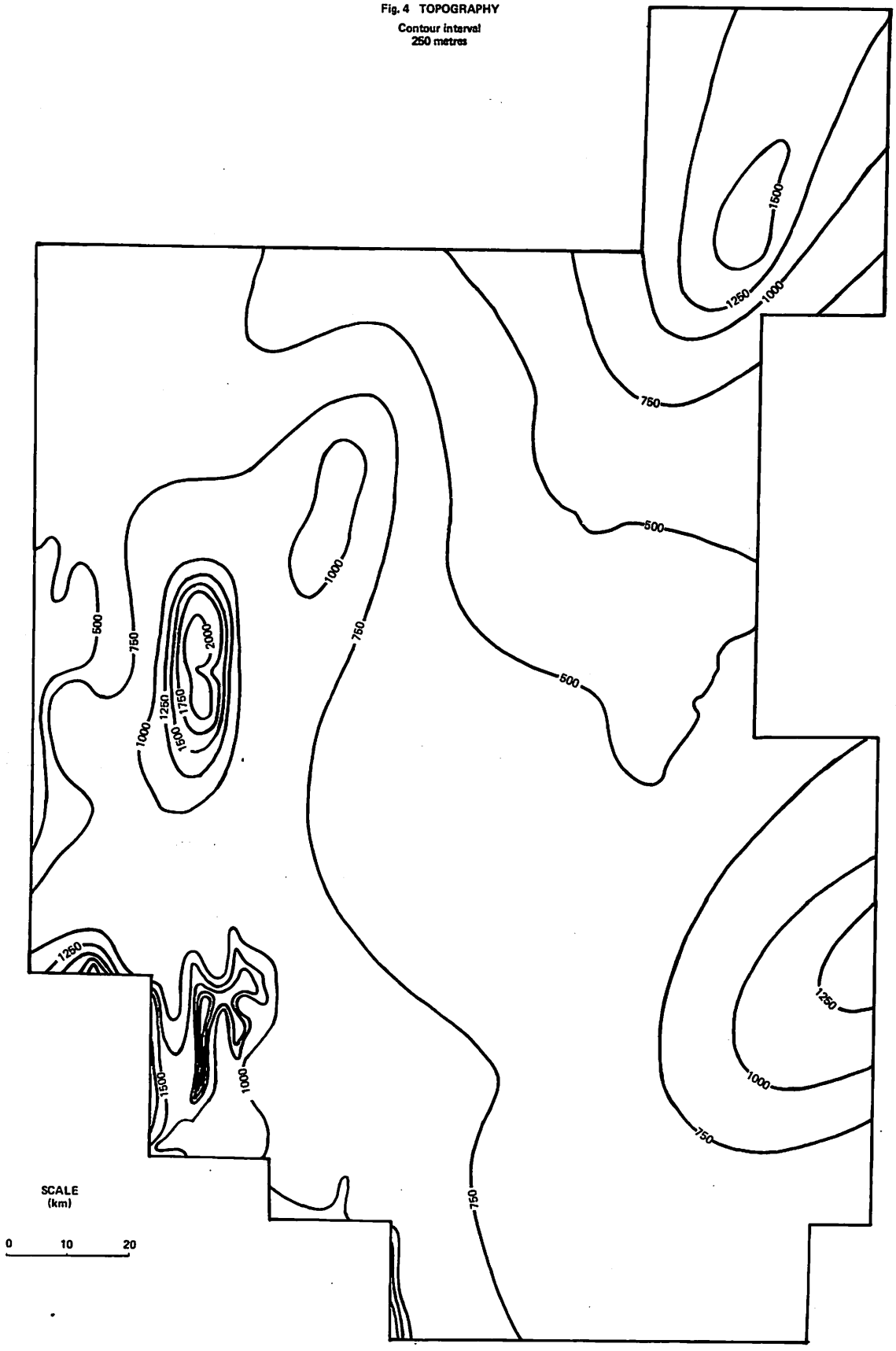
Two series of topographic maps exist for the study area at scales of 1:250,000 and 1:100,000 (Survey of Kenya series Y 633 and Y 503 respectively). However, topographic detail is stated in the mapsheet data to be poor and varies greatly on adjacent mapsheets.

To obtain a more standardized picture of topographic detail, elevations were measured with a small hand altimeter along the tracks within the study area. Variations in barometric pressure did result in variation in accuracy of the elevation readings of up to 30 - 70m. However, use of the altimeter allowed repositioning of some important contours where considerable doubt about their true position had existed before. A more uniform picture of topographic detail was then available throughout the study area (Figure 4).

The study area is generally an extensive plain lying at 530 - 760m elevation, the largest unit of which constitutes the Koroli, Hedad, and Kaisut areas. This region has a gentle upslope southwestward from the edge of the Marsabit lavas to the base of Nyiru, Ol Doinyo Mara and the Ndoto Mountains. It is broken occasionally by isolated low lava plateaus and gneissic hills and mountains and is open to the east both to the south of Marsabit Mountain and between it and the Huri Hills on the north.

Fig. 4 TOPOGRAPHY

Contour interval
250 metres



The Chalbi Desert forms a large depression (948km^2) in the north of the study area. It lies between 435m and 500m elevation. Lake Turkana lies at 410m elevation along the west edge of the study area. As such it is only about 65 - 100m lower than the bed of old Lake Chalbi, but is separated from it by an intervening ridge rising to 700m elevation.

Mt. Kulal, Marsabit Mtn. and the Huri Hills rise in isolation near or on the western, eastern and northeastern boundaries of the study area. Nyiru, Ol Doinyo Mara and the Ndoto Mtns, form its southwestern boundary.

The Huri Hills and Marsabit Mtn. are relatively low (1685m and 1865m respectively), with plateau-like summits, long gentle slopes and massive bases. Mts. Kulal, Nyiru, Ol Doinyo Mara and the Ndoto Range rise to greater elevations (2335, 3010, 2260, and 2885m respectively), have steeper, very abrupt slopes and much narrower bases. Mt. Kulal for instance, has a base roughly 30 by 60km as compared to about 50 by 90km for Marsabit Mtn. In addition, the eastern and western flanks of Mt. Kulal are deeply slashed by many extremely steep walled canyons while this is not so on Marsabit Mtn.

The Asie Hills, a low outlier of Mt. Kulal, extend for about 50km northeast to the edge of the Chalbi Desert. This range, which appears to be a low version of the Huri Hills, rises to only 1165m elevation.

The alignment of most of the mountains in the area generally parallels that of the Rift Valley i.e., north - south or slightly northwest - southeast. However, Marsabit Mtn. and the Huri Hills have a definite northeast - southwest alignment placing them broadside to the winds of the southeast monsoons.

2.4 Drainage

Seventy-seven percent of the study area (17,720km^2) lies within a drainage system leading to the Chalbi Desert. The Chalbi Desert forms a sump for an interior drainage system covering 36,615km^2. Twenty-five percent of this area lies within Ethiopia and drains into the Chalbi Desert via the Lugga Balal.

Most of the surface runoff within the study area then occurs within this closed interior drainage system. However, it is probable that a large proportion never reaches the Chalbi but is returned to the atmosphere directly through evaporation or, eventually, through transpiration by vegetation.

Other drainage systems flow into the Dida Galgalu Plains from the east slope of the Huri Hills, into Lake Turkana from the west slopes of Mt. Kulal and Mt. Nyiru, and into the Milgis River from the southern slopes of Marsabit Mtn. and from the Kaisut area. The Milgis River then empties into seasonal swamps southeast of Marsabit Mtn.

Subterranean drainage has been recorded by FAO (1971) who found lava formations north of Marsabit Mtn. to bear water at depth. The perennial springs found at the base of lava formations along the edge of the Chalbi Desert are probably related to this phenomenon. It is likely that the source of this water is infiltration of rainfall into the soils of the nearby large volcanic mountains (Kulal, Marsabit, and the Huri Hills).

2. 5 Vegetation

Vegetation of the study area has been classified and mapped at the continental level (Keay, 1959; Rattray, 1960), regional level (Edwards, 1945, Pichi-Sermili, 1955; Heady, 1960; Pratt, et al, 1966; Trapnell and Langdale-Brown, 1969; Pratt and Gwynne, 1977), national level, (Edwards, 1940) and district level (FAO, 1971). However, other than the brief survey carried out by FAO (1971), vegetation of the Project area has not been studied in the field. Field studies of similar vegetation within northern Kenya appear to be limited to those of Hemming and Trapnell(1957), Pratt (1966), Hemming (1972), and Barkham and Rainy (1976).

The herbaceous layer is emphasized by Heady (1960) and Rattray (1960) who show the study area to be primarily dominated by *Aristida* (Heady) and *Chrysopogon/Aristida* (Rattray) annual grassland respectively.

Pichi-Sermoli (1955), Edwards (1940, 1945) and Trapnell and Langdale-Prown (1968), in a basically ecological classification, show most of the area to be desert, desert scrub and sub-desert scrub. Trapnell and Langdale-Brown (1969) give the area a drier classification than do the former authors. A strictly physiognomic classification is used by Pratt, et al (1966) and Pratt and Gwynne (1977). They show the study area to be primarily wooded and/or bushed grassland replaced by or mixed with barrenland and/or dwarf shrubland in the Chalbi area and on low lying lavas. Whereas a refinement of knowledge about vegetation detail has occurred in the period between these two publications elsewhere in Kenya, it has not occurred within the study area.

FAO (1971) mapped the vegetation of the study area as part of a more extensive survey of the vegetation of Marsabit District. Vegetation units were determined by geomorphological features; 16 such units being grouped into land systems. The most extensive vegetation types within the study area were shown to be *Acacia reficiens - Duosperma eremophilum* dwarf shrubland and/or bushed dwarf shrubland on footslopes of the Marsabit land system and *Commiphora crenulata - Sericocomopsis hildebrandtii* bushed dwarf shrubland on sedimentary plains of the Kaisut land system.

3. Methods

Field and office procedures followed those of Herlocker and Dirschl (1972) and Herlocker (1975). Subjective estimates of vegetation attributes were made at stations located at systematic intervals along all roads and tracks within the study area. The major attribute considered was species dominance based on canopy cover within the overstory and, when present, the understory as well. Canopy cover, growth form and height of associated species were also noted. Canopy cover of larger woody vegetation was occasionally checked with an angle gauge (Cooper, 1957) and of dwarf shrubs and herbaceous vegetation by the step-point method (Costello and Schwan, 1946).

Field notes were referenced by station. The location of each station was marked on aerial photographs with a grease pencil. Aerial photography was RAF panchromatic (1:50,000) taken during 1956 - 1960. Obvious vegetation boundaries were noted in the field and marked on aerial photographs. These were the preliminary mapping units.

In the office, species dominance of a mapping unit was determined by comparing species dominance at successive stations (points) along tracks within the unit. The species or group of species dominant at all or most of these points was adopted as the dominant species of the mapping unit.

Where stations within a mapping unit differed from the rest in species dominance, these were either included with the rest (if few and scattered) or made into another mapping unit (particularly if numerous, grouped together and/or coincident with obvious site differences). Mapping unit boundaries were then redrawn.

Mapping units with similar dominant species were grouped into tertiary vegetation types. Mapping units not sampled in the field were placed into tertiary vegetation types based on stereoscopically determined similarities in topographic detail and gross physiognomic vegetation patterns.

Tertiary vegetation types could then be grouped into larger primary vegetation types based on physiognomic similarities such as height, growth form, and canopy cover.

4. Map uses

The vegetation map of Marsabit District (FAO, 1971) was the first approximation in detailed classification and delineation of plant communities of the District. The present map is the second approximation for the southwestern part of the District. It will eventually require revision as field experience increases knowledge of vegetation and better techniques for classification and mapping become available.

Vegetation classification follows Pratt and Gwynne (1977). Criteria are primarily physiognomic but are modified by functional, physiographical, and compositional criteria (Table 1). Using this system, the vegetation of the study area has been grouped into three main categories.

(a) Primary vegetation types (Figure 24, Table 2) are based on physiognomic criteria (forest, woodland etc.) qualified by functional criteria (evergreen, deciduous etc.).

(b) Secondary vegetation types (Table 3) are based on a combination of physiographic and somewhat more precise physiognomic and functional criteria than are used in primary vegetation types.

(c) Tertiary vegetation types (Figure 24, Table 4) are based on compositional criteria: i.e., dominant species.

For purposes of clarity and simplicity, only the primary and tertiary vegetation types have been mapped. Also, where a number of small tertiary vegetation types recur over an area in mosaic or catenary pattern, these have been included in a single composite unit for mapping purposes. An example of one such unit (no. 38) is given in Figure 13 to indicate the complexity of vegetation involved.

The map is a stratification of the vegetation of the UNESCO (IPAL) study area into ecologically homogeneous units; the tertiary vegetation types being the most homogeneous. Tertiary vegetation types in particular, delineate areas capable of supporting the same kind of relatively stable plant community homogeneous as to dominants in all layers and in biological potential. This is the habitat type of Daubenmire (1968) and is analogous to the range site (S.C.S., 1970; S.R.M., 1974) and forest site (S.A.F., 1950).

There are 9 primary, 34 secondary and 73 tertiary vegetation types. While the ratio between primary and tertiary types is 1:8.3, that between secondary and tertiary types is only 1:2.1. This indicates that much of the variation in vegetation of the study area is expressed and can be delineated by non-taxonomic criteria.

TABLE 1

Criteria for vegetation classification

Category	Life form	Height	Woody canopy cover	Herb cover	Vertical stratification	Notes
Forest	Trees	7-40m	closed		1-2 stories	
Bushland	Trees/Shrubs	<10m	>20%		single or layered	shrubs dominant
Woodland	Trees	<20m	"		"	
Shrubland	Shrubs	<6m	"		"	
Dwarf shrubland	Dwarf shrubs	<70cm	"		single	
Grassland	Grass		<20%*			
(Perennial/ annual)						
(Sparse)				<20%		
(Regular)		25-150cm	"	>20%		
(Short)		<25cm	"	"		
Dwarf		<10cm	"	"		

* Grassland with a scattered, open overstory (2 - 20% canopy cover) of woody plants is termed 'wooded, bushed or dwarf shrub grassland' depending on the dominant overstory life form. There may also be such designations as 'bushed or wooded dwarf shrubland'.

TABLE 2

Primary (physiognomic) vegetation types
in order of areal importance

	Area (km^2)	% total
Annual grassland	7655	33.3
Dwarf shrubland	6352	27.6
Shrubland	4649	20.3
Bushland	1378	6.0
Barrenland	948	4.1
Perennial grassland	780	3.4
Woodland	786	3.5
Evergreen to semi-deciduous bushland	328	1.4
Forest	124	0.5
Total Area	23,000	

TABLE 3

Secondary (physiognomic) vegetation types

	AREA (km^2)	
FOREST		124
Upland evergreen	115	
Lowland evergreen (ground water)	9	
EVERGREEN TO SEMI-DECIDUOUS BUSHLAND		328
Evergreen	41	
Evergreen to semi-deciduous	175	
Semi-deciduous	46	
Composite Unit	66	
WOODLAND		786
Semi-deciduous	46	
Deciduous with shrub understory	64	
Deciduous with dwarf shrub understory	676	
BUSHLAND		1378
Composite unit	90	
Deciduous	665	
Deciduous with dwarf shrub understory	566	
Deciduous with succulent dwarf shrub understory	57	
SHRUBLAND		4649
Evergreen	78	
Evergreen with dwarf shrub understory	14	
Evergreen with occasional perennial grass	21	
Deciduous	2084	
Deciduous with dwarf shurb understory	1840	
Deciduous with succulent dwarf shrub understory	612	
DWARF SHRUBLAND		6352
Dwarf shrubland	2562	
Bushed	3553	
Wooded	237	

	AREA (km^2)	
PERENNIAL GRASSLAND		780
Upland	608	
Wooded upland	144	
Short lowland	28	
ANNUAL GRASSLAND		7655
Herb	5	
Dwarf shrub herb	191	
Dwarf shrub short	1971	
Dwarf shrub short sparse	19	
Bushed dwarf shrub short	5086	
Bushed	51	
Wooded dwarf shrub short	249	
Wooded dwarf shrub	83	
BARRENLAND		948
Total		23,000

TABLE 4

Tertiary vegetation types

	(AREA km^2)
FOREST	
Upland Evergreen	
(1) *Cassipourea/Diospros/Olea/Teclea*	115
Lowland groundwater	
(2) *Hyphaene*	9
EVERGREEN TO SEMI-DECIDUOUS BUSHLAND	
Evergreen	
(3) *Carissa/Euclea/Rhus-Juniperus*	41
Evergreen to semi-deciduous	
(4) *Acacia hockii/Dichrostachys/Harrisonia*	175
Semi-deciduous	
(5) *Euclea/Lippia/Ormocarpum*	46
Composite unit (numerous deep, steep walled canyons)	
(6) Continum of deciduous bushland through evergreen forest	66
WOODLAND	
Semi-deciduous	
(7) *Combretum*	46
Deciduous with shrub understory	
(8) *Acacia tortilis* with *Duosperma/Solanum*	64
Deciduous with dwarf shrub understory	
(9) *Acacia drepanolobium* with *Duosperma*	7
(10) *Acacia etbaica/A. nilotica* with *Duosperma*	55
(11) *Acacia tortilis/A. etbaica/A. seyal* var. *seyal* with *Duosperma*	103
(12) *Acacia tortilis* with *Duosperma*	168
(13) *Acacia tortilis* with *Duosperma/Indigofera*	292
(14) *Acacia tortilis* with *Indigofera*	51
BUSHLAND	
Composite unit	
(15) Continum of deciduous bushland through evergreen to semi-deciduous bushland	90
Deciduous	
(16) *Acacia senegal/Boswellia/Commiphora*	665
Deciduous with dwarf shrub understory	
(17) *Acacia reficiens/A. tortilis/Commiphora* with *Duosperma*	322
(18) *Commiphora* with *Duosperma/Indigofera*	244
Deciduous with succulent dwarf shrub understory	
(19) *Acacia mellifera/A. reficiens/Commiphora* with *Euphorbia/Plectranthus*	57

	AREA (km^2)
SHRUBLAND	
Evergreen	
(20) *Suaeda*	78
Evergreen with dwarf shrub understory	
(21) *Salvadora* with *Duosperma*	14
Evergreen with occasional perennial grasses	
(22) *Salvadora* with *Sporobolus spicatus*	21
Deciduous	
(23) *Acacia horrida* subsp. *benadirensis/ A. paolii*	5
(24) *Acacia horrida* subsp. *benadirensis/ A. senegal/Commiphora*	44
(25) *Acacia mellifera*	409
(26) *Acacia mellifera/A. reficiens/A. seyal* var. *seyal/Commiphora*	674
(27) *Acacia reficiens*	754
(28) *Commiphora*/other spp.	198
Deciduous with dwarf shrub understory	
(29) *Acacia mellifera/A. reficiens/ Commiphora* with *Duosperma*	74
(30) *Acacia mellifera/A. reficiens* with *Duosperma/Sericocomopsis*	191
(31) *Acacia reficiens* with *Duosperma*	1575
Deciduous with succulent dwarf shrub understory	
(32) *Acacia mellifera/Commiphora* with *Euphorbia/Plectranthus*	69
(33) *Commiphora* with *Euphorbia/Plectranthus*	543
DWARF SHRUBLAND	
Dwarf shrubland	
(34) *Duosperma*	1237
(35) *Duosperma/Plectranthus*	92
(36) *Duosperma/Indigofera*	281
(37) *Indigofera*	952
(38) Composite unit*	---

* Areas of component vegetation types within composite unit have been included within their respective categories elsewhere in the table.

	AREA (km^2)
Bushed	
(39) *Duosperma* with *Acacia mellifera/ A. reficiens*	228
(40) *Duosperma* with *Acacia reficiens/ Commiphora*	439
(41) *Duosperma* with *Acacia seyal* var. *fistula*	230
(42) *Duosperma/Indigofera* with *Acacia reficiens/Commiphora*	1923
(43) *Indigofera* with *Commiphora/Euphorbia*	733
Wooded	
(44) *Duosperma* with *Acacia tortilis*	83
(45) *Indigofera* with *Acacia tortilis*	154
PERENNIAL GRASSLAND	
Upland	
(46) *Chrysopogon*	352
(47) *Chrysopogon/Themeda*	26
(48) *Panicum/Chrysopogon*	214
(49) *Setaria*/Misc. grass/herb spp.	---
(50) *Themeda*	16
Wooded upland	
(51) *Aristida/Chrysopogon/Pennisetum* with *Erythrina*	9
(52) *Dichanthium/Themeda* with *Juniperus*	25
(53) *Chrysopogon*	110
Short lowland	
(54) *Sporobolus spicatus*	28
ANNUAL GRASSLAND	
Herb	
(55) Misc. herb	5
Dwarf shrub herb	
(56) *Heliotropium*/misc. herb with *Duosperma/Indigofera*	161
(57) Misc. herbs with unknown dwarf shrub sp.	30
Dwarf shrub short	
(58) *Aristida/Sporobolus/Heliotropium* with *Indigofera*	308
(59) *Aristida* with *Duosperma/Indigofera/ Sericocomopsis*	1486
(60) *Aristida* with *Indigofera*/other spp.	177

	AREA (km^2)
Dwarf shrub short sparse	
(61) *Aristida/Cenchrus* with *Duosperma* (a composite unit)	5
(62) *Aristida* with *Indigofera*	14
Bushed dwarf shrub short	
(63) *Cenchrus* with *Commiphora-Indigofera/Sericocomopsis*	409
(64) *Aristida/Enneapogon* with *Acacia reficiens-Indigofera*	3516
(65) *Aristida* with *Acacia mellifera/ Commiphora/Jatropha-Indigofera*	469
(66) *Aristida* with *Acacia senegal-Duosperma/Indigofera*	368
(67) *Aristida* with *Acacia mellifera/ A. reficiens-Duosperma/Sericocomopsis*	262
(68) Unknown grass with *Acacia reficiens/ A. tortilis/Commiphora-Duosperma*	62
Bushed	
(69) *Aristida/Enneagopon* with *Acacia horrida subsp. benadirensis/A. senegal/Commiphora*	51
Wooded dwarf shrub short	
(70) *Aristida* with *Acacia tortilis-Lagenantha*	152
(71) *Sporobolus spicatus/* annual *Sporobolus sp.* with *Acacia tortilis — Indigofera/ Euphorbia/Dasysphaera*	97
Wooded dwarf shrub	
(72) Unknown grass with *Acacia seyal* var. *seyal-Duosperma*	83
(73) BARRENLAND	948

5. General environmental relationships

A wide range of primary vegetation types occurs within the study area (Figure 24,Table 2). The sequence of evergreen forest - evergreen to semi-deciduous bushland - woodland - bushland-- shrubland - dwarf shrubland (all deciduous) and annual grassland reflects decreasing water availability for growth, primarily due to reduced rainfall and increased potential evaporation. This relationship is most apparent in the elevational sequence of primary vegetation types from top to bottom of the major mountains and their locations relative to the mountains' wetter southeastern and drier northwestern and western flanks.

Perennial grassland, however, does not easily fit the generally close relationship between primary vegetation types and climate seen within the study area. Instead, in some areas, it probably reflects the modified response of vegetation to climate caused by specialized soil conditions while in others it reflects the modification of the original vegetation by fire. Also, although the barrenland primary vegetation type occupies the driest part of the moisture gradient, this is due to edaphic rather than climatic factors.

Similarly, differing soil characteristics are usually the reason for two or more primary vegetation types occurring together within the same climatic regime.

In northern Kenya, soils developed from lavas are generally loamy to clayey in texture whereas soils developed from other, older parent materials such as Precambrian gneisses and quaternary sediments, are sandier in texture (Hemming and Trapnell, 1957; Makin, 1968; Hemming, 1972).

In comparison with silty and clayey soils, sandy soils, because of their high permeability, have less surface runoff thereby allowing more water to penetrate deeper into the soil. More water is then available for plant growth — especially for deeper rooted species. Thus, a gradient from sandy to silty to clay soils results in a gradient of decreasing soil moisture potential which is reflected by changes in vegetation from tall, dense, woody, perennial and deeply rooted to short, sparse, herbaceous, annual and shallowly rooted (Smith, 1949; Noy-Meir, 1974).

Soils are further influenced by their topographic position. Those low on the topographic sequence receive surface runoff and subsurface drainage from higher ground. This considerably augments moisture received from rainfall. These soils also accumulate eluviated nutrients and fine soil particles making them more fertile but also somewhat heavier in texture.

Thus, the abrupt break between annual grassland on the Marsabit lavas (Figure 24,type 64) and dwarf shrubland on the adjacent Kaisut, Hedad and Koroli sedimentary soils (types 27, 31, 36, 37, 38, 40, 42, and 43) or between annual grassland on the Mt. Kulal lavas (type 59) and dwarf shrubland (type 37) in the northwest of the study area reflects the change from the loamier soil texture and water-shedding nature of the lava sites to the sandier soil texture and water-receiving nature of the lower, dwarf shrubland sites.

Soils are important in the occurrence of tertiary vegetation types. These primarily reflect local soil differences within the broader climatic pattern influencing a primary vegetation type. However, little is known yet about vegetation/soil relationships at this level within the study area.

6. Principal vegetation units

6. 1 Barrenland

The barrenland primary vegetation type cover 948km^2 or 4.1% of the study area (Table 2). It consists largely of the Chalbi Desert. The virtual absence of vegetation in the Chalbi Desert is considered largely due to edaphic rather than strictly climatic causes.

The Chalbi Desert is part of a closed drainage basin of about 36,615km^2. There is no outlet and all streams within the system flow into the Chalbi. In addition there are numerous springs welling up at the edge of the desert, which apparently originate through subsurface flow from the surrounding mountains (Kulal, Marsabit and the Huri Hills).

The accumulation of salts remaining after evaporation of seasonal floodwaters and of outflow from perennial springs (Figure 5) inhibits plant growth except under special circumstances as when annual grass and herb species, such as *Drake-Brockmania somalensis*, a saline tolerant grass species (Hemming and Trapnell, 1957), grow near outlets of the major tributary streams following discharge after seasonal rainfalls. The extent, amount, and timing is dependent upon the volume and frequency of the floodwaters. It is likely that the salts are temporarily diluted by these waters allowing ephemeral growth to occur until a combination of loss of soil moisture and rising salt content stop it again.

Floodwater silt deposits from the Balessa Kulal delta appear to have built up a low ridge of land raised somewhat above the rest of the desert and extending across its middle to the vicinity of Kalacha. This site has not been visited on the ground but from the air appears to support an open cover of low dwarf shrubs and, along drainage lines, a tall grass species — possibly *Sporobolus consimilis*. This vegetation is though to have come in primarily since the onset of the good rains in April 1977 (Lamprey, pers. comm.) and probably results both from the increased rainfall the somewhat better drainage afforded on the low ridge than on the adjacent lower lying, more saline/alkaline areas.

6. 2 Annual grassland

This is the most extensive primary vegetation type in the study area constituting 7655km^2 or 33.3% of the total area (Table 2). The vegetation is short in stature and is only locally dominated by herb species other than grass (Table 3). Most of the component tertiary vegetation types are described as "short, sparse" and/or "herb" indicating relatively dry or, perhaps in some cases, disturbed conditions. Virtually all of this vegetation type has a scattered to open (2 - 20% canopy cover) overstory of woody plants (primarily shrubs and dwarf shrubs) (Figure 6). Trees are seldom associated with annual grassland (i.e., there is little wooded grassland) (Table 3).

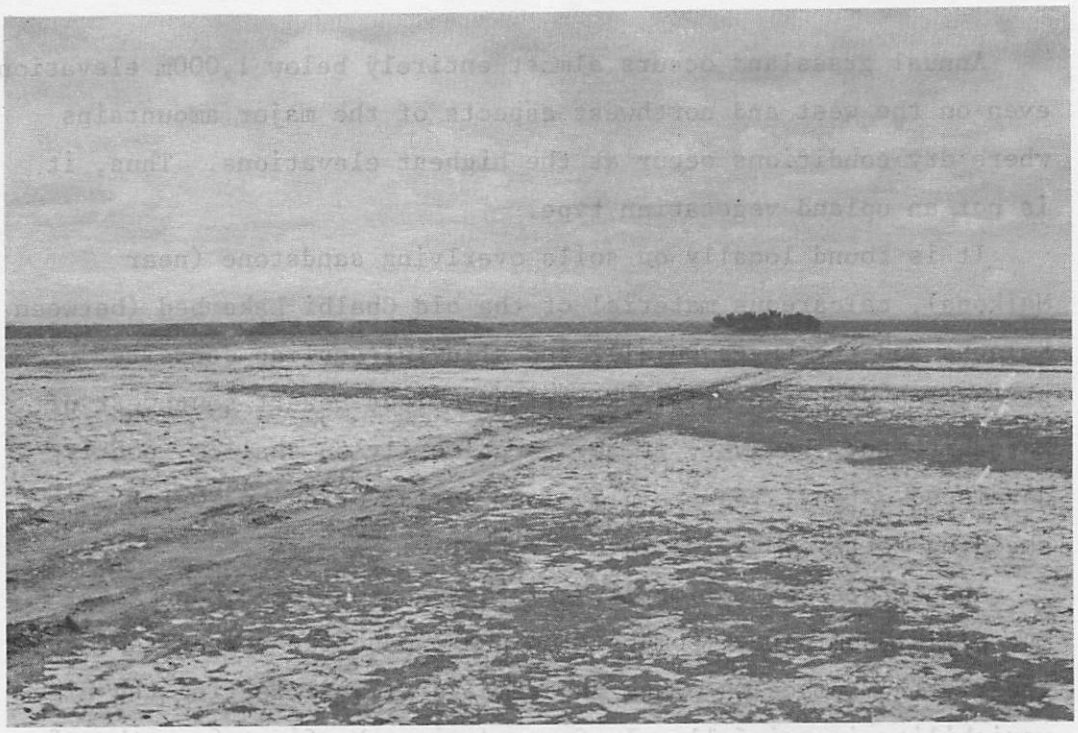


Figure 5: Salt encrustations on the surface of the Chalbi Desert. The only vegetation is a small stand of Doum Palm *(Hyphaene coriacea)*.

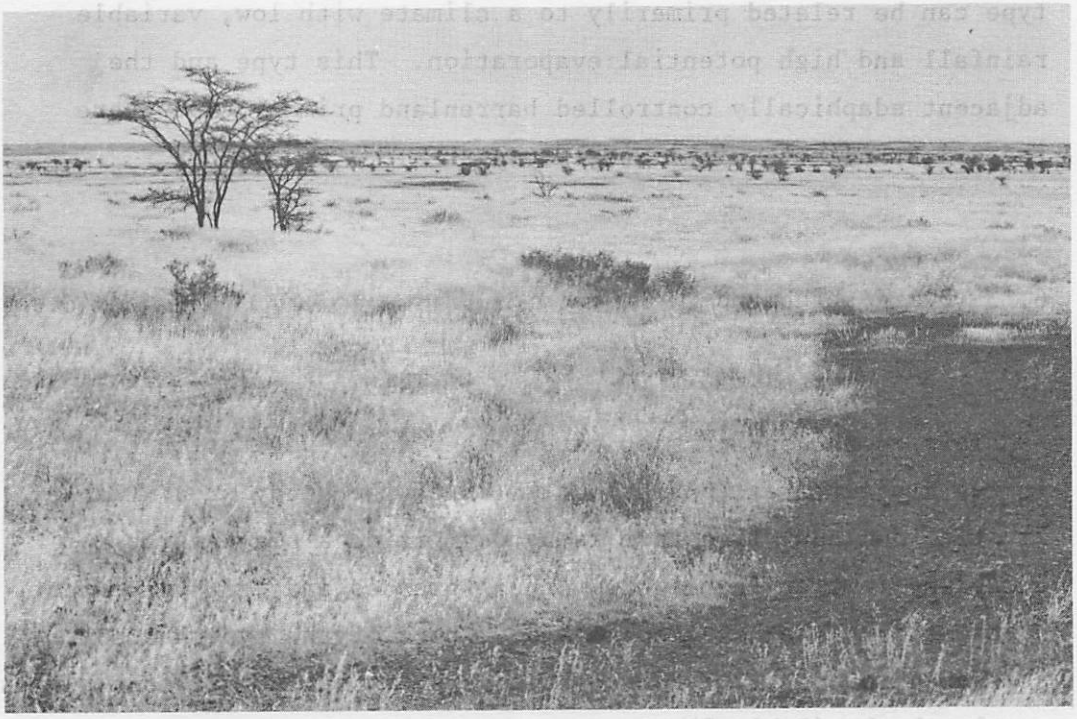


Figure 6: *Acacia reficiens* wooded *Aristida mutabilis* annual grassland on shallow lava soils following heavy rains in 1977.

Annual grassland occurs almost entirely below 1,000m elevation even on the west and northwest aspects of the major amountains where dry conditions occur at the highest elevations. Thus, it is not an upland vegetation type.

It is found locally on soils overlying sandstone (near Maikona), calcareous material of the old Chalbi Lake bed (between Kalacha and the Lugga Balal), and alluvial/aeolian deposits associated with the Milgis River and Kaisut Desert southwest of Marsabit Mtn. However, it occurs primarily on shallow, poorly developed, stony, loam to clay-loam soils, often on "water shedding" sitesoverlying lava.

Annual grasses (primarily *Aristida adscensionis*, and *A. mutabilis*) dominate. Composition and production appear to vary greatly from place to place and time to time reflecting the high variability in rainfall. In fact, during the first 6 months of this study, which fell at the end of an extensive 8 year drought (Edwards, et al., 1979) a herbaceous layer was conspicuous by its absence throughout the type (Figures 7 and 8).

The occurrence of the annual grassland primary vegetation type can be related primarily to a climate with low, variable rainfall and high potential evaporation. This type and the adjacent edaphically controlled barrenland primary type share the driest climate within the study area.

6. 3 Dwarf shrubland

This is the second most extensive primary vegetation type in the Project area (6352km^2 or 27.6% of the study area) (Table 2). The dominant life form is by definition a small shrub not exceeding 1 meter in height. Annual grasses and, to some extent, herbs make up the herbaceous layer. Much of the type has a scattered to open (2 - 20% cover) overstory of larger woody plants, mostly shrubs (Table 3).

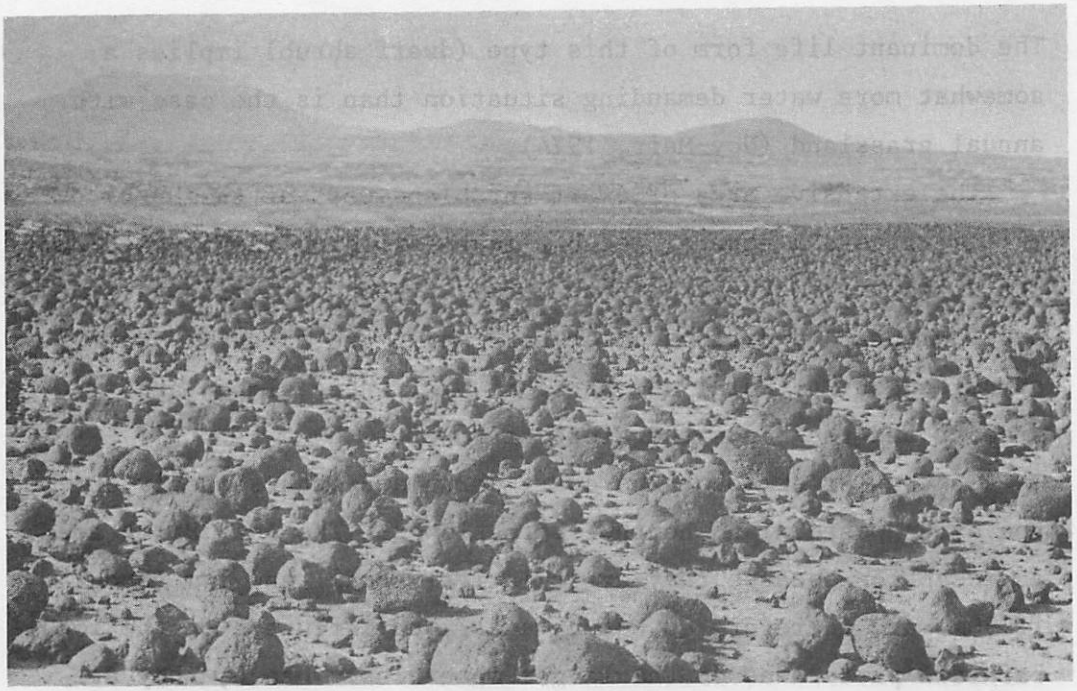


Figure 7: Desert pavement consisting of basaltic stones up to 0.3 metres in diameter. Although this appears to be barrenland it supports *Aristida mutabilis* annual grassland during the rains.

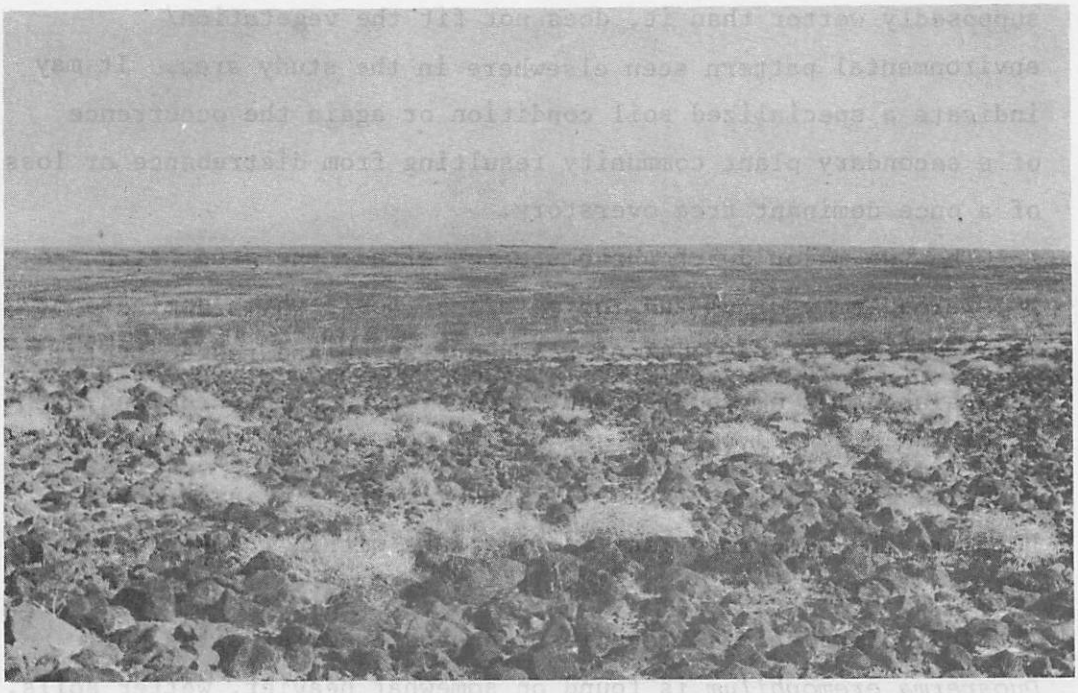


Figure 8: *Duosperma eremophilum* dwarf shrub *Aristida mutabilis* annual grassland near the Khomode escarpment. Little grass is apparent because of an extended period of drought. The trees in the background are *Acacia seyal* var. *fistula*.

The dominant life form of this type (dwarf shrub) implies a somewhat more water demanding situation than is the case with annual grassland (Noy-Meir, 1974).

The extensive area of dwarf shrubland west of the Huri Hills reflects a generalized but gentle rise in elevation toward the Hills and to the Ethiopian border. Roughly similar environmental conditions occur here as in the bands of dwarf shrubland on Mt. Kulal and Marsabit Mtn. where slopes are steeper and the bands therefore narrower.

On the larger mountains dwarf shrubland occurs mostly on the drier western and northwestern slopes. The Asie Hills are an exception because they are relatively small and low (about 1,150m) and therefore do not have as much influence on the local rainfall pattern as do the larger mountains. Hence, they are encircled almost completely by a band of dwarf shrubland at between 835 and 1,000m elevation.

The occurrence of dwarf shrubland on the southern slope of Marsabit Mtn. between two other types (shrubland and woodland) supposedly wetter than it, does not fit the vegetation/ environmental pattern seen elsewhere in the study area. It may indicate a specialized soil condition or again the occurrence of a secondary plant community resulting from distrubance or loss of a once dominant tree overstory.

The two major dwarf shrub species within the study area are *Duosperma eremophilum* and *Indigofera spinosa*, which dominate or co-dominate 71% and 63.6% of all dwarf shrubland respectively. They also occur as an important understory within shrubland, bushland, and woodland over an additional 3109km^2 and 587km^2 respectively (Tables 2 and 5). Thus, in terms of area covered, they are the most important woody plants within the study area (Figure 9, Table 5).

Indigofera spinosa occupies the sandier drier sites while *Duosperma eremophilum* is found on somewhat heavier, wetter soils.

TABLE 5

Area (km^2) occupied by the major woody plant species

SPECIES	OVERSTORY		UNDERSTORY			2-20% CANOPY COVER	GRAND TOTAL
	dominant	co-dominant	dominant	co-dominant	total		
Duosperma eremophilum	2217	2296	2318	791	7622	2427	10049
Indigofera spinosa	1839	2204	51	536	4630	7005	11635
Acacia reficiens	2329	1318			3647	6430	10077
Commiphora spp.	985	1905			2890	4086	6976
Acacia mellifera	409	1090			1499	959	2458
Euphorbia schimperii and *Kleinia sp.*				669	669	733	1402
Acacia tortilis	575	425			1000	548	1548
Plectranthus ignarius		92		669	761		761
Acacia senegal		709			709	419	1128
A. seyal var. *fistula*		674			674	230	904
Boswellia hildebrandtii		665			665		665
Sericocomopsis hildebrandtii				191	191	2157	2348
Acacia etbaica		158			158		158
A. nilotica		55			55		55
A. seyal var. *seyal*		103			103	83	186
Suaeda monoica	78				78		78
Acacia horrida		49			49	51	100
Combretum molle	46				46	110	156
Salvadora persica	35				35		35
Acacia drepanolobium	7				7		7

Fig. 9 DISTRIBUTION (AS DOMINANTS OR CODOMINANTS) OF THE TWO PRINCIPAL WOODY (DWARF SHRUB) PLANT SPECIES



Such an environmental relationship could be implied from their respective life forms; i.e., the large, multiple-stemmed, thornless and relatively large-leafed plant of *Duosperma eremophilum* as compared with the small, single-stemmed, thorny and small-leafed plant of *Indigofera spinosa*.

Thus, *Indigofera spinosa* dominates old stabilised sand dunes, (Figure 10) gently sloped compact sediment soils and compact soils of low, broad ridge tops (Figure 11) while *Duosperma eremophilum* dominates sedimentary plain soils of the Hedad (Figure 12) and sediments of gneissic Precambrian mountains in the southwest. The relatively more moisture demanding nature of *Duosperma eremophilum* is further shown by its occurrence at higher elevations on the major mountains and by its being the major dwarf shrub understory species within the study area. *Indigofera spinosa* forms a dwarf shrub understory over a much smaller area (Table 5).

The two dwarf shrub species co-dominate on sandy/silty soils of the southern and western Hedad and are often found in close catenary association in the southern Hedad and in the Kaisut. Here, a topographic sequence occurs — often with only a small amplitude — with *Indigofera spinosa* dominating compact soils on low, broad ridge tops and *Duosperma eremophilum* dominant within the shallow swales below (Figure 11). This often makes a complex mosaic (Figure 13).

Other important dwarf shrub species occur within the study area but are much less extensive than *Duosperma eremophilum* and *Indigofera spinosa*.

Plectranthus ignarius, Euphorbia schimperi and *Kleinia kleinioides* (the latter two species are included under *Euphorbia* on the map; Figure 24) dominate the dwarf shrub layer beneath *Acacia mellifera* and *Commiphora* bushland overstories (Table 4) between about 1,000 - 1,335m elevation on Mts. Kulal, Marsabit and the Huri Hills. This indicates a situation which is relatively wet and cool compared with other dwarf shrub communities. That on Mt. Kulal in particular appears to reflect temperature because it almost encircles the mountain at about the same elevation. That on Marsabit Mtn. occurs directly within the rain shadow at a similar elevation but does not occur on other aspects because of the higher rainfall at lower elevations on southern and southeastern slopes of Marsabit Mtn. than Mt. Kulal.

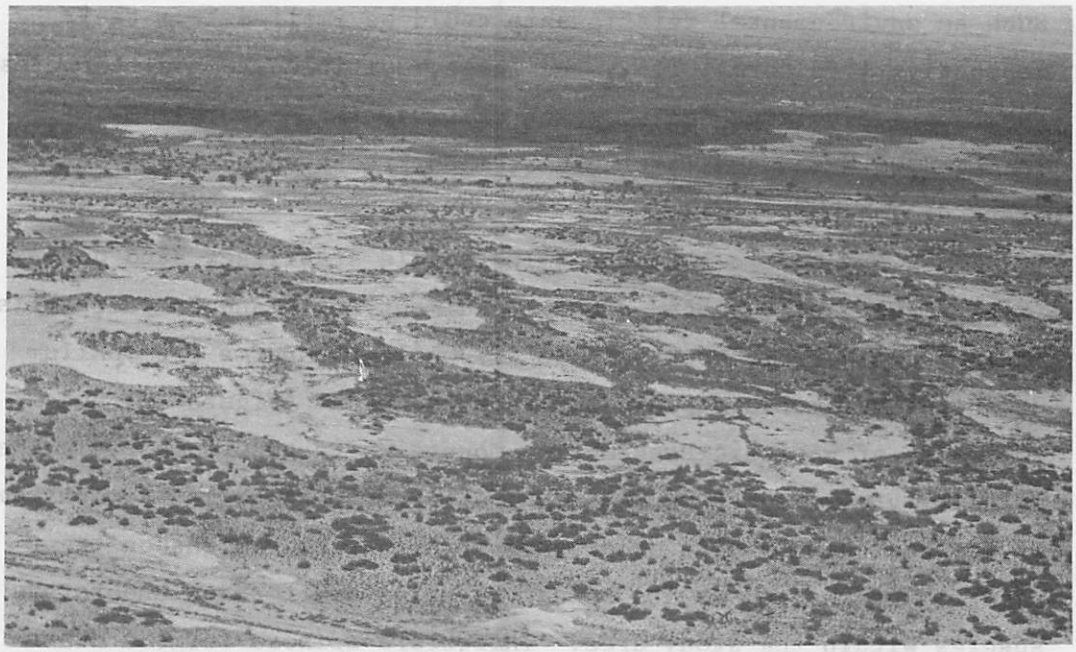


Figure 10: *Indigofera spinosa* dwarf shrubland on old stabilized sand dunes near Kargi. The larger shrub is *Euphorbia cuneata*. The white compacted silty soils between the dunes support little vegetation. The Marsabit lavas are in the background.

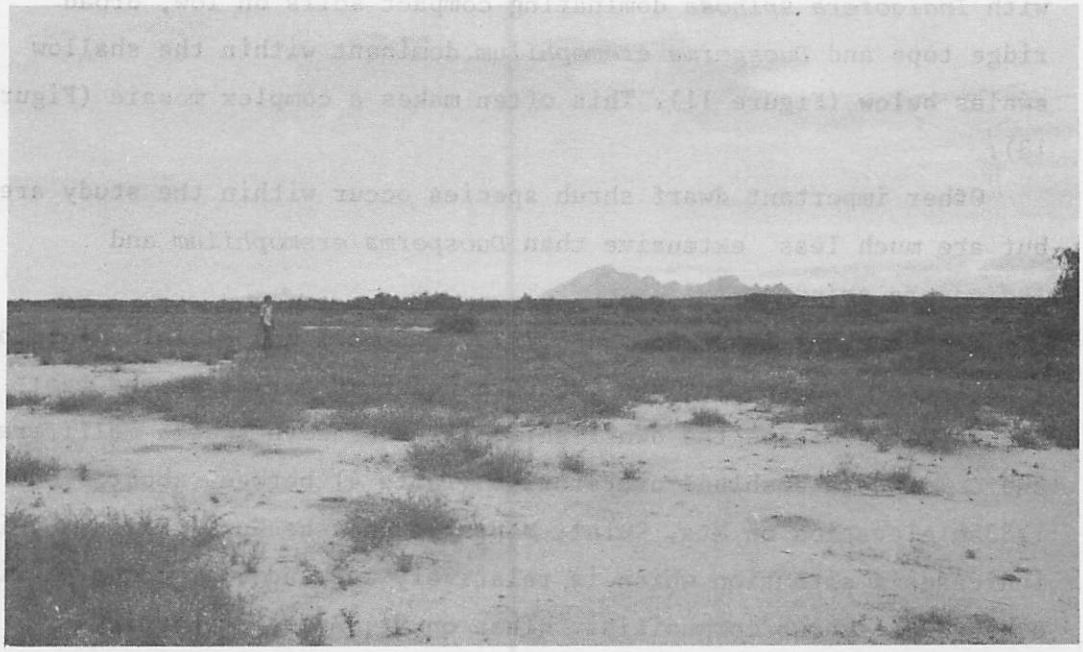


Figure 11: *Indigofera spinosa* dwarf shrubland on compact soils of low, broad ridge tops near Korr. *Duosperma eremophilum* dwarf shrubland occupies a gentle swale to the right.

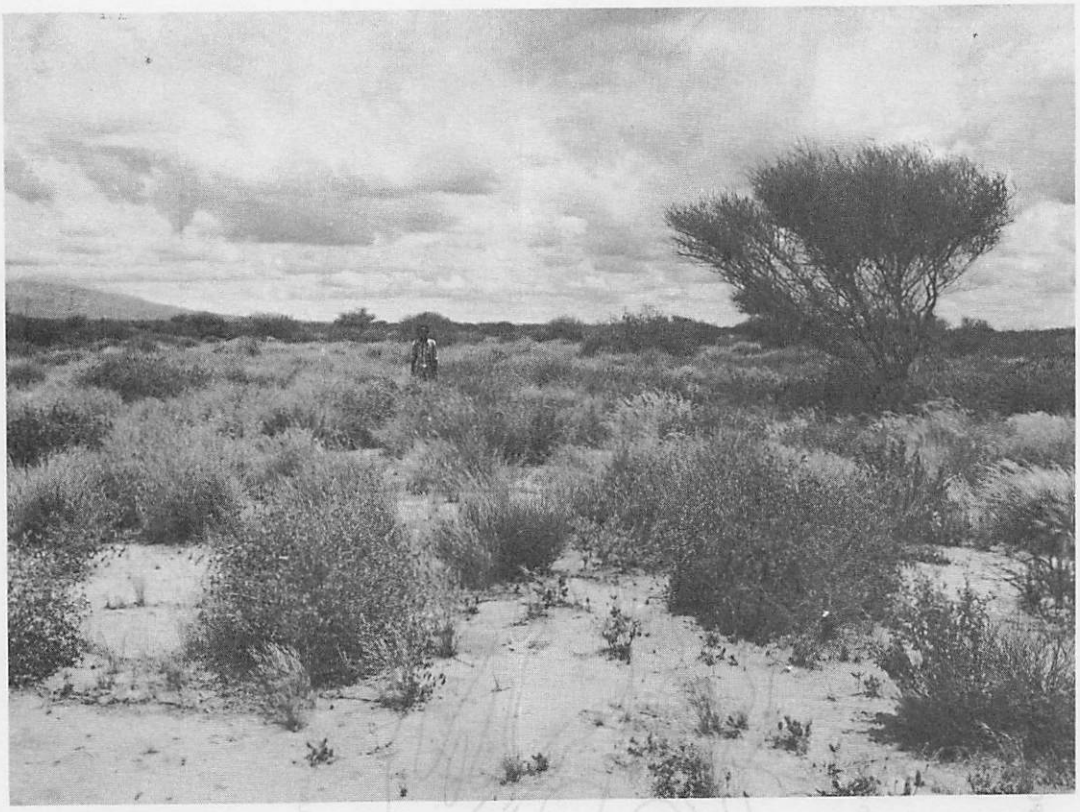
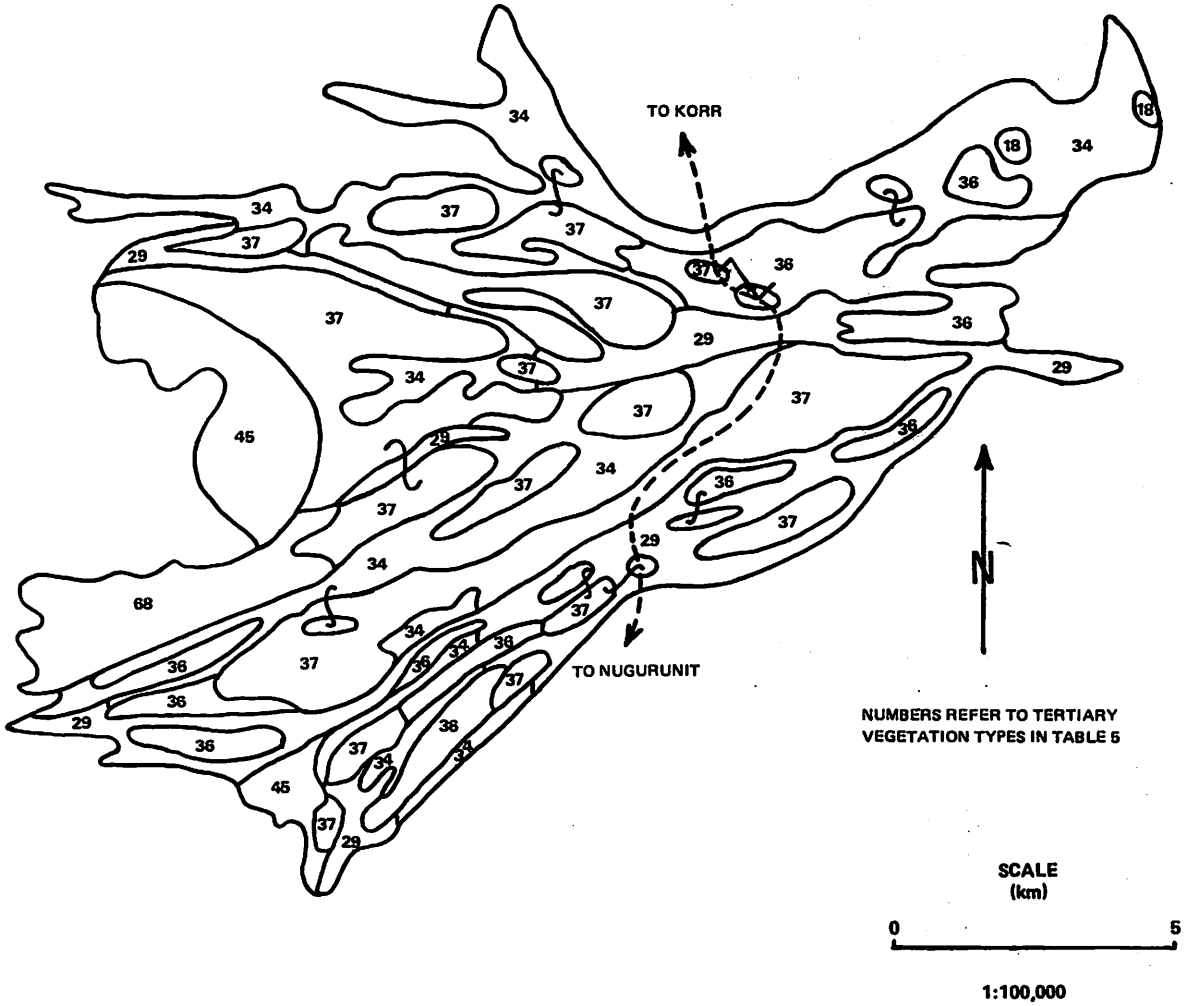


Figure 12: *Acacia reficiens* bushed *Duosperma eremophilum* dwarf shrubland on sandy sedimentary plain soils of the Hedad. *Blepharis linariifolia, Aristida adscensionis,* and *A. mutabilis* constitute the herb layer.

Fig. 13 TERTIARY VEGETATION TYPES OF COMPOSITE MAPPING UNIT NO. 38



The isolated occurrence of a *Euphorbia/Plectranthus* dwarf shrub layer in *Commiphora* shrubland, which extends at right angles across the prevailing topography (Figure 24, type 33) on the Huri Hills, probably indicates a specialized soil which overides the prevailing climatic conditions.

Sericocomopsis hildebrandtii is a co-dominant with *Duosperma eremophilum* (type 30) on pediment soils at the eastern base of Mt. Kulal. It may also occur in association with *Indigofera spinosa*, especially on the compact sandy/silty soils of low ridge tops within the Hedad. This species is noted by Agnew (1974) as being especially common on fine soils, by Hemming (1972) as occurring in patches along seasonally fluctuating water courses and by Barkham and Rainy (1976) as growing on sites where rapid percolation of rainwaters to deeper zones in the rooting profile reduce evaporation, making larger amounts of moisture available for plant use.

Lagenantha nogalensis, a gypsum tolerant succulent dwarf shrub similar in appearance but smaller than *Suaeda monoica* (Gilleland, 1952), occurs on white, calcareous soils of the old Chalbi Lake bed (type 70). The dwarf shrub stratum, although giving less than 20% cover, is almost monotypic to this species. This is the first recorded occurrence of this species in Kenya.

Dasysphaera prostrata is another important dwarf shrub species, which neither dominates or co-dominates a dwarf shrub layer. It occurs (a) along margins of the Chalbi Desert just behind the *Suaeda monoica* zone, (b) in shallow sumps, (c) on lava at/near the margins of Lake Turkana, (d) on whitish, probably calcareous outcrops of old lake bed materials. It indicates saline/alkaline soils which may have seasonally fluctuating water tables or be seasonally waterlogged (Hemming, 1972; Agnew, 1974; Barkham and Rainy, 1976).

6. 4 Shrubland

The third most extensive primary vegetation type in the study area, shrubland, covers 4649km^2 or 20.2% of the area (Table 2).

This type consists primarily of low (less than 6m height) (Table 1) deciduous shrubs — often with gnarled and multiple stems — and a herb layer of annual grasses and herbs (Figure 14). However, a small portion of the type is composed of evergreen shrub communities, some with perennial grass in the herb layer, occupying saline sites adjacent to the Chalbi Desert. Approximately half of the type has an understory of dwarf shrubs, (Figure 15) about 25% of which is dominated by succulent species(Table 3).

A higher moisture status than present in dwarf shrubland is implied by the dominant shrub life-form. Shrubland occurs on loam to clay-loam lava-derived soils at higher elevations on the major mountains and on gneissic-derived sandy/silty soils at lower elevations. The latter soils have a greater soil moisture potential than lava-derived soils (Noy-Meir, 1974), which compensates for the lower rainfall they receive.

In the northern Hedad much of the shrubland appears related to the convergence of seasonal drainage lines, which originate on Ol Doinyo Mara and Mt. Nyiru to the west. Shrubland in this area may also possibly be related to a zone of rainfall, extending from Kargi to Asie, which is somewhat higher than in the surrounding areas (Edwards, et al, 1979).

An apparent anomaly in this vegetation/environmental pattern is the occurrence of shrubland on lava plateaus north of Ilaut (in an area otherwise dominated by dwarf shrubland on sandy/silty soils) and scattered in small units throughout the northern Hedad between Kargi and Asie. Such sites would be expected to support annual grassland under the prevailing climatic conditions. Somewhat higher rainfall conditions may explain the occurrence of shrubland in the latter case (between Kargi and Asie). However, in the former case (north of Ilaut) other factors may apply. Experience in Turkana District (Hemming and Trapnell, 1957) suggests that the lava forms a thin layer over an older, probably gneissic surface, which is more moisture retentive than the lava above. The vegetation appearing on the lava surface would then be rooted within the underlying gneissic material as well.



Figure 14: *Acacia reficiens* shrubland on sandy sedimentary soils of the Hedad. The herb layer is dominated by the short lived perennial grass *Stipagrostis uniplumis*.

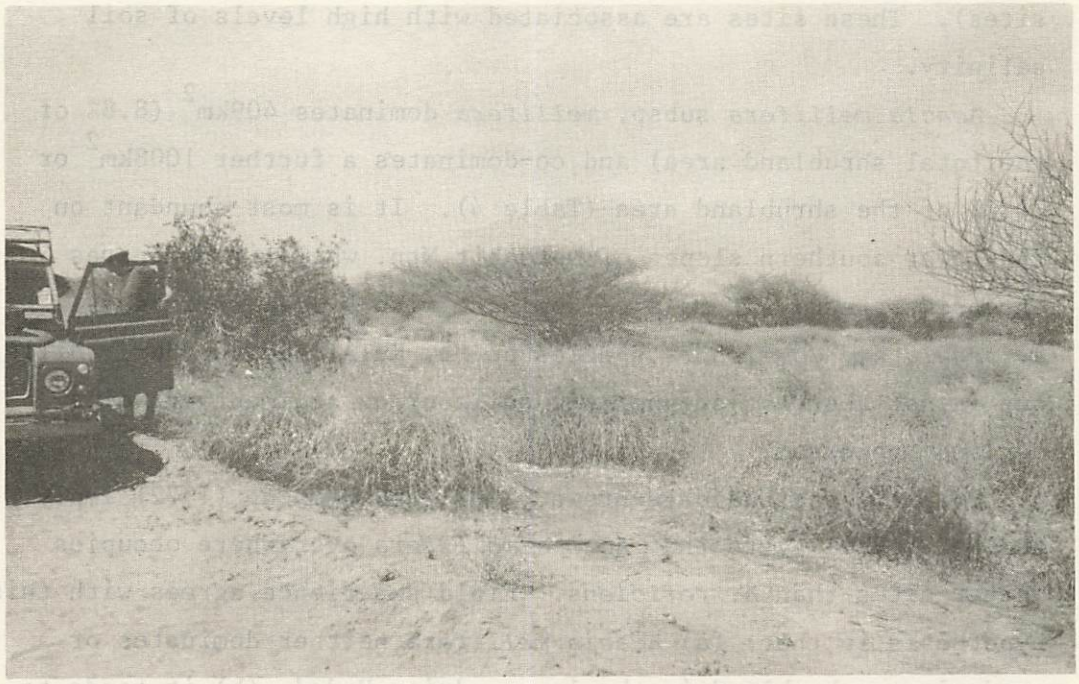


Figure 15: *Acacia reficiens* shrubland with *Duosperma eremophilum* dwarf shrub understory. Sandy sedimentary plain soils of the Hedad near Balessa Kulal.

Barkham and Rainy (1976) found that similar lava plateaus near Samburu Park often contained vegetation association not found on nearby sedimentary and basaltic derived soils because of their olivine basalt origin.

Acacia reficiens subsp. *misera* is the most extensive dominant shrub species and the third most abundant woody plant species within the study area. It dominates 2329km^2 and is co-dominant (primarily with *Acacia mellifera* and *Commiphora* species) over an additional 939km^2 of shrubland. This constitutes 50% and 20.6% of the shrubland area respectively for a total of 70.6% (Table 4).

Acacia reficiens is a co-dominant on sandy/silty soils in the Koroli and northern Hedad and is a co-dominant with *Acacia mellifera* at higher elevations on lava soils. Although *Acacia reficiens* is said to mark the transition to semi-desert vegetation (Trapnell and Langdale-Brown, 1969), Barkham and Rainy (1976) infer that it dominates in situations of moderate to moderately high moisture availability (including some seasonally waterlogged sites). These sites are associated with high levels of soil salinity.

Acacia mellifera subsp. *mellifera* dominates 409km^2 (8.8% of the total shrubland area) and co-dominates a further 1008km^2 or 21.7% of the shrubland area (Table 4). It is most abundant on the lower southern slopes of Marsabit Mtn. where it dominates extensive areas. It is a co-dominant with *Acacia reficiens, A. seyal,* and *Commiphora* species on Mt. Kulal and the Huri Hills, but is not abundant on gneissic soils or on sedimentary soils derived therefrom.

Trapnell and Langdale-Brown (1969) and Hemming (1972) imply and FAO (1971) state that *Acacia mellifera* everywhere occupies wetter sites than *A. reficiens*. Field experience agrees with this hypothesis in that: (a) *Acacia mellifera* neither dominates or co-dominates bushland in the lower, drier Hedad, (b) it tends to occur in mesic shallow swales when it is associated with *A. reficiens* in the Hedad, (c) it occurs in cooler, wetter situations at higher elevations on the mountains than does *A. reficiens*, and (d) it suffered higher mortality than associated *A. reficiens* trees during the last part of the recent 8 year drought.

Elsewhere in East Africa *Acacia mellifera* is found on black clay soils where it begins as wooded grassland and — too often, due to overgrazing — ends as bushland (Lind and Morrison, 1974). Caution should be excercised to ensure that this does not happen within the study area as well.

Commiphora species dominate 785km^2 and co-dominate 861km^2 (11.6% and 18.5% of the shrubland area respectively) for a total of 30.1% (Table 4).

The genus has been treated as a group in this case. Species identification has been uncertain so that our knowledge of species/environmental relationships is not as clear for the *Commiphora* spp. as it is for other shrub species. However, a general pattern of their distribution as a group can be seen from the map (Figure 24).

Commiphora species dominate shrubland in the drier midslope situations on Mt. Kulal and Marsabit Mtn., on the top of Asie and on low lava plateaux in the Hedad. The occurrence of *Commiphora* species as a dominant group in a single isolated unit in the Huri Hills (type 33) probably indicates a specialized soil condition. *Commiphora* species dominate with *Acacia reficiens*, *A. mellifera* and *A. seyal* var. *seyal* on Mt. Kulal and the Huri Hills.

At lower elevations *Acacia mellifera* and *A. reficiens* are more important than *Commiphora* on lava and sedimentary soils regardless of the rainfall regime.

Commiphora bushland is generally considered a more moisture demanding vegetation than *Acacia* bushland (Trapnell and Langdale-Brown, 1969). The dominance of *Commiphora* species at higher elevations within the project area probably indicates a relatively drier situation than optimum for *Acacia mellifera* and cooler than optimum for *A. reficiens*. Elsewhere in the region *Commiphora* species generally occur on shallow and extremely well drained soils (Gillett, 1941: Barkham and Rainy, 1976). Water availability and soil salinity levels typical of *Commiphora* sites are relatively low to moderate; less than those for *Acacia tortilis* but more than for *A. senegal* (Barkham and Rainy, 1976).

To date nine *Commiphora* species have been collected from the study area: *C. africana, C. candidula, C. erlangerana, C. flaviflora, C. madagascariensis, C. paaolii, C. rostrata, C. samharensis,* and *C. schimperi*. *Commiphora erlangerana* and *C. rostrata* were collected by Grum (1976).

Evergreen shrubland (113km^2; 2.4% of all shrubland (Table 3) is dominated by *Suaeda monoica* and *Salvadora persica*. Both are indicators of saline conditions (Dale and Green way, 1961; Anderson, 1963; Waisel and Ovadia, 1972; Hemming, 1973; Barkham and Rainy, 1976.

Sporobolus spicatus (grass), another indicator of saline or alkaline conditions (Bogdan,1958a, 1958b) is associated with *Salvadora persica* in type 22. The position of *Suaeda* and *Salvadora* communities adjacent to the Chalbi Desert, a saline/alkaline sump, reflect their relationship with soil salts. *Suaeda monoica*, appears the most salt tolerant as it grows immediately adjacent to the Chalbi Desert. This agrees with findings in south Turkana by Hemming and Trapnell(1957) and also in Israel (Waisel and Ovadia, 1972), where this species occurred in wet saline sites of terminal drainage basins. There, *Suaeda monoica* plants occur where the water table is from 1.3 - 3.9 meters below the surface and where the soil contains 0.1 - 3.5% chloride. Further salinization of the upper soil is caused by the high salt content of the litter.

Communities dominated by *Salvadora persica* usually occur further back from the edge of the Chalbi Desert. However, they are also found in the immediate outwash area of the Lugga Balal, where seasonally high water probably dilutes accumulated salts, and at Gamura springs near Maikona. Elsewhere, *Salvadora persica* is often associated with *Acacia tortilis* woodland or wooded dwarf shrubland on riverine alluvium. In some situations it may be a successional species to *Acacia tortilis* (Gillett, 1941).

Several other shrub species, although not dominants, are discussed below primarily because they appear to be of potential economic value or to be indicators of environmental degradation.

Acacia senegal apparently is represented within the study area by two varieties. Variety *senegal* grows to about 10m height along seasonal streams on riverine alluvium. Variety *kerensis* is a low shrub to 4m height, which grows as scattered individuals across the wetter parts of the Hedad and Koroli, on the lower, rocky gneissic soils of the Ndotos, Ol Doinyo Mara and Mt. Nyiru, and in shallow drainage lines at the base of the low lava hills found in the Koroli. It is probably most abundant in the latter two areas. This species may be potentially valuable as a source of gum arabic.

Acacia nubica occurs within shrubland as apparently randomly scattered individuals and stands but is also associated with areas of degraded vegetation and soils. Hemming and Trapnell (1957) and Hemming (1972) found the same situation in southern Turkana where *Acacia nubica* dominated (a) transition zones between vegetation on river banks and drier vegetation further from the river; (b) dominated (with *Calotropis procera*) degraded soils around stock watering points (c) actively colonized post-cultivation sites (usually on sands) and newly deposited riverine alluvium. It is evidently also tolerant of limited seasonal flooding.

Calotropis procera, a shrub having milky latex, is a pioneer species of newly deposited alluvium throughout most of the study area as well as in Turkana District and Somalia (Gillett, 1941; Hemming, 1972). Because of this and the fact that it is apparently inedible and unuseable, it is sometimes also abundant in degraded areas immediately around settlements. The worst example within the study area is the settlement of Loglogo.

Balanites (probably *orbicularis*) is not a pioneer species as are *Acacia nubica* and *Calotropis procera* but may be an indicator of environmental degradation through overcutting because it is often retained when surrounding woody vegetation is cut near settlements. This is because of its edible fruit and its poor quality as firewood. Its distribution is limited to sites bordering those of *Acacia tortilis* on the dry side (Hemming, 1972).

6. 5 Bushland

The bushland primary vegetation type covers a much smaller area (1,378km^2; 6% of the study area) than the preceeding, drier vegetation types (Table 2). This consists of a mixture of deciduous shrubs and trees (the latter of low height). A little less than half of the type has an understory of dwarf shrubs, a small proportion of which are succulent (Table 3).

Bushland vegetation was distinguished from shrubland based on the presence of a conspicuous number of trees, mixed with the dominant shrubs (Pratt and Gwynne, 1977). In this case tree species were usually *Acacia tortilis* subsp. *spirocarpa, A. senegal* var. *kerensis, Balanites aegyptiaca,* the taller, single stemmed species of the genus *Commiphora* and, at higher elevations on Mt. Kulal, *Acacia seyal* var. *fistula*. The tree species concerned, while conspicuous, were not important enough to achieve dominance; this being restricted to shrub species. Dominant shrub species were *Acacia mellifera, A. reficiens, A. senegal* and *Commiphora* spp.

This type occurs mainly on the rocky slopes and pediments of the old Precambrian gneissic Nyiru, Ol Doinyo Mara and Ndoto Mtns. and their outliers. Where such parent material occurs, bushland ranges from about 665 to 1,335m elevation and is the principal primary vegetation type transitional between lowland and upland areas. Elsewhere, it occurs only on Mt. Kulal at higher elevations on lava-derived soils where it grades into woodland and evergreen to semi-deciduous bushland above.

The absence of shrubland from and the virtual restriction of bushland to the mountains, hills and pediments of gneissic origin in the southwest of the study area indicate that this particular soil/geological complex allows a somewhat more favourable growing environment that would be expected from climatic criteria alone. This may be due to the more deeply weathered soil, or perhaps deep cracks in rocks, which retain moisture at depth for subsequent use by tree roots.

Certainly, the tree life form implies a greater moisture need than for the shrubs, dwarf shrubs or annual grasses dominating adjacent, but differing soils at similar elevations in the Kaisut and Hedad. Hemming and Trapnell (1957) also found vegetation on basement complex hillsides in South Turkana to be much thicker and richer in species than that on lava hillsides.

Bushland vegetation in the vicinity of Ilaut appears degraded. Many small drainage lines cut across the pediment here, bare soil surfaces are evident, and *Acacia nubica* and — immediately around the settlement itself — *Balanites* are abundant.

6. 6 Woodland

Woodland comprises only 786km^2 or 3.5% of the study area (Table 2). Trees, the dominant life form, are primarily deciduous thorn trees from 5 - 15m in height although some semi-deciduous broadleaved trees of the same height range occur as well (Table 3). Most of the type (94%) has an understory of which 91.4% is composed of dwarf shrub species. The remainder consists of shrub species (Table 3), which occur in some riverine situations.

The woodland primary vegetation type occurs either at higher elevations on the major mountains (highest on Mt. Kulal) where climatic conditions are suitable to support it or at low elevations on sandy alluvial soils along the larger seasonal streams. Increased moisture storage capacity of the sandy soils and periodic stream flow compensate for the otherwise low rainfall and high potential evaporation conditions typical for the area.

The increased moisture supply of these sites is reflected by the larger life form (trees) supported, the beginning of a semi-deciduous state in some communities, and by the increase in the proportion of the type supporting an additional understory of dwarf shrubs and shrubs (i.e., a greater structural complexity).

Woodland occurring at the higher elevations is dominated by *Combretum molle*, *Acacia etbaica*, *A. nilotica* subsp. *subalata*, *A. drepanolobium* and *a. tortilis* subsp. *spirocarpa*. *Acacia seyal* (var. *fistula* and var. *seyal*) is locally important. *Chrysopogon plumulosus*, *Themeda triandra* and *Dichanthium insculptum* are associated perennial grass species.

Combretum molle semi-deciduous woodland with a *Chrysopogon plumulosus/Themeda triandra* perennial grass layer (Figure 16) appears to occupy the wetter end of the woodland environmental gradient. This agrees with experience elsewhere in East Africa (Lind and Morrison, 1974; Norton-Griffiths, et al, 1975). It occurs on the east and southeastern face of the Huri Hills where it is surrounded by *Combretum* wooded *Chrysopogon/Themeda* perennial grassland. The large leaf, tall stature, and semi-deciduous nature of *Combretum molle* reflect this relatively wet situation.

The community dominated by *Combretum molle* on Marsabit Mtn. appears generally denser, shorter, more complex in composition and more disturbed in its herbaceous layer than that on the Huri Hills. Perennial grasses appear less common. This probably reflects the greater use of Marsabit Mtn. by livestock than of the Huri Hills.

Combretum molle is not abundant on Mt. Kulal, where it would be expected to occur on the wetter east and southeastern slopes above deciduous *Acacia etbacica/A. nilotica* woodland and below evergreen to semi-deciduous bushland. This is probably because of the intensively divided topography of many deep, sheer walled canyons, often with knife-like ridge tops. Instead, this supports a drier vegetation characterized by tree euphorbias.

Combretum molle woodland is probably a fire-induced vegetation type successional to evergreen or semi-deciduous bushland or to a form of low sclerophyll forest (Langdale-Brown, et al, 1964; Glover and Trump, 1970; Lind and Morrison, 1974; Herlocker, 1975). In fact, evergreen to semi-deciduous bushland is present in small rocky, steepwalled canyons cutting through *Combretum molle* woodland and wooded grassland on the Huri Hills and it is possible that a low sclerophyll forest could exist on the deeper soils between some of the canyons.

The difference in tree density and cover between type 53 (*Combretum* wooded grassland) and type 7 (*Combretum* woodland) may be due entirely to different intensities and frequencies of grass fires. However, relative distinctness of the woodland/wooded grassland boundary suggests soil differences as well.

Occurring just below *Combretum molle* woodland on the Huri Hills and below evergreen to semi-deciduous bushland on Mt. Kulal are deciduous woodland communities in which *Acacia etbacica* and *A. nilotica* subsp. *subalata* co-dominate. On the Huri Hills these share dominance with *A. tortilis* subsp. *spirocarpa* and *A. seyal*. *Duosperma eremophilum* forms a dwarf shrub understory and *Chrysopogon plumulosus, Cenchrus ciliaris* and *Sporobolus pellucidus* are important in the herb layer.

Acacia nilotica subsp. *subalata* occurs at higher elevations throughout much of East Africa and, in Uganda, sometimes indicates overgrazed and eroded communities derived from savanna and steppe vegetation (Langdale-Brown, et al, 1964; Trapnell and Langdale-Brown, 1969; Lind and Morrison, 1974).

Acacia etbaica occupies a similar environmental situation in Somalia, eastern Ethiopia, and northern Kenya where it occurs below evergreen montane vegetation and on alluvial soils with evergreen bushland. It is sometimes successional to both communities (Gilleland, 1952; Pichi-Sermolli, 1955). This appears to be the case with evergreen to semi-deciduous bushland on Mt. Kulal.

This community or related communities does not seem to occur on Marsabit Mtn. (at least within the study area), where its position is taken by a small area of *Acacia tortilis* woodland and a larger area of *Duosperma eremophilum* dwarf shrubland in which *A. tortilis* forms a scattered open overstory.

Acacia drepanolobium occurs locally within *Acacia tortilis/ A. etbaica/A. seyal* var. *seyal* woodland on the Huri Hills and completely dominates a small area (7km^2) of shallow bench soils within the *A. etbaica/A. nilotica* type of the southern flank of Mt. Kulal.

Its presence generally reflects a poorly drained, probably calcareous soil, less favourable to plant growth than surrounding soils (Burtt, 1942; Birch, 1952; Dale and Greenway, 1961; Langdale-Brown, et al, 1964; Glover and Trump, 1970; Lind and Morrison, 1974). *Duosperma eremophilum* forms a dense understory and *Sporobolus pellucidus* and *Brachiaria serrata* are important perennial grasses.

The remainder of the deciduous woodlands occur below 1,000m elevation and are dominated by *Acacia tortilis* subsp. *spirocarpa* (Figure 17). *Duosperma eremophilum* and/or *Indigofera spinosa* form a definite dwarf shrub understory. *Leptothrium senegalense* is an important perennial grass species in the herb layer. These communities occur on sandy alluvial soils beside seasonal streams. They also occur on alluvial/colluvial soils of river valleys at the base of Mt. Nyiru, Ol Doinyo Mara, and the Ndoto Mtns. These sites receive rainfall, streamflow, and, in mountain valleys, surface and subsurface runoff. Thus, sufficient soil moisture exists to support woodland communities which could not exist here if dependant only on rainfall. *Acacia tortilis* makes optimal use of such sites by a combination of wide spreading shallow roots and a deep tap root (Glover, 1951).

Acacia tortilis subsp. *spirocarpa* was found to grow in similar situations elsewhere in the arid regions of northern Kenya, Somalia and Ethiopia (Gillett, 1941; Gilleland, 1952; Hemming and Trapnell, 1957; Trapnell and Langdale-Brown, 1969; Barkham and Rainy, 1976). However, these publications also stressed the indifference of this species to parent material, its frequent association with calcerous-even gypsic-sils (Gilleland, 1952; Hemming and Trapnell, 1957) and its tolerance of a range of soil water availability and salinity situations, varying from low (for both) to moderate (water) and moderately high (salinity) (Barkham and Rainy, 1976). In the wetter part of its range *Acacia tortilis* occurs on rainfed soils (Bogdan, 1958; Herlocker, 1975) and may often be a component of vegetation successional to savanna and steppe vegetation (Phillips, 1930, Langdale-Brown, et al, 1964; Barkham and Rainy, 1976).

Acacia tortilis woodland communities in the study area have understories primarily dominated by *Duosperma eremophilum* and/or *Indigofera spinosa,* although *Solanum* sp. is an important understory component along the Milgis River.

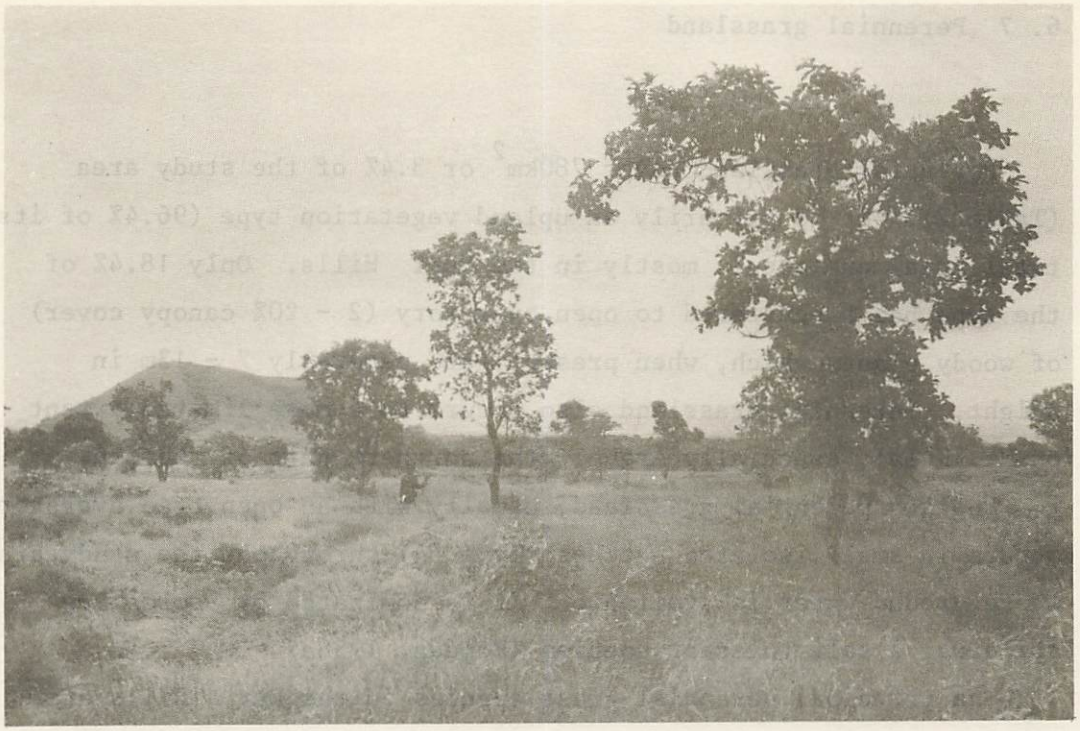


Figure 16: *Combretum molle* woodland on the east face of the Huri Hills. This stand is open enough to verge on being *Combretum molle* wooded *Chrysopogon plumulosus/Themeda triandra* grassland.

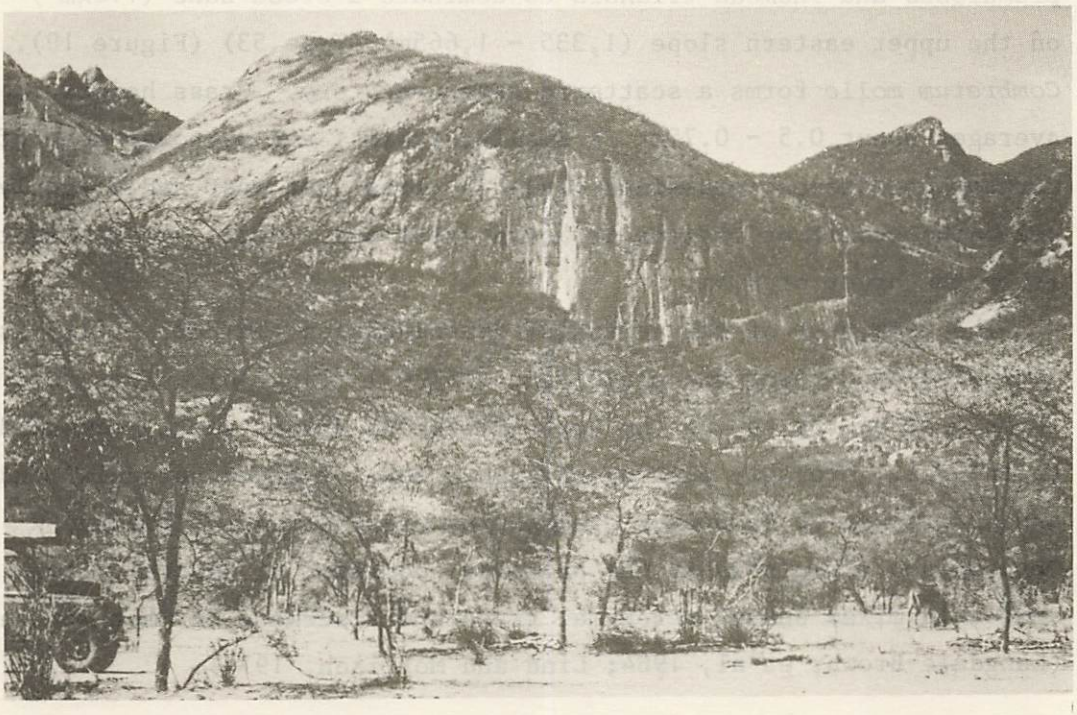


Figure 17: *Acacia tortilis* woodland at Ngurunit. This stand occurs on colluvial foot slope soils at the base of the Ndoto Mtns.

6. 7 Perennial grassland

Perennial grassland cover 780km^2 or 3.4% of the study area (Table 2). It is primarily an upland vegetation type (96.4% of its total area) and occurs mostly in the Huri Hills. Only 18.4% of the type has a scattered to open overstory (2 - 20% canopy cover) of woody plants which, when present, are generally 7 - 13m in height. Perennial grassland also occurs to a more limited extent on Mt. Kulal, especially Arabel, the northern part of the Mtn.

Lowland perennial grassland, usually with an open tree overstory, occurs in small isolated patches (Type 54) throughout the study area where ground water is available. It is dominated by *Sporobolus spicatus*, a salt tolerant species (Bogdan, 1958a).

The principal perennial grass species on the Huri Hills are *Themeda triandra* and *Chrysopogon plumulosus*. *Themeda triandra* - thought by FAO (1971) to be here a dwarfed drought form — dominates a small 16km^2 plateau, at the very top of the Huri Hills at about 1,665m elevation (Type 50) (Figure 18). *Chrysopogon plumulosus* and *Themeda triandra* co-dominate a broad zone (110km^2) on the upper eastern slope (1,335 - 1,665m) (Type 53) (Figure 19). *Combretum molle* forms a scattered tree overstory. Grass height averages about 0.5 - 0.75m. A smaller (26km^2) and narrower zone of *Chrysopogon/Themeda* grassland (Type 47) lies just west and slightly below the summit of *Themeda triandra* grassland. Here, grass height is on the order of 0.5m.

The remainder of the perennial grasslands on the Huri Hills is dominated by *Chrysopogon plumulosus* (352km^2) (Type 46). This area forms most of the top of the Huri Hills and slopes gently downward to the west, probably passing through a zone of mixed perennial and annual grasses to *Duosperma eremophilum* dwarf shrubland beyond. *Chrysopogon plumulosus* is the principal dominant of natural climax semi-arid mixed annual/perennial grassland elsewhere in East Africa (Langdale-Brown, et al, 1964; Lind and Morrison, 1974).



Figure 18: *Themeda triandra* grassland at the summit of the Huri Hills.



Figure 19: *Chrysopogon plumulosus/Themeda triandra* grassland near the top of the Huri Hills. The light and dark toned grasses are *Chrysopogon* and *Themeda* respectively.

Themeda triandra grassland appears to occupy the wetter and colder parts of the Huri Hills where fog is common during parts of the year. *Chrysopogon/Themeda* grassland probably reflects a transition to the warmer and drier *Chrysopogon plumulosus* grasslands. *Themeda triandra*, itself, is an indicator of frequent burning and of relatively low grazing pressures (Heady, 1966; Pratt and Gwynne, 1977).

Four other grassland types, which reflect specialized local soil conditions, occur in the Huri Hills.

A mixture of annual *Aristida* spp. and an, as yet undetermined perennial species, occur on rocky soils beneath an open, scattered overstory of *Erythrina burtii* trees(Type 51).

Setaria incrassata grassland marks the drainage pattern within the level to gently sloping *Chrysopogon plumulosus* grasslands. Drainage appears slow, resulting in seasonally flooded and poorly drained soils. This vegetation also occurs in a narrow semi-circle at the base of volcanic cones, again indicating a special drainage condition. This type was not mapped because of its complex pattern and small scale.

Another grassland type occurs on shallow murram soils of volcanic cones. Slopes are steep and drainage is probably very free resulting in a fairly dry situation. This type, which was included within the larger *Chrysopogon plumulosus* type, is characterized by *Heteropogon contortus* and *Sehima nervosum*. *Erythrina burtii, Combretum molle,* and *Commiphora* spp. tree species occur on the lee side away from the wind.

Panicum/Chrysopogon/Misc. herb grassland (Type 48) occurs at the eastern base of the Huri Hills and to the northeast between the Huri Hills and Furole Mtn. on the Ethiopian border. This is a real mixture of many species of grasses and herbs (both perennial and annual), occasional dwarf shrubs and shrubs. The soil is soft and often exposed with frequent stones and rocks at the surface. The general aspect is one of frequent disturbance of the soil and the vegetation community it supports.

Dichanthium insculptum and *Themeda triandra* at higher elevations and *Chrysopogon plumulosus/Cenchrus ciliaris* at lower elevations (Fao, 1971) dominate grasslands at Arabel, the northern end of Mt. Kulal (Type 52).

Upland perennial grassland occupies a zone which appears topographically analogous to that supporting evergreen to semi-deciduous bushland elsewhere within the study area. To this extent it does not fit well into the overall vegetation/environmental pattern (sequence) typical within the study area. This suggests that it is edaphic or successional in origin.

On the northern end of Mt. Kulal (Arabel), perennial grassland is, at least in part, a fire-maintained secondary community sucessional to evergreen forest and evergreen to semi-deciduous bushland. Relict tree and bush species characteristic of these types occur within the upper part of this grassland. Evidence of destruction, caused by burning of forest and bushland stands on nearby slopes, is very apparent.

Dichanthium insculptum/Themeda triandra grassland in particular appears successional to evergreen to semi-deciduous bushland and to *Juniperus procera* dry evergreen forest. Remnants and relict trees/bushes of *Juniperus procera, Rhus natalensis* and *Carissa edulis* occur in the upper part of this type and on steep slopes of nearby canyons. This appears to be the drier end of the Mountain as the vegetation types which are found at both ends of Mt. Kulal occur at higher elevations in the north. Permanent water is less abundant at Arabel, thus protecting the area from heavy grazing by livestock. However, this protection tends to preserve a grass cover which is sufficent to fuel relatively more frequent grass fires than occur on the better-watered southern end of the Mountain; hence the apparently greater impact of fire at Arabel as compared with Gatab. This situation was probably exacerbated during the 1960's when the area was avoided by residents owing to inter-tribal clashes (FAO, 1971).

The situation on the Huri Hills is less obvious. Anderson (1975) suggests that this area might once have supported evergreen forest which was destroyed by Boran carrying out a mixed agricultural/pastoral economy. However, FAO (1971) suggest that forest probably never existed here. Arguments in favour of Andersen's views are as follows:

(a) Perennial grassland in the Huri Hills does occupy a zone which, judging by vegetational patterns on Mt. Kulal and Marsabit Mountain, would have been expected to be evergreen to semi-deciduous bushland;

(b) In some areas species occur which are typical of evergreen to semi-deciduous bushland, as well as a tree species (*Croton macrostachyus*) which is known to be a pioneer in early developing forest (Langdale-Brown, et al, 1964);

(c) On the uppermost eastern face of the Huri Hills, *Chrysopogon/Themeda* perennial grassland has an open overstory of *Combretum molle*. This species often dominates fire maintained communities successional to evergreen bushland and low forest (Langdale-Brown, et al, 1964). Also some of the above mentioned relict trees and shrubs occur there.

Arguments in favour of the FAO view are as follows:

(a) The most extensive areas of grassland, dominated primarily by *Chrysopogon plumulosus*, have no such relict tree or bush species;

(b) Where these do occur, they are often (but not always) on rock outcrops or termite mounds whch would reduce the impact of fire or modify otherwise imperfect soil conditions for woody plants;

(c) Fire-tolerant *Erythrina burtii, Combretum molle* and *Commiphora* spp. occur on the lee side of the small volcanic cones projecting from the grasslands, on shallow murram soils. This indicates the probability that soil conditions prevent woody plants from growing on the plateau below because fire would probably be an even more important inhibiting factor to woody plant growth on the steep slopes of these volcanic cones than it is on the surrounding plateau.

Therefore, at the present state of knowledge it is possible to hypothesize that the Huri Hills perennial grasslands are probably fire-maintained successional communities on the uppermost, wettest, eastward-facing slopes (*Chrysopogon/Themeda* grasslands), but are edaphically controlled throughout the rest of the area (primarily *Chrysopogon* grassland).

6. 8 Evergreen to semi-deciduous bushland

This type covers only 328km^2 or 1.4% of the study area (Table 2). It is restricted entirely to the upper elevations of the major mountains and is most extensive on their wetter southern and eastern faces. For instance, evergreen to semi-deciduous bushland is the most extensive vegetation type within the composite mapping unit (Type 6, Figure 24)on the east face of Mt. Kulal.

This primary vegetation type forms a transition zone between evergreen forest and deciduous/semi-deciduous bushland at lower elevations. Following a gradient from wet to drier environment, a continuum of physiognomy occurs. This goes from tall, dense, evergreen forest with more vertical structure though successively shorter, more deciduous, open and simply structured vegetation. The deciduous component consists of plants such as *Commiphora* spp. and *Croton dichogamus* which occur in the lower, drier part of the type or on shallow, rocky soils elsewhere.

The most characteristic (often dominant) species are *Rhus natalensis, Carissa edulis, Euclea divinorum, Aspilia mossambicensis, Lippia ukambensis* and, in the upper parts, scattered *Juniperus procera*. *Harrisonia abyssinica* is a common shrub on Marsabit Mtn. This vegetation type appears to have been more modified by man than any other in the study area. Its environment is wetter than any other type except evergreen forest. Rainfall is higher and better distributed. Perennial grass will grow where openings occur in the bush canopy. Hence, the type supports both year round grazing and, occasionally, marginal agriculture. On the other hand, the type becomes seasonally dry and is more apt to support fires than the adjacent wetter forest. Further, it is not afforded official protection as is most of the evergreen forest.

Evergreen to semi-deciduous bushland rings Mt. Kulal just below evergreen forest but it is most extensive on the eastern and southern flanks of the Mountain indicating a relatively higher rainfall there.

At Arabel (the northern end of the Mountain) this type is largely absent, having been degraded by fire, and is now represented only by relict bush stands, often with emergent *Juniperus procera* trees, standing in *Dichanthium/Themeda* grassland (Figure 20).

Fire is seen to be an important factor on the southern end of Mt. Kulal as well. Evergreen to semi-deciduous bushland occurs here as a mosaic of bushland stands — often with emergent *Juniperus procera* trees — and perennial *Dichanthium/Themeda* grassland (Figure 21). In the upper parts, this mosaic includes stands of evergreen forest where evergreen to semi-deciduous bushland has come in as a secondary successional community following destruction of forest by fire. This mosaic, heavily used by livestock occurs across a series of deep, steep walled rocky canyons. The result is a very diverse pattern of vegetation communities reflecting different stages in succession, use by livestock, and degrees of elevation, aspect and rockiness.

In the upper part of the type, degradation of bushland leads to establishment of perennial *Dichanthium/Themeda* grassland. Further overuse leads to the occurrence of unpalatable annual grass and herb species such as *Eragrostis tenuifolia, Chenopodium* spp. and *Solanum incanum*.

The evergreen to semi-deciduous bushland type on Marsabit Mtn., as on Mt. Kulal, is most extensive on the southern and southeastern flanks of this Mountain, reflecting the higher rainfall there. It covers a larger area than on Mt. Kulal because of the relatively gentle gradients. The differentiation into relatively evergreen as opposed to more semi-deciduous components, is also less apparent due partly to the above reason but also to the advanced degradation of the vegetation is probably secondary (successional) to a form of low, dry sclerophyllous forest. This vegetation type on Marsabit Mountain is heavily degraded at present. Fire is less a factor than overuse by livestock.

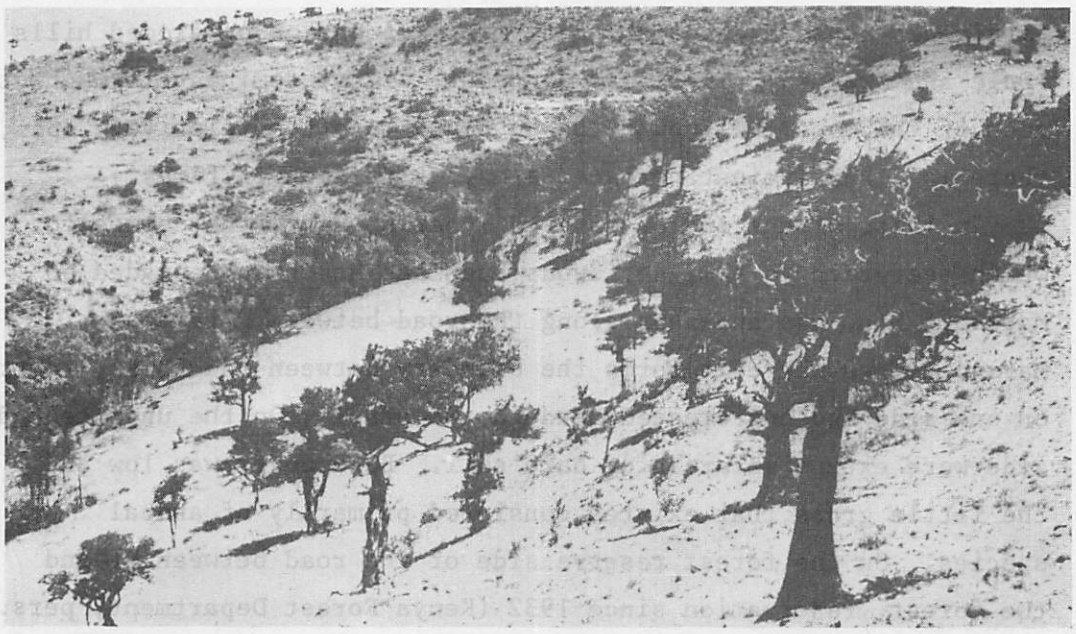


Figure 20: *Juniperus procera* wooded *Dichanthium insculptum/Themeda triandra* grassland at Arabel, the northern part of Mt. Kulal. This vegetation has been derived from evergreen to semi-deciduous bushland through frequent burning. A remnant stand of evergreen forest occupies the wetter, more protected valley bottom.



Figure 21: Evergreen to semi-deciduous bushland at Gatab, southern Mt. Kulal. Note the mosaic of bushland stands and fire derived grassy areas dominated by *Dichanthium insculptum* and *Themeda triandra*.

Harrisonia abyssinica, a shrub typically found on on eroded hills (Dale and Greenway, 1961), is abundant, if not dominant throughout much of the type. Although the bushland is often relatively open, there is insufficient herbaceous matter to support fires.

In 1976, at the end of an eight year drought, the degree to which evergreen to semi-deciduous bushland had been degraded on Marsabit Mtn. was apparent along the road between Karawe and Marsabit Town where it forms the boundary between the forest reserve on one side and unprotected land on the other. On the unprotected side were extensive areas of bare soil. Bush cover was low and the little grass that existed consisted primarily of annual species. On the forest reserve side of the road between it and the forest, reservation since 1932 (Kenya Forest Department, pers. comm.) has resulted in what appeared to be somewhat denser bush stands between which existed a dense cover of tall *Pennisetum mezianum* grassland, in this case a successional type to evergreen to semi-deciduous bushland.

Bush vegetation may eventually thicken up on both sides of the road. This would be caused by protection from fire on one side and the absence of a competing herbaceous layer on the other. However, should occasional fires occur on the protected side, the resultant "hot" fires would probably produce a gradual loss in bush cover. This is the same process that has caused the loss of evergreen to semi-deciduous bushland at Arabel and may have been responsible for destroying the same vegetation type in the Hurf Hills. At present, evergreen to semi-deciduous bushland in the Huri Hills is restricted to steep walled, narrow, rocky canyons on the eastern slope.

6. 9 Evergreen forest

Upland evergreen forest constitutes 124km^2 or 0.5% of the total study area (Table 2). This is considerably less than for Kenya as a whole or for East Africa where forestland consititutes 7% and 3% of the land area respectively (Morgan, 1973).

However, not all evergreen forest of ecological significance to the project area has been included because those forest on Mt. Nyiru, the Ndoto Mountains and the eastern half of Marsabit Mountain lie just outside the project area boundaries.

Evergreen forest caps the major mountains of the area where rainfall is greatest, cloud cover most extensive, and potential evaporation and temperatures least. Additional precipitation is probably obtained from moisture condensation from heavy mists which occur frequently during the year. Such mists are probably important to the long term maintenance of these forests (Edwards, et al, 1979).

Evergreen forest within the study area is dominated primarily by *Cassipourea malosana, Diospyros abyssinica, Olea hochstetteri,* and *Teclea simplicifolia* (Figure 22). *Cassipourea malosana* is probably the principal element. However, two major communities occur: one on Mt. Kulal (1835 - 2335m) and the other on Mt. Marsabit (1165 - 1865m). Also, remnants of *Juniperus procera* forest occur on the upper slopes of Ol Doinyo Mara, which is 2260m in elevation (FAO, 1971).

On Mt. Kulal, *Juniperus procera* also occurs as a successional species at the forest's edge at higher elevations. *Juniperus procera* dominated forest is considered as intermediate between wet and dry forests in East Africa (Lind and Morrison, 1974).

The lower zone and particularly it transition to evergreen to semi-deciduous bushland, has been burnt and disturbed to a greater degree than the wetter zone above it. For instance, at Arabel, on the north side of the Mountain, it occurs mostly as relict *Juniperus procera* trees on the broader, grassy ridge tops. It is also being progressively destroyed on the steep slopes of adjacent canyons. The progression of successive burns on canyon walls laterally up the canyon towards the main spine of the mountain is clearly evident. This shows a succession outward of zones containing (a) recently burnt trees still standing and some still alive, (b) all dead and some standing, (c) all dead and down, and (d) occasional dead and down trees still remaining on the ground.

Elsewhere within the forest, *Cassipourea malosana* and, to a somewhat lesser extent, *Olea hochstetteri* dominate. They are associated with *Ocotea kenyensis, Casearia battiscombei*, and *Nuxia congesta* and, at higher elevations, with *Allophylus abyssinicus, Teclea nobilis,* and *Prunus africana* as well.

Evergreen forest on Marsabit Mtn. has the same basic composition as that on Mt. Kulal yet differs in the absence of *Juniperus procera* and the occurrence of *Strombosia scheffleri, Ekebergia capensis, Premna maxima,* and *Croton megalocarpus* as important species. The latter species, a typical dominant of lower montane forests (Verdcourt, 1964; Lind and Morrison, 1974), is especially common.

It is interesting that evergreen forest has a much lower altitudinal limit (1165m) on Marsabit Mtn. than on Mt. Kulal. Indeed, all of Marsabit forest occurs below the lower limit for forest on Mt. Kulal (1835m). This suggests rainfall is greater on Marsabit Mtn. as — to support forest — it would have to be to compensate for the generally higher temperatures (and, hence, potential evaporation) at lower elevations.

It is possible that, although considerably lower in elevation (by 465m) than Mt. Kulal, the overall greater mass of Marsabit Mtn. may have an equal or even greater ability to lift unstable moist monsoonal air masses, thereby inducing rainfall. Also, its presence approximately 120km southeast of Mt. Kulal means that it is the first to encounter moisture-laden air masses of the southeast monsoon and that subsequent wind currents to the west and northwest of the Mtn. are probably modified somewhat from their original pattern. Both factors could ultimately affect rainfall on Mt. Kulal.

Evergreen forest does not exist in the Huri Hills. However, there is the possibility that it is capable of existence there given adequate protection from fire and cutting.

If it is capable of occurring on the Huri Hills, as thought possible by Andersen (1975) but not probable by FAO (1971), it will be within Type 7 (*Combretum molle* woodland) and, perhaps, to some extent within Type 53 (*Combretum molle* wooded *Chrysopogon/ Themeda* perennial grassland).

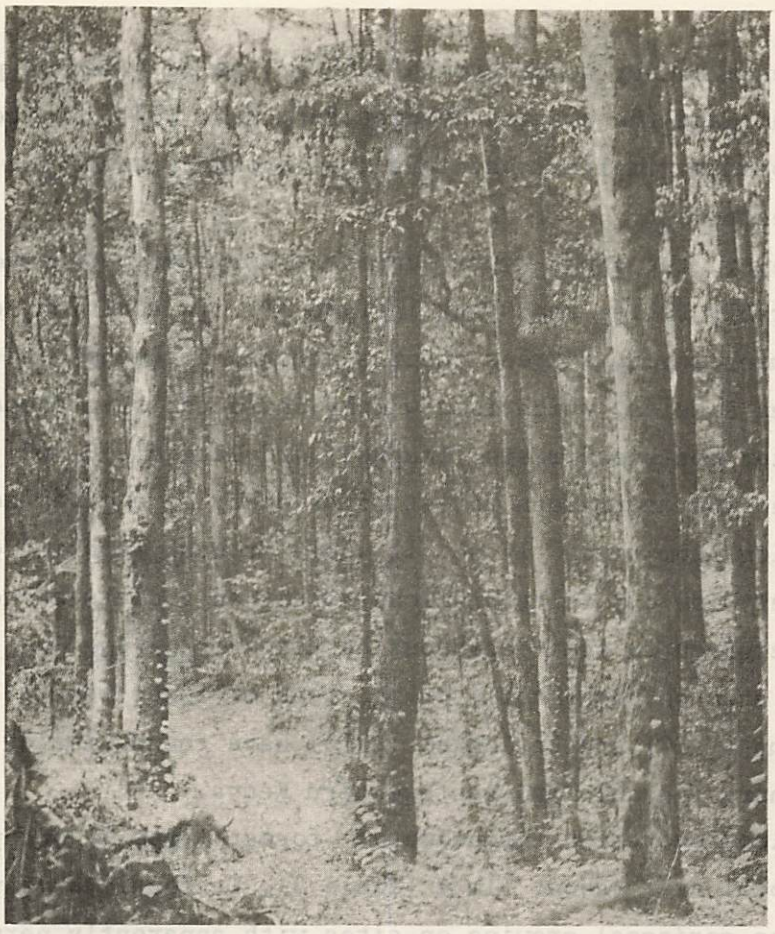


Figure 22: Evergreen forest on Mt. Kulal. The principal dominants are *Cassipourea malosana, Diospyros abyssinica, Olea hochstetteri* and *Teclea simplicifolia*.



Figure 23: *Hyphaene coriacea* (Doum Palm) lowland evergreen (groundwater) forest near North Horr.

The absence of any woody growth within Type 50 (*Themeda* perennial grassland) and the dwarfed drought form(FAO, 1971) of the dominant grass species implies that this type probably would not support evergreen forest.

However, the other types support a *Chrysopogon/Themeda* cover considerably taller than that in Type 50. In addition, occasional *Croton macrostachyus* trees occur scattered throughout both types. This tree species, which is a widely characteristic component of the wetter montane forests (Trapnell and Langdale-Brown, 1969) indicates that evergreen forest might occur here given adequate protection from fire. If so, it would probably consist of a relatively low dry sclerophyllous forest on pockets of good soils with evergreen to semi-deciduous bushland occurring over the greater area on rocky soils or in areas of lower rainfall. Glover and Trump (1970) and Herlocker (1975) have found similar situations in northern Tanzania and southwestern Kenya.

Lowland evergreen (groundwater) forest (Type 2) occupies a very small total area (about 91m^2) (Table 3). It consists of palm trees *(Hyphaene coriacea)* growing on sites with apparently permanent groundwater (Figure 23). These evidently vary in salinity from low to high (Hemming, 1972; Barkham and Rainy, 1976). The type consists of scattered small stands along the edge of the Chalbi Desert and at the base of Mt. Kulal at Gus, Laridabach, Mawingaten and Oltorut.

7. Summary

The UNESCO(IPAL) project area is an extensive plain (530 - 760m elevation) underlain primarily by pleistocene basaltic lavas and quaternary sediments. Lava and Precambrian mountains — the latter the source of the quaternary sediments — ranging from 1685 to 3030m elevation, occur around the perimeter of the project area. An old lake bed (the present Chalbi Desert) forms a large shallow depression (948km^2) in the north. This is a sump for a 36,615km^2 interior drainage system, part of which is in Ethiopia. Seventy-seven percent of the 23,000km^2 project area is within this system.

The climate is the most arid in East Africa and is similar to that throughout northern Kenya, Somalia, and eastern Ethiopia. Rainfall is low, highly variable and bi-modal in distribution (April and November mostly). Potential evaporation is high.

Thus, the larger part of the study area is within the semi-desert eco-climatic zone. Moister zones occur at higher elevations culminating in a small area of the montane forest eco-climatic zone at the summits.

A wide range of primary physiognomic vegetation types (9), which includes a large number of compositionally defined tertiary vegetation types (73), occurs within the study area.

Primary vegetation types are apparently well correlated with climate as modified to some extent by geology and geomorphology. Tertiary types are much more closely related to local soil differences and, also in some cases, reflect different land use histories.

Vegetation physiognomy ranges from annual grasses with scattered dwarf shrub overstory to tall, dense evergreen trees with an understory of shrubs and small trees. This physiognomic gradient reflects a parallel gradient in moisture availability ranging from low to relatively high.

The principal primary vegetation types within the project area are annual grassland, dominated by *Aristida adscensionis* and *A. mutabilis*; dwarf shrubland, dominated by *Duosperma eremophilum* and *Indigofera spinosa*; and shrubland dominated by *Acacia reficiens*. The last three species are the most abundant woody plant species within the study area.

These primary vegetation types together with barrenland, occupy the drier part of the environmental gradient within the study area. The wetter vegetation types are less extensive as they are restricted to higher elevations and to certain lowland riverine sites. Successional stages of vegetation are more apparent here both because more stages are possible within moist environments and because use of modification of vegetation by man (cutting, burning and grazing) has probably been more intensive.

Bushland, dominated by *Acacia mellifera, A. senegal, A. reficiens* and *Commiphora* spp., occurs primarily on residual gneissic — derived soils which appear more water retentive than adjacent lava and sandy sedimentary soils.

Woodland embraces an enviromental gradient within which *Acacia tortilis* subsp. *spirocarpa* dominates the drier end (mostly below 1,000m elevation), *Acacia etbaica* and *A. nilotica* subsp. *subalata* the more moist middle and *Combretum molle* the wetter end. The latter two communities appear to be fire maintained and successional to evergreen to semi-deciduous bushland and, possibly — in the case of *Combretum molle* — even to evergreen forest.

Evergreen to semi-deciduous bushland has a large number of characteristic and locally dominant woody species among which are *Aspilia mossambicencis, Carissa edulis, Euclea divinorum, Harrisonia abyssinica* and *Lippia ukambensis*. This is probably the most highly modified of any primary vegetation type in the study area because its relatively moist climate and nearness to permanent water (in the nearby evergreen forest) encourage greater use by man. Also, because it is drier it is ecologically more prone to degradation than evergreen forest.

Perennial grassland occurs mostly on the Huri Hills. It occupies a zone which is topographically analygous to that occupied by evergreen to semi-deciduous bushland elsewhere within the study area. *Chrysopogon plumulosus* dominates edaphically controlled climax communities on the lower, hotter, drier sites. On higher, colder, wetter sites *Themeda triandra* or a mixture of *Chrysopogon* and *Themeda* dominate fire-maintained communities successional to evergreen to semi-deciduous bushland or to evergreen forest.

Evergreen forest occupies mountain summits where rainfall is highest, evaporation lowest and fogs and mists are common. *Cassipourea malosana* is probably the most abundant and characteristic tree species throughout. However, the two major forest areas differ compositionally in that *Juniperus procera* is exclusive to Mt. Kulal whereas other species such as *Strombosia scheffleri* and *Croton megalocarpus* occur only on Marsabit Mtn. The differences are probably related to the different elevations at which the two forests occur.

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