Vegetation cover assessment in Turkana District, Kenya

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Study area

Turkana District in north-western Kenya (Fig. 1) marks the end of a depression extending from Somalia across northern Kenya. However, the central part and most of the west of the district are covered by a range of hills. The lowest areas are the Lotikipi Plain in the north-west and the area around Lodwar town.

The Turkana have lived longest in an area a little north of Lodwar. Their expansion into the southern region is comparatively recent and is, in fact, continuing today (Gwynne, 1977). The northern region of Turkanaland was subject to the pressure of Ethiopian expansion until quite recently; it was not until 1926 that the area was finally considered part of Kenya. Historically the Turkana began their initial expansion southward out of the Tarach Valley. The first people they encountered were the Samburu, who were the principal occupiers of central Turkanaland. They were pushed out, as were the Rendille and the Borana. This southward expansion may partly explain the hostility which exists today between the Turkana and their neighbouring tribes.

Most of the studies carried out in the district have been on the sociology of the people. However, the Royal Geographical Society conducted an expedition in southern Turkana in 1968, one result of which was a report on geomorphology and major vegetation types. (Gwynne, 1969)

Because of the low productivity of the area, little development has taken place. In fact before independence in 1963 it was a closed district within which the Turkana people roamed with their livestock. But after 1963 the government intensified its activities and security, medical care and famine relief were provided whenever they were needed. This has steadily increased the human population, which in turn has increased livestock numbers. Because of available facilities people have concentrated their manyattas around centres like Lodwar, Lokitaung, Likichar and Kakuma.

Since the nature and the distribution of existing vegetation provide useful clues to the prevailing biophysical influences and to the modifying effects of past and current human use, it is possible to develop a useful prelimary index to primary productivity. Climate, soil, land form and land use are some of the factors that determine the vegetation types found in an area.

The Turkana people depend on and utilize trees and woody vegetation for making manyattas and homesteads. The consumption of wood in the form of fuel is at present very low, maybe in the order of 0.1 m^3/head/annum of solid-wood-equivalent (Synott, 1979). Soft timber trees like *Delonix* and *Commiphora* are used for milk pots, bowls, stools and drinking troughs. In addition many trees and shrubs have foliage or fruit that are used as human foods.

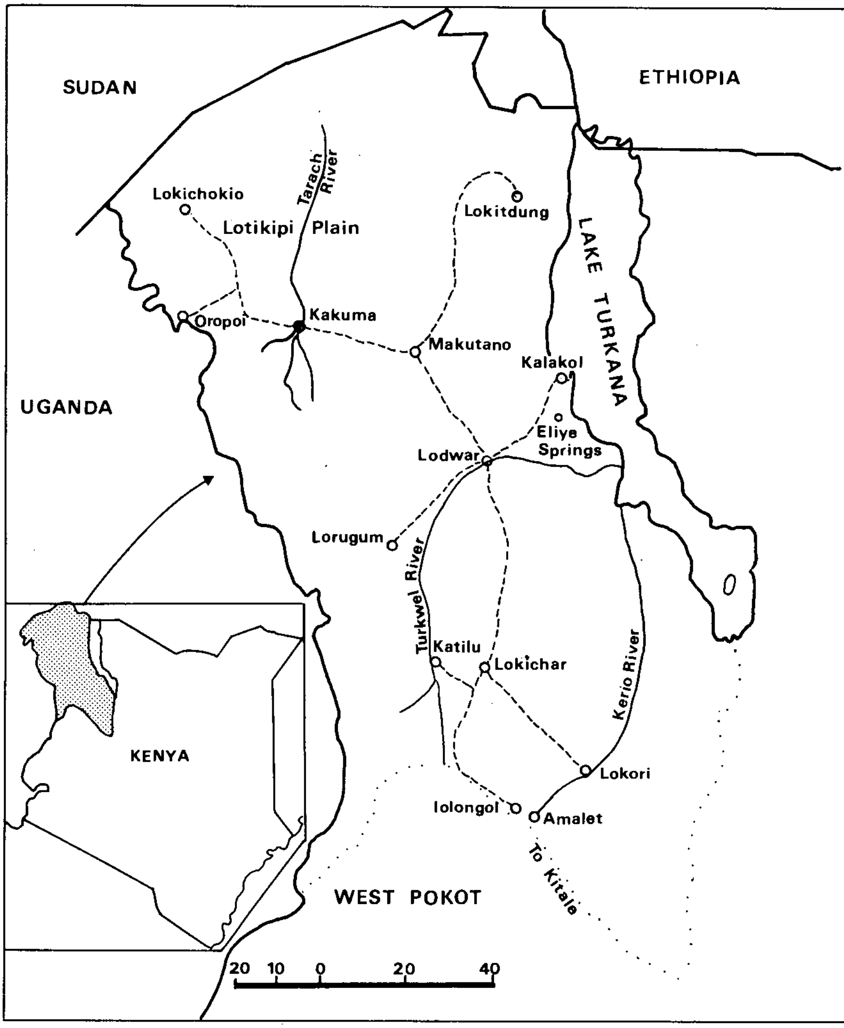

Fig. 1 Location map of Turkana District

Areas of depletion radiate from the trading centres. Burning of fires at night to keep away wild animals and to protect people from cold weather is more common at higher elevations than in the plains (NORAD, 1979). The use of charcoal in the district is increasing, especially among the urban people. Some people make charchoal and export outside the district and this trade will probably increase with increasing traffic.

Climate

From December through March the north-east monsoon originates over Arabia and passes over Somalia before reaching Turkana District (Herlocker, 1979). It brings a flow of hot, dry air masses resulting in little rain. Rainfall occurs under the influence of the south-east monsoon, which orginates over the Indian Ocean and is relatively cool and moist. However, distribution of rains in the district is controlled by the land masses. The western part along the Uganda border has more rain than any other part, due partly to orographic lifting of air masses loaded with moisture from Lake Turkana.

Rainfall data show that the area bordering Uganda receives not less than 500 mm annually (Herlocker , 1979). Another isohyet derived from rain- fall figures from Lokitaung from 1975 – 1981 shows that the northern to hilly border of Kenya and Sudan also receives more than 500 mm annually. The lower limit of rainfall for subsistence farming is 500 mm, although its seasonal distribution is also a factor.

Rainfall distribution

Monthly rainfall figures show that it rains all year round, but the period from March to May receives more than half of the total annual rainfall. Stations around Lake Turkana, like the Kalokol Fisheries Department Met. station in Turkana and North Horr in Marsabit show September, October and December as dry months. Again what is shown as monthly rainfall actually falls within one or two days. So, most of it is lost as runoff. Generally as rainfall decreases there is more fluctuation as to the time of its occurence. It may rain in an area one or two days in a year or the rain may fail altogether. Lokichoggio meteorological station recorded 140 mm of rain in May 1978, while in May 1981 this station recorded only 10.6 mm. Also in June 1980 this same station recorded no rain at all, while in June 1981 it recorded 105.9 mm. This type of fluctuation makes consideration of rainfall distribution diffult.

Land forms and soils

Most of the district is covered by lava flows, which generally occur in a north-south direction and, because of their altitude, form the major central hills. The landscape is generally called uplands and peneplains. These features are covered with shallow, poor soil with no organic matter. Directly below the top soil is unconsolidated weathering rock. This means that middle soil between the top soil and the rock is lacking (Muchena and Van der Pouw, 1981). The Turkwel and Kerio rivers reach the lake bed, of which the sediments are relatively low in organic matter and acidic. The soils have a tendency to seal strongly on the surface leading to a low infiltration rate and hence a lot of run-off.

The vegetation in this area is mainly scattered *Acacia* bush and a cover of annual herbaceous plants. The density of the woody plants increases on hilly ground. This vegetation pattern is repeated again and again until it becomes monotonous. However, it is punctuated by *Maerua* sp. and *Acacia tortilis* along the river-banks.

On the western side of these uplands and peneplains are the piedmont plains, which have been developed under dry climatic conditions. Soils are weakly developed and are low organic in matter. The drainage condition of these soils ranges from well to poorly drained. Most of the vegetation is classified as shrub.

The Lotikipi Plain is a flood plain composed of young soils which have been developed on alluvium of recent origin. The soils occur mostly on either side of the Tarach River. Fluvisols, which have irregularly decreasing organic matter are encountered in the Lotikipi Plain.

Most of the mountains and major scarps that border Uganda are covered by Cambisols (young weathered soils).They have relatively high natural fertility and a texture finer than sandy loam. These soils extend into the Cherangani Hills. Between these scarps and the central lava flow is a narrow band of soil which runs from Lokichar southwards. As this soil is poor in organic matter and is shallow, stony and rocky, the area is not well suited for arable agriculture. The only good arable soils are confined to the Ugandan border.

The two major rivers, Turkwel and Kerio, have essentially alluvial soils in which a silty sand overlays a coarse sand. At the Kerio delta and the lake shores the soils are more saline than elsewhere and are frequently overlaid by windblown sand (Gwynne 1977). The Lorin Plateau in the south-west is covered with a reddish sandy-loam in association with large areas of dark grey soils with impeded-drainage.

Methodology

Since the district is so large and this was the first attempt to produce a vegetation map, the best approach was the use of Landsat imagery. This was a quick way to get reliable information about environmental parameters like soil and vegetation types. Satellite imagery for October 1975 and June 1979 were used because they had less cloud cover. Then the area sampling frame method was used in locating stands (Olang, 1982). More stands were selected than were needed for sampling so that those that could not be reached because of lack of either security or roads were replaced without any bias being introduced.

The methods used in data gathering were the point centre quarter method (PCQ) and the quadrat method; the standard methods for collecting data on plants. PCQ was used in collecting data on woody biomass, while the quadrat method was used in estimating the composition and production of the herb layer (Kucher, 1978).

Vegetation types and biomass

The work we did in the field was to enable us to answer some questions which in turn would be of help to decision-makers. The biggest question was rangeland production in terms of quantity and its variation from place to place and year to year. Such questions are answered on the basis of the interpretation of data gathered.

Areas delineated on Landsat as separate strata proved to be different vegetation types, eight of which were recognized (Fig.2). A closer correlation between rainfall and vegetation types was introduced.

Near-barren or Sparse (N-B1 and N-B2).

The crown cover of woody plants was 1%. Out of ten plants recorded, six were less than 2 m in height. According to Pratt and Gwynne (1977), a near-barren condition is where woody vegetation contributes less than 2% of ground cover. Woody vegetation was dominated by *Acacia reficiens* while herbaceous cover was dominated by *Aristida mutabilis* and herbs by *Mallugo cerviana* and *Jatropha villosa*.

This near-barren condition was found in two areas. That north of Lodwar (N-B1) was due to lava flow, whereas the area south of Lodwar (N-B2) was due to overgrazing. The denuded area was dominated by *Aristida mutabilis, Acacia reficiens, Indigofera spinosa* and *Duosperma* spp. Total non-woody and woody cover was 7%. Herbaceous biomass was 80 kg/ha, but because of the nature of the rainfall distribution in the area, variation in plant production is great. A year can pass without an area receiving rainfall and this means a change in biomass from 80 kg/ha to zero. Nor does the 80 kg represent annual production because there are two rainy seasons and there were no exclosures to keep away grazing animals. Lastly this biomass excludes woody plants taller than 0.7 m.

Dwarf shrubland (DS)

The next vegetation type in terms of productivity is dwarf shrubland. It was rather difficult to draw the boundary line between these two types as the change was so gradual. Woody plants were hardly more than one metre in height except in depressional areas where soil was deeper. Woody cover was 5% while herbaceous biomass was 170 kg/ha. The area was dominated by *Acacia reficiens, A. horrida, Indigofera spinosa* and *Cadaba farinosa.* These woody plants seemed to be the major source of food as they were heavily brownsed.

The herbaceous standing crop was 170 kg/ha ranging from 84 kg to 260 kg per hectare.

Shrubland (S)

Extending more to the south and north but very little to the west is the shrubland. The western part of the district gets more rain so it supports bush rather than shrub.

The biomass of the standing crop in the north was 350 kg/ha, while that in the south around Katilu was 590 kg/ha. The north was dominated by *Acacia reficiens* and *Cordia sinensis*, while the southern area was dominated by *Acacia reficiens* and *A. senegal.* The grass species found in the north were more palatable than those found in the south. Those in the north included *Chloris virgata, Eriochloa fatmensis, Eragrostis ciliaris* and *E. racemosa*, while in the south *Enneapogon cenchroides* was dominant.

The standing crop found in the north must have been reduced by livestock that were found grazing there, while in the south there was no sign of their utilizing it.

Shrub-grassland (SG)

An ecotype between grassland and bush, shrub grassland was sampled in an area between Kakuma and Lokichokio in the north-western corner of the district. The woody cover was 6% while the herbacious standing crop was 800 kg/ha, most of which was contributed by *Eragrostis cilianensis, E. racemosa* and *Chlosis virgata.* Woody species were dominated by *Acacia reficiens, A. mellifera* and *Grewia tenax.*

Grassland (G)

The area in the Lotikipi Plain and around Eliye Springs is extensively covered by grassland. The Lotikipi Plain gets flooded during heavy rains. In September 1982, when we visited the area, it had just been heavily grazed. This might account for the low weight of the standing crop, 290 kg/ha.

Herbaceous cover was dominated by *Setaria sphacelata, Eragrostis racemosa, Becium obovatum* and *Barleria acanthoides*.

Riverine (R)

Along the Turkwel, Kerio and Tarach rivers the vegetation type is riverine. Its width depends on the landscape of the area through which the rivers pass. In a flat plain it is extensive and *Maerua crassifolia*, which is an evengreen shrub, marks the extent of the floods. *Acacia tortilis* dominates the vegetation and the third major species is *Ziziphus mucronata*.

Although the biomass of the herbaceous plants was only 200 kg/ha, this was because livestock was around all the time. Water is easily reached by excavating the sand. Flowers and pods of *Acacia tortilis* are other sources of forage, especially for goats. Some people even cut the branches of this acacia so that goats can browse the leaves.

Bushland (B)

Bushland type vegetation is found in the south of the district and along the border with Uganda. It is also found around Lokitaung and in an earea north of Lokori in south Turkana. The woody cover was about 41%, tree height was more than 8 m. Herbaceous cover was 42% of which 30% was contributed by grasses.

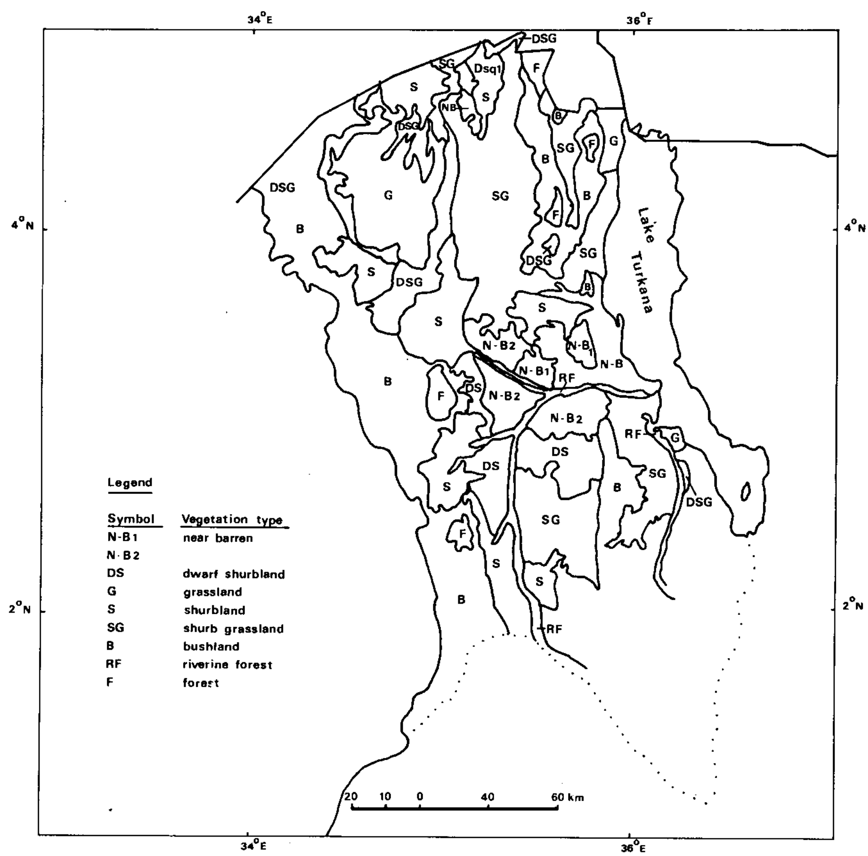

 Fig. 2 Vegetation map of Turkana District

Although *Acacia reficiens* was still the dominant, there were three other abundant species, which show that the climate was not so hostile as in the other areas discussed. Grasses were dominated by perennial species like *Digitaria milanjiana, Panicum maximum, Sporobolus confinis* and *Echinochloa haploclada*. Herbaceous biomass was 1020 kg/ha.

Table 1. Vegetation classification.

Symbol	Woody cover %	Herb cover %	Standing crop kg/ha	Vegetation type	Major species
N-B1	1	3	160	Near-barren	Acacia reficiens, A. condyloclada and Aristida mutabilis.
N-B2	2	5	260	Near-barren	Condition due to over-grazing and was dominated by Acacia reficiens, Duosperma eremophilum and Jatropha villosa.
DS	5	7	340	Dwarf shrubland	Acacia condyloclada Balanites orbicularis, Aristida mutabilis and Tragus berteronianus
G	–	12	580	Grassland	Tribulus terrestris, Mollugo cerviana, Tetra-pogon cenchriformis, Seteria sphacelata and Becium obovatum
S	18	16	680	Shrubland	Enneapogon cenchroides, Chloris virgata, Aristida mutabilis, Acacia reficiens and Cordia sinensis
SG	6	25	1600	Shrub-grassland	Acacia reficiens, A. mellifera, Grewia tenax and Cadaba farinosa
B	40	42	2040	Bushland	Acacia reficiens, A. mellifera, Boscia coriacea, Dactyloctenium aegyptium and Digitaria milanjiana
RF*	44	6	400	Riverine forest	Acacia tortilis, Maerua crassifolia, Indigofera spinosa and Jatropha villosa
F				Forest	

* This area was visited soon after it had been extensively grazed, which might account for the low figure.

Forage production and utilization

It is generally thought that precipitation, more than any other factor, determines plant growth in semi-arid regions. There are many indications of an almost linear relation between annual rainfall and annual production of rangelands (Penning de Vries, 1983). In the Sahel region Penning de Vries found above-ground dry matter of 400-500 kg/ha with less than 200 mm per year and 1000 kg/ha with 200-400 mm of rainfall.

We obtained a close relationship between rainfall and standing crop during our field work. Areas receiving less than 300 mm annual had standing crop ranging from 160 to 340 kg/ha, areas receiving 300 to 500 mm annually had 680 to 1600 kg/ha and the area with more than 500 mm annually had above 2000 kg/ha (see Fig.5). All these figures were standing crop and not actual production, so the actual production would have been closer to what Penning de Vries got from the Sahel region.

Forage cultivation

A number of irrigation schemes have been proposed and some are being constructed, which are producing for the local people. Cash crops like cotton are also being considered. But the local people are basically cattle owners, who have already started concentrating around these schemes with their livestock. There should be a plan for forage crops, which will be used as supplementary feed to the natural grass.

Other areas where forage crops could be grown are the proposed water spreading schemes (NORAD 1979). This would enable the local people to maintain milking cows and retain a high nutrition level. Forage plants that might be considered include alfalfa, *Chloris gayana, Panicum maximum* and *Cenchrus ciliaris.*

Stocking rates

The number of animals that can utilize an area without causing any deterioration to the range condition is expressed as the stocking rate. The number of animals per given area depends on its current production; the production gradually increases, then the number of animals will also increase. Several factors must be taken into consideration when calculating the stocking rate: the weight of a mature animal, the percentage of herbage production that can be utilized without causing overgrazing and the percentage clipped but not necessarily eaten by animals.

Animals living in dry areas like Turkana have little choice as far as food is concerned and eat almost anything that comes their way. But still there are some plants or parts of plants that they will never eat. Also the figures we are using are for herbaceous plants only and do not include palatable woody plants. Although it is considered desirable that a carry-over of 50% of the net yield be allowed (Telfer and Scotter, 1975) areas, that produce mostly annual plants, do not require this carry- over. Annual plants will die off as soon as they have produced seeds. It also appears that in arid and semi-arid grazing lands of the world, a moderate grazing intensity gives optimal returns, at least, over a short interval, because plants do not receive enough water to withstand heavy intensity of use (Van Dyne et al., 1980).

Animals grazing in arid and semi-arid areas walk long distances to pasture and also to water. So much walking together a with small body weight means higher food intake, which ranges from 2.5% to 3.6% of their body weight (Van Dyne et al., 1980). Since the calculation of the stocking rate will be based on the standing crop, the figure we shall arrive at will be on the low side, i.e. more animals could be grazed in the whole district. However, this report as a starting base will go a long way in helping planners. Stocking rates can later be adjusted up or down based on range condition at a given time.

Calculation of stocking rates

The stocking rate for each vegetation type is calculated separately and if the area is known then actual livestock numbers can be calculated.

Near-barren (N-B1,2).
The area had an average standing crop of 160 kg/ha and a mature cow has an average weight of 350 kg.
Allowable forage offtake is 160 x 50/100 = 80 kg
A mature cow eats 3/100 x 350 = 10.5 kg/day
Food requirement for one year is 10.5 x 365 = 3833 kg
Area required for one mature cow is 3833/80 x 1 = 48 ha/year

Dwarf shrubland (CDS).
Standing crop was 340 kg/ha with allowable offtake of 170 kg kg/ha. Area for each mature cow is 3833/170 x 1 = 23 ha/year

Grassland (G).
Standing crop was 580 kg/ha with allowable offtake of 290 kg/ha. Area required by each mature cow would be 3833/290 x 1 = 13 ha/year

Shrubland (S).
Standing crop was 680 kg/ha with allowable offtake of 340 kg/ha. Area required by each mature cow would be 3833/340 x 1 = 11 ha/year

Shrub-grassland (GS).
Standing crop was 1600 kg/ha with allowable offtake of 800 kg/ha. Area required by each mature cow would be 3833/800 x 1 = 5 ha/year

Bushland (B).
Standing crop was 2040 kg/ha with allowable offtake of 1020 kg/ha. Area required by each mature cow would be 3833/1020 x 1 = 4 ha/year

Riverine Forest (RF).
Standing crop was 400 kg/ha with allowable offtake of 200 kg/ha. Area required by each mature cattle is 3833/200 x 1 = 19 ha/year

Grazing system

As a general rule, pastoral and semi-pastoral people have common rights within their tribal boundaries to grazing and water. In a sense, cattle are 'land', since it is their number that gives the pastoralist his security, and the greater the number, the more land he uses (Pratt and Gwynne, 1977). Grazing animals are the means for either economic exploitation or destruction of

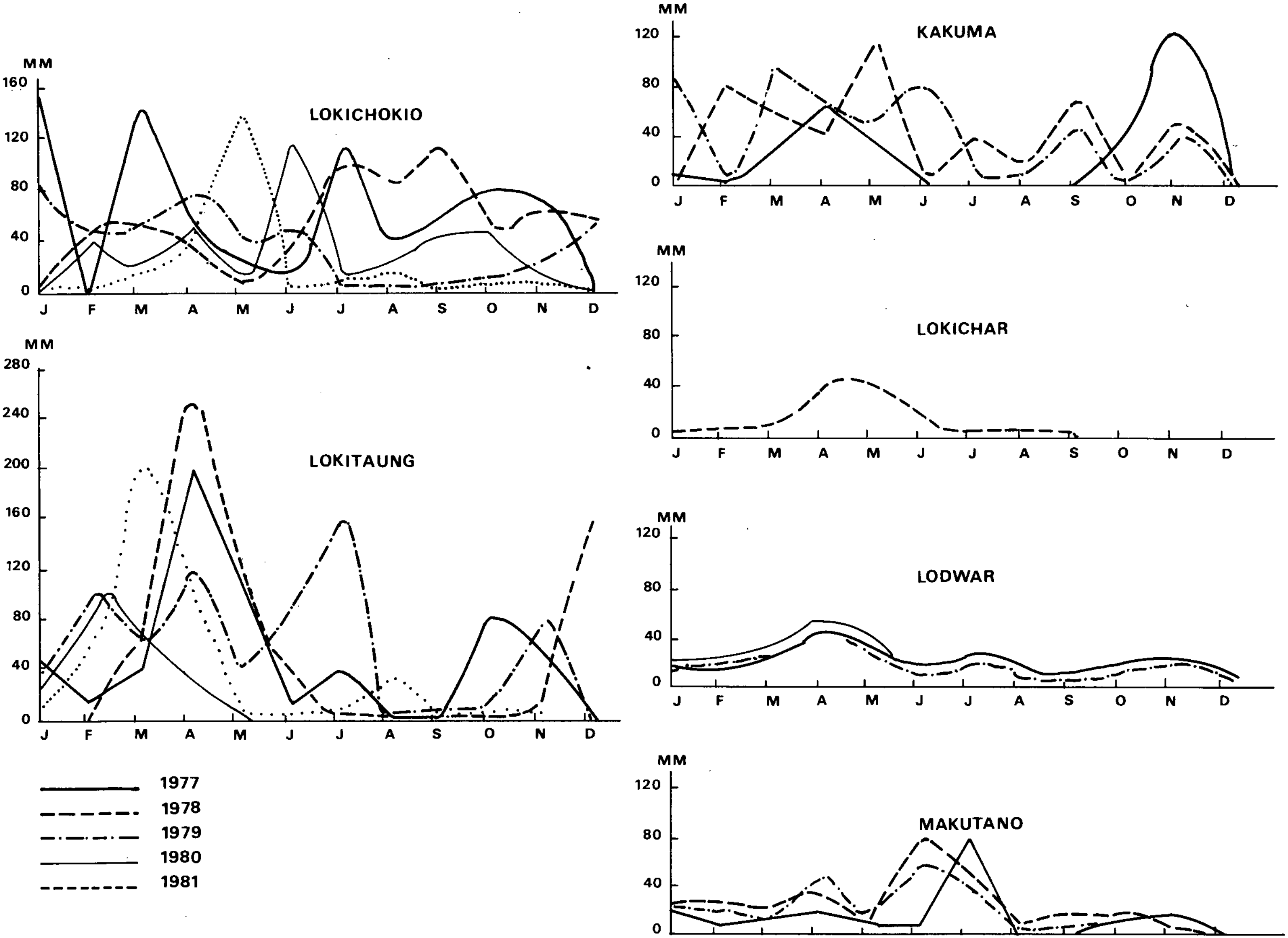

Fig. 3 Rainfall at six stations in Turkana District from 1977 to 1981

rangeland. Grazing management provides the means to manipulate the grazing animals so as to effect use without misuse.

The grazing system currently used in the district is seasonal livestock movement. Animals are either confined to one area every wet season or move naturally between wet and dry season. In addition, animal movement is controlled by insecurity. There are constant raids along the common borders with other tribes. With the wet and dry season grazing system, areas that suffer the most are those grazed regularly with each coming of the rains during the growing season. Although the rains fall in two seasons the long rains between April and May and the short rains between November and December, at times an area may miss either the long rains or the short rains in one year, especially the *Aristida mutabilis* area (Fig. 3).

During the long rains most of the livestock graze in the *Aristida mutabilis* area, then they move to the *Sporobolus helvolus* area in July and stay up to September. Then a few cattle try to move into parts of the *Sporobolus confinis* areas in late September and early October. But because of cattle raids most of this area is always left ungrazed.

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Evaluation af seasonal and drought effects on range trend analysis in Kajiado District, Kenya

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Introduction

The study is located in Kaputiei Division of Kajiado District in Kenya (Fig.1). The area lies in the semi-arid climate which receives an annual rainfall of between 500 to 800 mm.
Kaputiei falls into three physiographic sections: the Athi-Kapiti plains with soils developed from Athi-Kapiti phonolites; the central uplands with soils formed on basement complex rocks; and South Kaputiei erosional plains with both volcanic- and red sandy soils.

The Athi-Kapiti grassland is charaterized by *Themeda triandra* and *Acacia drepanolobum*, while the central uplands have woody grasslands dominated by *Acacia tortilis* and *A. mellifera*. The South Kaputiei is covered by a bush-grassland vegetation which is dominated by *Acacia* sp. and *Commiphora* sp. as well as *Chloris roxburghiana* and *Chrysopogon aucheri.*

The Kenya Livestock Development Programme (Phase 1) started the group ranch development strategy in Kaputiei as a pilot scheme. The aim of the group ranch development approach was to establish some form of grazing control among the joint owners of each ranch. Vegetation transects were established in these group ranches in 1967 with the aim of monitoring the effectivess of grazing management plans within each group ranches. My study was undertaken to re-monitor the original transects in order to evaluate the range condition and trend in the Kaputiei Group Ranch Pilot scheme. ILCA's financial assistance in meeting field expenses in this study is kindly acknowledged.

Materials and Methods

Twenty-five of the original 29 transects were located in 1976/77 with the help of the site description of each transect and the participation of one of the persons involved in siting the transects. Each transect with a well defined starting and end point was 300 meters long. Frequency and basal cover measurements were taken along each transect line. A circular wire plot of 0.96 ft.square was placed along the transect line at intervals of 3 meters. Frequency measurements were taken in 100 plots along the transect, while basal cover estimates were taken at an interval of 15 meters along the line. The frequency of a species is defined as the number of times the species is observed in 100 sample plots. The basal cover was estimated ocularly as the proportion of the sample plot covered by the stems of tussock or bunch

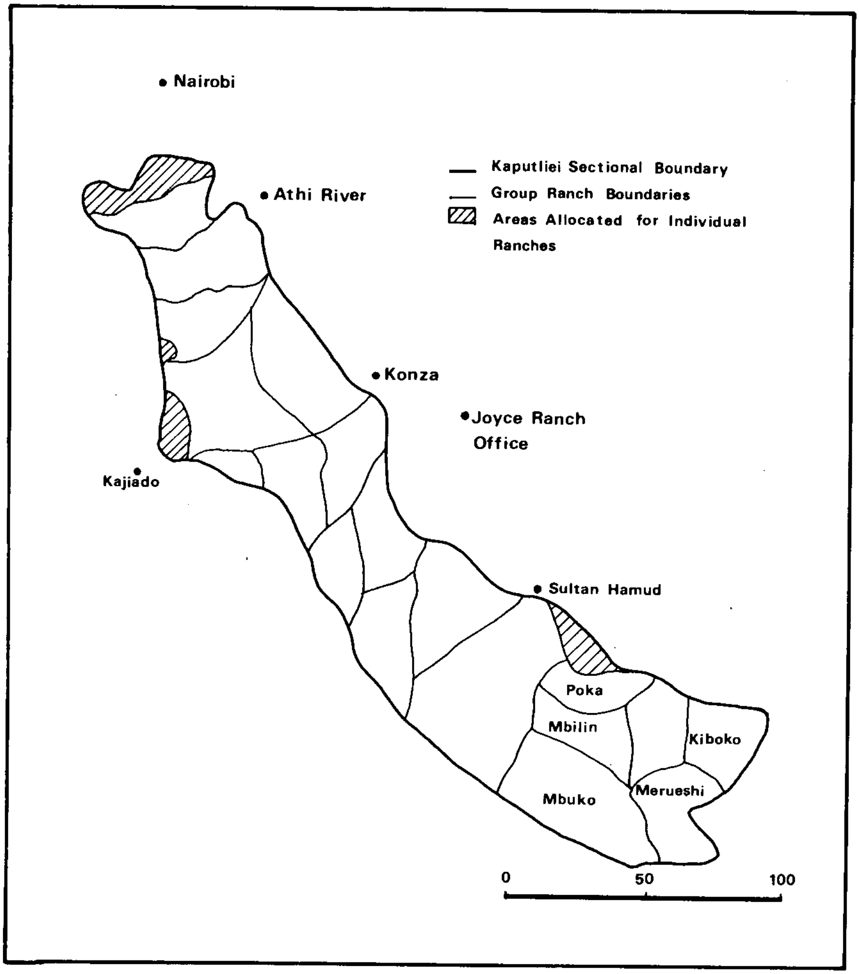

Fig. 1 The Kaputiei group ranching scheme

perennial grasses.

A photographic record was taken at the beginning and end of each transect.

Results

A. Long-term range trend

The long term frequency changes of perennial grasses and ephemeral species are shown on Table 1a and 1b.

Table 1a: The long term species frequency changes in three transects in South Kaputiei, Kajiado District, for perennial grasses.

Measurements	Poor condition Transect 1			Fair condition Transect 12			Good Transect 4		
Soil Type Frequency	(Red sandy soil)			Red sandy soil			Black cotton soil		
	1969	1977	1982	1969	1977	1982	1969	1977	1982
A. Perennial grasses	%100 sample								
Cenchrus ciliaris	0	7	0	0	7	5	–	–	–
Chloris roxburghiana	18	6	39	23	27	43			
Chrysopogon aucheri	8	2	2	25	0	0	1	3	3
Dichanthium insculptum	–	–	–	14	19	23	2	3	3
Digitaria macroblephara	95	10	19	94	38	35	–	–	–
Eustachys paspaloides	2	0	0	–	–	–	–	–	–
Pennisetum massaicum	22	4	10	10	0	0	–	–	–
Pennisetum mezianum	5	0	0	–	–	–	65	70	69
Sporobolus fimbriatus	2	0	0	4	2	0			
Themeda triandra	4	0	0	–	–	–	5	11	5
Ischaemum afrum x brach.	–	–	–	–	–	–	36	55	75
Lintonia nutans	–	–	–	–	–	–	26	29	28
Setaria phleoides	–	–	–	–	–	–	6	14	31
Sorghum spp.	–	–	–	–	–	–	0	34	27
Panicum coloratum	–	–	–	–	–	–	7	0	0
Echinochloa sp.	–	–	–	–	–	–	1	1	1
Total frequencies	156	29	70	170	93	106	149	220	242

The frequency of perennial grasses in Transects 1 and 12 decreased between 1969 and 1977, but in Transect 4, the total species of perennial grasses increased from 149 to 220. Between 1977 and 1982, transect 1 shows improvement of total frequencies from 29 in 1977 to 70 in 1982. In transect 12 there was only a slight improvement of total species frequencies of perennial grasses during this period from 93 to 106. The total species freqency in transect 4 increased from 220 to 242 between 1977 and 1983. Transect 4 is located in a calf paddock area, while transect 1 and 12 are near human settlements.

The results of ephemeral and forb species are shown on table 1b. The data for 1969 show that *Aristida* spp. dominated in Transect 1. In general there were few ephemeral grasses in 1969 than in 1977. The forbs frequency measurements in 1969 are not available. But the results of the data for 1977 and 1982 show that ephemeral grasses are more abundant in poor range condition areas (transect 1 as compared to transect 4). The same observation

Table 1b: The long term species frequency changes in three Transects in South Kaputiei, Kajiado District, for more ephemeral grasses and forbs.

	Transect 3			Transect 12			Transect 4		
Frequency measurement	1969	1977	1982	1969	1977	1982	1969	1977	1982
B. Ephemeral grasses									
Aristida spp.	35	0	0	8	1	1	–	–	–
Eragrostis (ten., aeth, ci.)	3	44	73	0	4	20	–	–	–
Sporobolus spp. (ang.pull.,fastious)	0	24	40	0	0	6	–	–	–
Brachiaria spp.	–	–	–	0	1	5	0	0	6
Dactyloctenium aegypt.	0	0	24	0	0	16			
Tragus berteronianus	6	7	3	–	–	–	–	–	–
Microchloa, Oropetium	16	0	7	0	2	3	–	–	–
Dichanthium papillosum	–	–	–	–	–	–	7	0	–
C. Forbs									
Indigofera spinosa	–	12	7	–	39	5	–	0	11
Tribulus terrestris	–	29	16	–	–	–	–	–	1
Hermannia sp.	–	–	–	–	12	24	–	–	–
Zaleya pentandra	–	–	–	–	–	–	–	–	10
Solanum incanum	–	0	17	–	–	–	–	0	13
Astripomoea sp.	–	–	–	–	–	–	–	–	–
Ipomoea	–	35	42	–	17	0	–	–	–
Bulb	–	14	0	–	–	–	–	–	–
Commelina sp.	–	0	18	–	0	2	–	–	–
Sedges	–	–	–	–	10	2	–	–	43
Amaranthus sp.	–	13	0	–	–	–	–	–	–
Ocimum sp.	–	0	5	–	8	4	–	–	–
BASAL COVER Percentage (%)	17.3	1.8	4.0	18.8	4.0	5.3	12.0	23.0	20.0

Table 2: Long term changes in ephemeral grasses (in %).

Grass spp.	*Eragrostis*				*Aristida*				*Sporobolus*			
Year	1969	1977	1981	1982	1969	1977	1981	1982	1969	1977	1981	1982
Transect 1	4	57	66	73	35	0	3	1	0	24	36	34
Transect 12	0	0	72	16	8	1	0	1	4	2	0	2
Transect 14	11	53	–	56	29	1	–	4	0	5	–	11
Transect 15	1	31	–	9	59	0	–	1	65	23	–	58
Total (%)	16	141		154	131	2		7	69	54		105

holds for forbs which tend to increase as the perennial grasses become less frequent and therefore less important. It is significant to note the decrease of *Indigofera spinosa* in Transect 12 between 1977 and 1982 which is probably as a result of the improvement of the status of perennial grasses during this period.

The changes of ephemeral grasses represented by three genera: *Eragrostis* spp. *(aethiopica; cilianensis, tenuifolia)* and *Aristida* spp. *(adoensis, adscensionis, keniensis)* and *Sporobolus (pellucidus, festivus, angustifolia)*. Table 2 shows that in transects 1, 12, 14 and 15, *Aristida* species were very important in 1969, while *Eragrostis* dominated the ephemeral grasses in 1977 and 1982. *Sporobolus* spp. have been common in 1969 and 1977 but seem to have increased by a factor of two in 1982.
The basal cover in transects 1 and 12 decreased drastically between 1969 and 1977 and had not shown any significant improvement by 1982/83 (Table 1b). However, in transect 4 the improvement of total species frequencies since 1969 is also accompanied by basal cover change from 12% to 20%. Table 3 shows a more complete picture basal cover trends. In general the basal cover decreased between 1967 and 1969 and then continued to decrease between 1969 and 1977 except for transect 4, 7, 8 and 5. These transects are located on well managed lands and are also on black clay soils (Vertisols or Planosols). All the other transects are located on red sandy soils which are more susceptible to overgrazing and surface soil erosion due to their closeness to the water pipeline.

Table 3: Basal cover estimates of Kaputiei vegetation transects (in %)

Transect		1967	1969	1977	1982
Group Ranch & Transect					
Mbilin	1	17.0	17.3	1.8	4.0
Mbilin	2	20.3	28.8	4.3	16.8
Mbuko	3	17.0	10.5	1.5	20.0
Poka Transect	4		12.0	23.0	20.0(1983)
Kiboko	12	52.0	18.8	4.0	5.3
Mbuko	14	31.8	14.0	0.5	6.5
Merueshi	15	24.8	7.0	1.0	4.6
Poka	13	52.0	15.5	20.5	
Athi-Kapiti	8	56.0	24.3	32.5	
Athi-Kapiti	7	67.0	8.5	22.5	20.0
Athi-Kapiti	5	22.5	19.3	21.0	

B. Seasonal changes

The analysis of seasonal effects on frequency is illustrated by Table 4. The seasonal frequencies of dominant perennial grasses in transects indicated in Table 4 do not alter the general trend of decrease of perennial grasses since 1969. Transects 1 and 15 showed a very low total frequency of perennial grasses in both the wet and dry season in 1977 as compared to the total frequency data in 1969. These two transects in 1977 represented poor range condition sites.

Table 4: Seasonal effects on frequency measurements (perennial grasses).

Month	May	Oct.	Dec.
Year	1977	1977	1969
Season	Wet	Dry	Wet
Transect 1 (Poor)			
Chloris roxburghiana	6	5	18
Chrysopogan aucheri	2	2	8
Digitaria macroblephara	10	6	95
Pennisetum massaicum	4	0	22
Total (%)	22	13	143
Transect 7 (Good)			
Cynodon dactylon	26	12	26
Digitaria macroblephara	45	62	56
Pennisetum stramineum	53	65	50
Themeda triandra	53	50	49
Total (%)	177	189	181
Transect 15 (Poor)			
Chloris roxburghiana	0	6	10
Cynodon dactylon	0	3	43
Pennisetum mezianum	0	4	1
Sporobolus angustifolia	23	6	65
Total (%)	23	19	119
Transect 27 (Fair)			
Cenchrus ciliaris	4	7	0
Chloris roxburghiana	4	2	4
Chrysopogan aucheri	7	11	19
Cynodon dactylon	22	23	32
Dichanthium insculptum	6	7	7
Digitaria macroblephara	32	31	45
Eustachys paspaloides	17	19	30
Themeda triandra	12	12	9
Total (%)	104	112	146
Transect 28 (Fair)			
Chloris roxburghiana	9	5	3
Digitaria macroblephara	37	33	50
Eustachys paspaloides	10	6	12
Heteropogon contortus	7	2	1
Pennisetum stramineum	12	9	8
Eragrostis superba	16	10	24
Themeda triandra	2	9	8
Total (%)	93	74	106

Transects 27 and 28 in fair range condition do not show significant variation of total species frequencies between wet and dry season of 1977.

The seasonal dynamics of ephemeral plants, however, show a contrasting situation (Table 5), particularly in degraded range sites. The wet season is dominated by the ephemeral plants, but during the dry season most of these plants dry up. The bimodal rainfall in April/May and November/December is characterized by peaks of ephemeral plants, which soon die back and exist in form of seeds (Fig. 2).

Table 5: Seasonal frequency changes in ephemeral grasses and forbs at a degraded range site (Transect 15).

Year	1977			
Month	March	May	October	December
Season	Dry	Wet	Dry	Wet
Grasses				
Tragus berteronianus	0	1	0	2
Sporobolus spp.	0	23	10	24
Eragrostis ciliaris	2	25	11	94
Eragrostis aethiopica	0	6	0	33
Total frequencies	2	55	21	193
Forbs				
Astripomea	0	16	1	10
Sedges	0	20	31	27
Leucas martinicensis	0	15	0	41
Polygonum sp.	0	11	0	43
Zaleya pentandra	0	69	0	61
Tribulus terrestris	0	54	0	76
Indigofera spp.	0	28	0	23
Total frequencies	0	213	32	281

Basal cover estimates in May and November 1969 show significant changes for transects located on red sandy soils, and no significant changes were observed for transects in Athi-Kapiti black clay soils (Planosols and Vertisols) (Table 6).

Table 6: Seasonal variation of basal cover estimates.

Year Month		1969 May	 November
Area			
South Kaputiei			
Red sandy soils (Erosional plains)			
Transect	1	17.3	6.0
	2	28.8	8.5
	3	10.5	6.0
	12	18.8	17.0
	14	14.0	6.0
	mean	17.9	8.7
	(n = 5)	6.9	4.8
Athi-Kapiti Range site			
Black clay soils (Planosol Plains)			
Transect	5	19.3	17.0
	6	5.8	6.0
	7	8.5	13.0
	8	24.3	27.0
	9	15.5	16.0
	mean	14.7	15.8
	(n = 5)	7.6	7.6

C. Drought factor.

It was a drought year in 1976 in which the total annual precipitation constituted only 44% of the main annual rainfall. (Fig 3).
Drought seems to increase the basal cover as shown on Table 7.

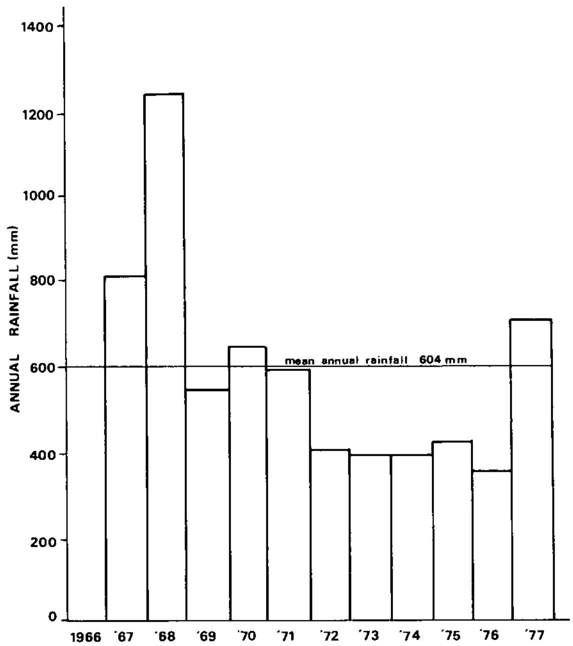

Fig. 2 Variation of the total annual rainfall from 1966 to 1977 at Makindu Meteorological Station

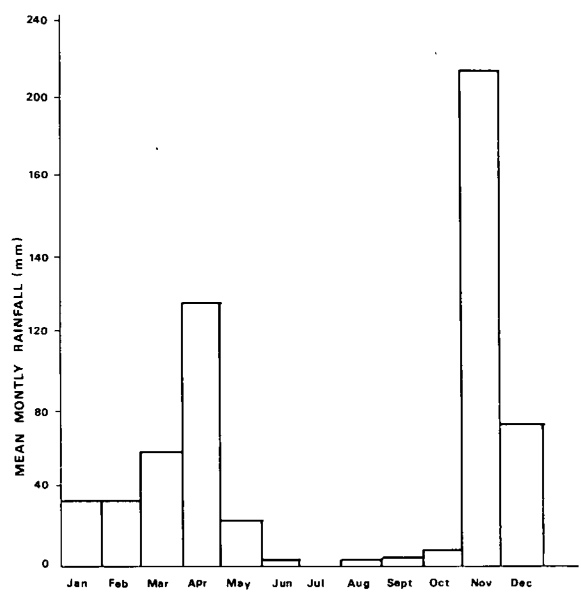

Fig. 3 Mean monthly rainfall for the period 1967 to 1977 at Makindu Meteorological Station

Table 7: Effect of drought on basal cover estimates.

		No drought 1969		(After 1976 drought) 1977	
Season		Wet	Dry	Wet	Dry
Month		May	Nov	May	Oct
Number	Transect condition				
7	Excellent	8.5	13.0	25.5	42.8
9	Excellent	15.5	16.0	19.0	30.3
1	Poor	17.3	6.0	1.8	0.5
12	Poor	18.8	17.0	4.0	0
2	Poor	28.8	8.5	4.3	0

Transects 7 and 9 were in excellent condition in both 1969 abd 1977, yet there was significant increase in basal cover from wet to dry season. However, for transects in poor condition the effect of drought is not apparent, because basal cover decreases from wet to dry season.

Botanical composition as indicated by frequency measurements shows that drought may not be a significant factor in influencing long term trend measurements. The total frequency measurements in Transect 7 in good condition did not vary significantly in the two consecutive years after drought. However, transects in poor to fair condition (1, 12) show no significant improvements between the first and second year after the drought (Table 8).

Discussion and conclusions

The influence of season and drought on rangeland vegetation measurements is important because of the possible misinterpretation of the long-term vegetation trends due to grazing management. Although the results presented in this paper were not collected from a statistically designed experimental study, a few conclusions can be made.

The seasonal variation of frequency measurements of perennial grasses are unlikely to mask the long term vegetation trend. Hence the date of monitoring the botanical composition changes within the same season is unlikely to cause variations which can confound the long-term trend of botanical composition changes.

However, when monitoring the dynamics of ephemeral plants in the rangeland, seasonal influences are much greater than long-term changes. The only exception in this regard is with reference to the genus: *Aristida* (Table 5). The species in this genus are good indications of long-term vegetation trends.

The seasonal effects on basal cover estimates for perennial grasses show great

Table 8: Effect of drought on the botanical composition of perennial grasses.

	Percentage frequencies		
Month	May	June	May
Year	1977	1978	1969
Transect 12	(Fair condition)		
Chloris roxburghiana	27	19	23
Dichanthium insculptum	19	16	14
Digitaria macroblephara	38	52	94
Total	84	87	131
Transect 1	(Poor condition)		
Chloris roxburghiana	6	3	18%
Digitaria macroblephara	10	12	95%
Pennisetum massaicum	4	5	22
Total	20	20	135
Transect 7	(Excellent condition)		
Digitaria macroblephara	45	31	56
Pennisetum mezianum	24	17	17
Pennisetum stramineum	53	45	50
Themeda triandra	53	62	49
Total	175	155	172

variation between wet and dry season measurements. The basal cover measurements should therefore be specific for a particular season and for approximately the same phenological stage of perennial grasses.

The influence of a single drought year (like 1976) on the frequency and basal cover measurements is also an important factor to evaluate. Frequency measurements of perennial grasses (Table 7) for 1977 and 1978 indicate that the 1976 drought had little effect on perennial grasses in good range condition sites. The low frequency percentage on poor condition sites (Transect 1 an 15) may be due to combined effects of drought and long-term overgrazing. The status of perennial grasses in 1977 and 1969 was the same in Transect 7, thus indicating that drought per se was not responsible for the low frequencies of perennial grasses in transect 1 and 15 (Table 4).
Drought seems to favour basal cover improvement on range sites in good to excellent condition (Transect 7 and 9) and to decrease basal cover measurements from wet to dry season in range sites in poor condition (Transects 1, 2 and 12).
To summarize, the frequency of perennial grasses is the single most important

rangeland measurement which does not suffer from seasonal and drought effects. Basal cover measurements vary from wet to dry season. This variation is greater for range sites in poor range condition. Drought promotes basal cover improvements in rangelands in good condition, while it tends to intensify the reduction of basal cover from wet to dry season.
The combined long-term monitoring of botanical composition of perennial grasses cover measurements will reflect the range trend due to grazing. Ephemeral plants dominate rangelands in poor condition and they also show great fluctuation from wet to dry season.