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POPULATION STRUCTURE AND MANAGEMENT OF GRASSLAND TYPES IN RWENZORI NATIONAL PARK, UGANDA

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RESUME

Structure des populations et aménagement de divers types de savanes dans le Parc national Rwenzori, Ouganda.

. Trois aires d'expérimentation ont été installées respectivement en savane floristiquement pauvre, en savane floristiquement riche et en savane à *Imperata*. Des données relatives à la composition floristique, le nombre d'individus de chaque espèce, la production primaire nette épigée ont été rassemblées. Pour chaque aire, des parcelles furent aménagées avec divers traitements : pâturage, mise en défens, incendie et protection vis-à-vis des feux.

Les données observées fournissent des informations pour l'aménagement des savanes du Parc national du Rwenzori.

Three study areas dealing respectively with poor mosaic, species-rich and *Imperata* grasslands were investigated regarding their floristic composition, number of individuals per species and above-ground net primary production.

Grazed and ungrazed plots, burnt and unburnt plots were established in each area. Results give information on further management of the Rwenzori national Park's grasslands.

INTRODUCTION

Rwenzori National Park lies on the equator in the Rift Valley of Western Uganda between 29^{o} 45'E and 30^{o} 15'E and 30'S and 15'N. It is surrounded by the Rwenzori horst to the north, and lakes Idi Amin Dada (formerly Lake Edward) and George to the West and North-east respectively, while to the north-west lies the Escarpment of the Western Rift. The Park which stands at some 899-1344 m above sea level covers an area of 1978 km^2. The two lakes are connected by the

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32 km long, about 792 m wide and 3 m deep Kazinga Channel.

The Park is underlaid by sedimentary rocks of pre-Cambrian age. Overlying them are the Pleistocene sediments of various types whose strata consist of unconsolidated gravels, sands, silts, clays and covered by variable layers of fine grained volcanic ash. On these sediments developed soil types which HARROP (1960) described as eutrophic, brown, rich in mineral nutrients and with a high reserve of weatherable minerals. But later the soils of the study areas (Fig. 1) were redescribed as grey in Area A by BROOKS (1957) and LOCK (1967), and loamy black in Areas B and C by LOCK (1967).

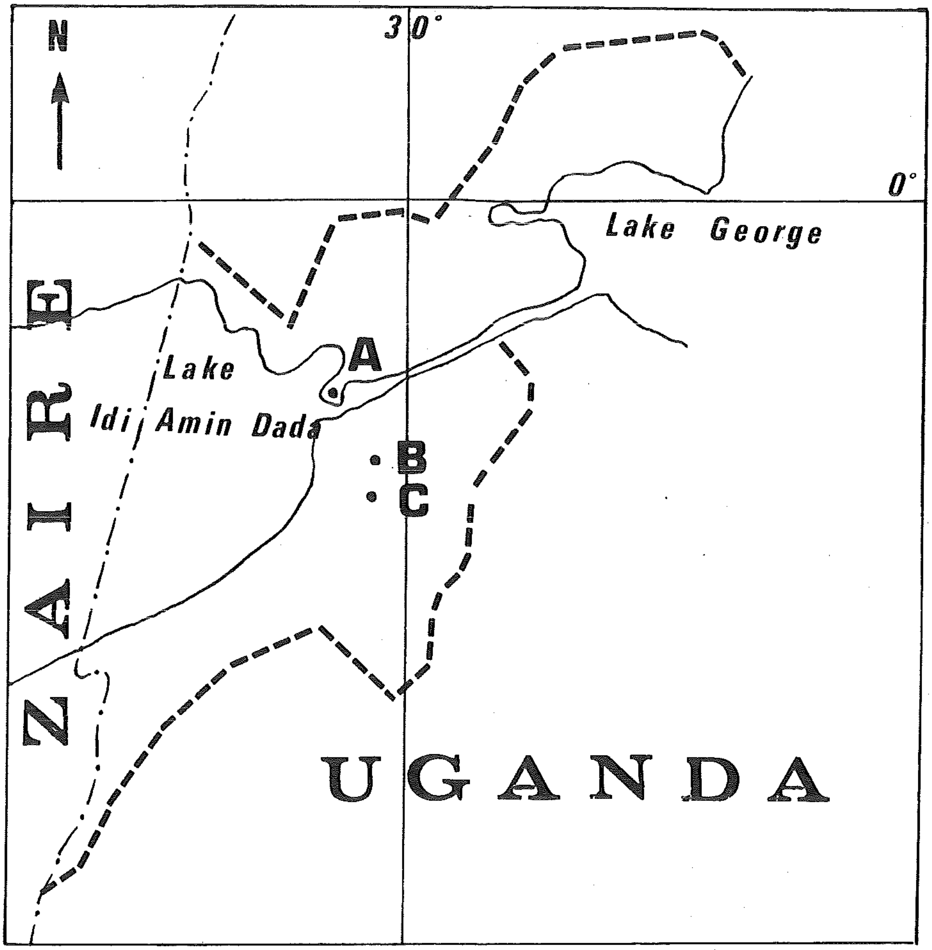

Figure 1 : Position of the three study areas A,B,C in Rwenzori National Park, Uganda.

The climate of the Park displays the relative constancy typical of the equatorial savanna. There are two wet seasons (March–early June, and late August–

November) separed by two dry seasons (December–February and late June–early August) (Table 1). Though the dry seasons are not completely rainless the small showery rainfall is of no availability to the plants. For study area A LOCK (1967) showed that measurable rain fell in less than 40 °/o of the days of the year and that 62.5 °/o of the annual total of rain fell on less than 7 °/o of the days of the year.

TABLE 1. *The mean rainfall(MM) of the three study areas recorded during January 1971 – December 1974.*

	J	F	M	A	M	J	J	A	S	O	N	D	Total/Year.
Area A	39.2	28.3	56.4	112.5	78.2	59.2	39.9	97.2	82.0	64.1	91.5	66.9	808.4
Area B	48.5	93.2	87.1	155.1	96.3	64.0	19.5	100.6	101.3	86.6	126.9	57.5	1036.6
Area C	65.6	41.0	50.7	137.8	65.2	64.8	29.2	104.6	94.1	65.9	136.9	51.3	907.1
Mean for whole Park.	34.8	45.6	91.8	120.2	87.0	44.5	32.1	70.8	83.3	108.5	104.5	57.1	880.2

Because of the diversity of landforms and the environmental variations, the Park contains vegetation types varying from forests to aquatic flora. These vegetation types support large numbers of small and large animals (BOURLIERE, 1965) constituting the highest biomass in the world (PETRIDES and SWANK, 1965 ; STEWART, 1966 ; FIELD, 1968 ; LAWS and FIELD, 1970). Both directly and indirectly the animals exert a controlling influence on the character and distribution ot the vegetation types.

Since the area was gazetted a National Park in 1952; the animal populations increased in it so rapidly that by the 1950's they were causing serious overgrazing problems (BERE, 1959; LOCK, 1967, 1972). The problems of overgrazing by hippopotamus (*Hippopotamus aphibious*, Linn.) in the Park was first reported by PETRIDES and SWANK (1958) and the effect of this overgrazing was summarised by BERE (1959). Further research by HEADY (1966), FIELD (1968), and LOCK (1972) showed that hippo overgrazing resulted into the deterioration of the vegetation and it encouraged the establishment and growth of *Sporobolus pyramidalis*, Beauv. and the other less nutritious plants. The overgrazing with its disastrous degeneration effects on the structure and performance of the vegetation types inevitably lead to the cropping of 7,000 hippos in the late 1950's and early 1960's. The cropping resulted into rapid improvement of the vegetation (THORNTON, 1971) and prevention of soil erosion in the overgrazed belts (3-5 km from the shores and inland wallows). Since then the hippo population has risen to the original (precropping) level and the vegetation along the shores are now mosaic (LOCK, 1972).

Beyond 5 km from the shores the grassland is the fire – climax type (FIELD, 1970; LOCK, 1972) and forms the main grazing ground for the large mammals other than hippos. The influence of the herbivores and of uncontrolled fires in the species-rich *Hyparrhenia/Themeda* fire–climax grassland is becoming equally profound. In several areas this type of grassland has been invaded by fast-spreading unpalatable grasses such as *Cymbopogon afronardus* Stapf and *Imperata cylindrica*, Beauv.

This paper reports on the population structure and the contribution, in terms of dry matter production, of the main component species, in three grassland types in relation to the potent factors of grazing and burning, and suggests practices to be used in the management of the grassland types.

STUDY AREAS.

Each of the three study areas (Fig. 1) falls within each of the vegetation zones of the Park given by BROOKS (1957) and LOCK (1972) as follows : Areas A (zone III), B (zone II) and C (zone I). The amount and distribution of rainfall in the three areas is given on Table 1. The ditched circular enclosures in Areas A, B and C, were constructed in 1969.

Area A is situated in a poor, Sporobolus grassland dominated by *Sporobolus pyramidalis* and *Chloris gayana* Kunth in Mweya Peninsula. It is heavily overgrazed by hippopotamus, buffaloes, elephants, waterbucks, bushbucks, warthogs and some rodents and birds. Because of the heavy overgrazing, several palatable species are no longer found there (LOCK, 1972) and the tussocky *S. pyramidalis* is abundant. The soil is still rich but is being eroded. The overgrazing hardly leaves enough plant material for burning to take place.

Area B is situated in the species-rich grassland dominated by *Hyparrhenia filipendula* Stapf and *Themeda triandra*, Forsk, 5 km South-east of Area A. The area is moderately grazed by buffaloes, Uganda kob, waterbuck, warthog and to less extent by elephants. Except in isolated patches the grazing is uniform though selective grazing by the kob is noticeable. Annual burning is a common feature of the area. The soil is black and richer than that in Area A. Environmental conditions are more favourable in this area than in Area A.

Area C is 2 km south of Area B situated in *Imperata* grassland. This area was originally a *Hyparrhenia/Themeda* grassland but was later invaded by *I. cylindrica*. This grass is a weedy species which establishes by seed in the moist depressions and then spreads vegetatively by means of rhizomes. As it advances it competes strongly with the associate species and gradually suppresses them to the point of elimination *C. afronardus*, a tussocky tall grass, is a codominant species in the area. Both species are highly competitive and they are rarely grazed except in the young stages of growth following fire. The soil of the area is rich.

METHODS.

The study started in January 1971 with collecting data (using 1 m² quadrats) on the species composition and frequency distribution of the three grassland types. Permanent 1 m^2 plot replicated three times were established inside and outside the study Areas A and B, and observations were made on the changes in the number of individuals per species during the advanced stages of the wet and dry seasons. There were therefore four population counts per year during the 1971 - 1974 period. The means for the replicates were worked out and the grand mean number of individual plants calculated for each species (unidentified forb plants were grouped as herbs) for the two wet and two dry seasons.

In January 1973 1 m^2 plots replicated thrice, were established in each of the burnt and unburnt portions both inside and outside the enclosures. In study Area A there was no burning. The plots were selected such that the size and density of the dominant and codominant species were about the same in all the plots. In February 1973 burning was applied to half of the inside and outside portions of Areas B and C. Twelve months later the vegetation in these plots was harvested at the ground level and for each plot sorted out into the major two species separately and the rest of the plants grouped together. The material harvested was oven-dried and weighed. The amount clipped was regarded as the amount of herbage available to the herbivores that grazed up to the ground level.

RESULTS.

(a) Floristic composition of the vegetation types.

All the species present on the three study Areas are listed in Table 2. The overgrazed Sporobolus grassland (Area A) had at least forty three species followed by Area B with thirty six and Area C with thirty five species. The lists also show the frequency distribution of the species. Areas B and C have each two species uniformly distributed. Only the dominant and codominant species in each study area contributed relatively high in the net primary production while the majority of the species did not contribute significantly in the dry matter production.

In Area A (Table 3) *S. pyramidalis* virtually maintained the highest density in the grazed area. *S. pyramidalis, Heteropogon contortus* (L.) Roem and Schult., *Sporobolus festivus* A. Rich., *Eragrostis tenuifolia* (A. Rich) Steud, *Bothriochloa insculpta* A. Comus, *Aristida adoensis* A. Rich., *H. filipendula* and *Harpachne schimperi* A. Rich are grass species which showed higher densities under grazed than ungrazed conditions. *Polygala erioptera*, DC. and *Indigofera erecta* Hochst ex A. Rich are two leguminous species which occurred in larger numbers in grazed than ungrazed areas. On the other hand *C. gayana, Cenchrus ciliaris* L. *Digitaria scalarum* (Schweinf.) Chiou and *Alysicarpus vaginalis* DC. occurred in larger numbers in the ungrazed than grazed areas.

In area B (Table 4) *H. filipendula* had the highest density throughout the four years period. This consistancy in density was followed by *T. triandra. Sporobolus stapfianus* Gand and *Microchloa kunthii* Desv. showed high but erratic

TABLE 2 : *Species composition and frequency in the three study areas.*

SPECIES.	A	B	C
Sporobolus pyramidalis	100	61	17
Chloris gayana	92	42	+
Aristida adoensis	83	+	
Bothriochloa insculpta	81	69	+
Cenchrus ciliaris	78		
Anthericum momiliforme	58	42	
Microchloa kunthii	50	89	22
Sporobolus festivus *	50	86	50
Tephrosia pumila	50	39	+
Alysicarpus vaginalis	47	44	39
Hyparrhenia filipendula	47	100	61
Heteropogon contortus	47	28	+
Sida ovata	47	11	
Polygala erioptera	44	39	33
Indigofera colutea	42	+	39
Digitaria scalarum	33	+	11
Harpachne schimperi	33		
Ocimum americanum	25	22	
Mariscus sieberiana	22	8	33
Dyschoriste radicans	19		
Indigofera paniculata	17		
Cassia mimosoides	17	+	+
Commelina bonghalensis	14	+	
Eragrostis tenuifolia	8		
Erigeron species	8	28	
Asparagus africanus	6	+	11
Chloris pycnothrix	6		
Portulaca quadrifida	6		
Chrysochloa orientalis	3		
Dactyloctenium aegyptium	3		
Chloris myriostachya	3		
Tragus berterianus	3		
Panicum brevifolium		3	
Kyllinga macrocephala		3	
Cymbopogon afronardus		14	100
Euphorbia hirta		17	
Solanum indicum	+	19	
Indigofera spicata		44	
Alysicarpus glumaceus	+	44	39
Brachiaria platynota		61	44
Carex echinochloa		64	22

TABLE 2. (continued).

Imperata cylindrica			100
Themeda triandra		100	94
Digitaria diagonalis			78
Maerua triphylla			44
Panicum maximum			28
Tephrosia nana	+	+	28
Setaria sphacelata		+	22
Brachiaria decumbens			11
Cynodon dactylon			11
Hyparrhenia dissoluta			6
Euphorbia inaequilaterata	+		
Euphorbia prostrata	+		
Phyllanthus aspericaulis	+		
Phyllanthus maderasparensis	+		
Indigofera	+		
Dichrostachys cinerea	+		
Azima tetracantha	+		
Vigna friesiorum		+	
Pseudarthria hookeri		+	+
Uvaria picta		+	
Ipomea species		+	
Clitorea tomenta		+	
Crotolaria bernieri			+
Crotolaria aculeata			+
Kyllinga cylindrica			+
Psophocarpys lancifolius			+
Acacia hockii			+
Laggera alata			+
Tainum portulacifolium	+		
Talinum caffrum	+		
Total number of species.	45	38	36

Plus signs (+) indicate presence of species.

* Difficult to distinguish between Sporobolus stapfianus and Sporobolus festivus.

TABLE 3 : *The mean number of individual plants in 1 m^2 quadrats per grass species in Sporobolus grass (Area A)*

	1971				1972				1973			
	Ungrazed.		Grazed.		Ungrazed		Grazed.		Ungrazed.		Grazed.	
	D	W	D	W	D	W	D	W	D	W	D	W
S. pyramidalis	12.3	12.7	30.5	31.0	10.7	11.3	35.5	37.0	4.4	4.4	23.7	27.2
C. gayana.	6.2	6.0	1.2	2.0	8.2	8.9	0.3	0.7	5.2	9.2	0.7	0.7
H. filipendula	0	0	5.0	5.7	0	0	6.0	9.0	0.7	0.3	9.7	9.7
A. adoensis	11.5	12.7	5.7	6.3	12.4	10.5	8.4	10.0	3.0	2.5	8.3	5.8
C. ciliaris	14.0	13.3	8.5	1.0	13.0	8.9	8.5	1.2	13.9	16.2	1.0	8.5
B. insculpta	0.7	1.3	3.5	4.0	1.4	1.7	18.0	5.2	0	0	7.0	4.5
S. festivus	3.2	4.0	6.2	11.0	2.5	1.9	9.0	5.2	0.7	0.3	10.0	7.9
H. schimperi	2.4	3.0	1.5	2.7	0.6	0.3	2.2	3.5	0	1.0	3.3	3.3
H. contortus	3.0	2.7	2.3	4.0	25.2	24.3	26.7	25.2	0.9	1.2	24.7	24.0
E. tenuifolia	1.3	1.3	1.5	3.0	0.3	0.3	1.0	1.8	0	0	2.0	0.3
M. kunthii	2.5	2.7	0	0	0.7	2.0	0	0	0	0	0	0
D. scalarum	0.2	0	0.7	0.7	0.5	12.3	1.0	0.3	0	0.3	0	0.3
C. pycnothrix	0	0	0	0	0	0	0	0	0	0	0	0
M. sieberianus	0.5	0.3	0	0	0.3	0	0.3	0.3	0	1.0	0	0
E. hirta	0	0	0	0	0	0	0	0.7	0	0	0.3	0
O. americanum	0	1.0	0	0	0.7	0.7	0	0	0.9	0.7	0	0
T. berteronianus	0	0	0	0	0	0	0	1.3	0	0	0	0
Setaria trinervia	0	0	0	0	0	0	0	1.0	0	0	0.3	0
Cassia mimosoides	0	0	0	0	0	0	0	1.0	0	0.3	2.7	0.3
Indigofera arecta	0	0	0	0	0	0	0	5.0	0	0	4.3	1.3
A. meniliforme	0	0	0	0	0	0	0	2.3	6.9	5.2	0	5.0
Alysicarpus vaginalis	0.3	3.7	0	0	0.3	3.3	0	1.3	0	1.0	3.0	0.3
Tephrosi a pumila	0.5	1.0	0	0	0.5	0.3	0	5.7	0	3.0	1.3	3.5
Polygala erioptera	0	0	0	0	0	0	0	12.0	0	0	8.7	1.7
Unidentified forbs	8.2	14.0	16.3	28.7	5.7	11.0	7.7	11.4	7.4	11.7	0	3.3
Sida ovata	0	0	0	0	0	0	0	0	0.3	0	0	0
Solanum indicum	0	0	0	0	0	0	0	0	0	0	0	0
Total population	66.8	79.7	82.9	100.1	83.0	97.7	124.3	141.1	44.3	58.3	111.0	107.6
Total species (not forbs)	14	14	11	11	15	14	11	21	10	15	16	17

D = Mean for two dry seasons.
W = Mean for two wet seasons.

TABLE 4 : *The mean number of individual plants in 1 m^2 quadrats per grass species in a Hyparrhenia/Themeda Grassland (Area B)*

Species.	1971				1972				1973			
	Ungrazed.		Grazed.		Ungrazed.		Grazed.		Ungrazed.		Grazed.	
	D	W	D	W	D	W	D	W	D	W	D	W
H. filipendula	63.3	61.0	87.0	100.7	58.5	51.5	84.4	81.5	49.2	45.0	70.4	64.7
T. triandra	36.3	43.9	20.7	21.0	37.2	35.7	25.2	29.7	36.7	35.3	29.6	24.3
S. pyramidalis	0	0.3	1.0	1.0	0.3	0.5	0.4	1.2	0.3	0	1.2	1.3
S. stapfianus	10.3	14.7	29.7	29.9	13.0	8.9	23.4	22.7	4.2	9.3	20.1	20.7
M. Kunthii	4.0	19.4	47.3	121.4	4.4	1.2	54.3	64.4	2.2	0	34.3	48.7
C. gayana	0	0.3	0	0	0.8	1.0	0	0	0.8	1.3	0	0
C. afronardus	0.3	0.9	0	0	1.4	1.3	0	0	1.4	1.3	0	0
B. insculpta	0	0.3	6.0	7.2	1.7	1.4	7.0	5.5	1.7	0.7	4.0	4.3
C. echinochloa	5.6	1.4	6.0	4.2	1.7	1.4	9.0	6.2	1.7	1.3	6.8	5.7
P. brevifolium	0	0.3	0	0	0.3	0	0	0	0.3	0	0	0
A. vaginalis	1.0	1.3	0	0	0.3	0.5	0	0.3	0.3	1.0	0	3.0
C. mimosoides	0	0	0	0	0	2.3	0	0	0	1.3	0	1.7
I. paniculata	0	0	0	0	0	0	0	0	0	0.7	0	1.0
H. contortus	0	0	2.7	3.5	0	0	0	0	0	0.7	0	0
T. pumila	0	0	1.0	0.7	0	0	0	1.0	0	0.4	0	2.3
E. tenuifolia	0	0	0	0	0	0	0	0.3	0	0.9	0	0
Unidentified forbs	13.3	19.2	14.0	13.0	9.2	16.2	0.8	6.7	4.3	5.0	2.8	4.3
M. sieberianus	0	0	0	0	0	0	0	0.7	0	0.3	0	0
B. platynota	1.3	0.5	0	0	1.0	1.0	0	0.3	1.0	1.0	0	0
Total population	137.4	163.5	215.4	302.6	129.8	122.9	204.5	220.5	104.1	105.5	169.2	182.0
Total species (not forbs)	9	12	9	9	12	12	7	12	12	15	8	11

D = Mean for two dry seasons. M = Mean for two wet seasons.

densities. *H. filipendula, S. pyramidalis, S. stapfianus* and *Carex echinochloa* Kunze maintained higher densities in the grazed than ungrazed areas. *T. triandra, C. gayana, C. afronardus* and herbs showed higher densities in the ungrazed than grazed areas.

The effect of the seasons (see Table 1) on the composition of the swards may be seen in Tables 3 and 4. In study Areas A and B more species were recorded in the permanent plots during the wet seasons and fewer species during the dry seasons. The total vegetation density and the total number of species were related to the amount of rainfall in the different months.

(b) Above - ground net primary production.

The above-ground net primary production is represented here (Table 5 and 6) by the peak standing crop defined as the total dry weight of the herbage at the end of the growing season (HEADLEY and KIECKHEFER, 1963). In study Area A (Table 5 a) *S. pyramidalis* formed 58.0 $^{0}/o$, *C. gayana* 8.5 $^{0}/o$ while the other species 33.5 $^{0}/o$ of the peak standing crop in the grazed area. In the ungrazed area *S. pyramidalis* was suppressed (produced only 5.2 $^{0}/o$) and *C. gayana* (48.6 $^{0}/o$) and the other species (46.2 $^{0}/o$) produced the bulk of the dry matter. The total dry matter production was significantly higher in the ungrazed than grazed areas.

In Area B the relative importance of the dominant, codominant and the rest of the species in the dry matter production may be seen in Table 5 b. There was greater biomass production in the ungrazed than grazed areas. Plants in the burnt areas had greater potential to produce more weight than in the unburnt areas. In the burnt area *H. filipendula* and *T. triandra* produced the greater (80.7 $^{0}/o$) proportion of the dry weight while the other species produced 19.3 $^{0}/o$ of the vegetation by dry weight under grazed conditions. In the ungrazed areas the plots were exclusively of *H. filipendula* and *T. triandra*. In the areas protected from fire the relative importance of *H. filipendula* and *T. triandra* in productivity was reduced, but more in the ungrazed than grazed areas. Because of accumulation of woody and fibrous remains of the plants, the total dry weight was more than twice in the ungrazed than grazed areas.

In the *Imperata* grassland *I. cylindrica* produced the greater bulk of the production in both the grazed and ungrazed burnt areas, followed by *C. afronardus* and a few other species. Whether grazed or not burning late in the dry season maintained productivity of *I. cylindrica, C. afronardus* and the few other species in the grassland. In the unburnt areas the dry matter production was made largely by *C. afronardus* in the grazed areas and by *C. afronardus* and *I. cylindrica* in the ungrazed areas. Where grazing and fire were excluded the other plants were eliminated.

The effect of burning regimes on the net primary production of two grassland types may be seen on Table 6. In both areas the percentage contributions made by the dominant, codominant and the other species in the swards were

TABLE 5 : *The mean dry matterproduction (gm per 1 m^2)* of the plants in*

(a) Sporobolus grassland.

Species.	Grazed.	Ungrazed.
S. pyramidalis	171.85 (58.0)	23.05(5.2)
C. gayana	24.06 (8.5)	216.17(48.6)
Other species	98.64 (33.5)	205.64(46.2)
Total	294.55	444.86

(b) Themeda/Hyparrhenia grassland.

	Burnt		Unburnt	
Species.	Grazed.	Ungrazed.	Grazed.	Ungrazed.
H. filipendula	112.50(27.0)	229.94(40.9)	49.35(18.4)	64.76(11.8)
T. triandra	223.23(53.7)	331.95(59.1)	91.76(34.2)	154.53(28.1)
Other plants	80.43(19.3)	0	126.81(47.4)	331.38(60.1)
Total	416.16	561.89	266.92	550.67

(c) Imperata grassland.

	Burnt		Unburnt	
Species.	Grazed.	Ungrazed.	Grazed.	Ungrazed.
I. cylindrica	239.70(52.1)	396.29(57.4)	29.58(8.2)	359.45(45.0)
C. afronardus	184.02(40.0)	221.44(32.2)	288.73(82.9)	440.46(55.0)
Other plants	36.31(7.9)	71.60(10.4)	126.81(47.4)	0
Total	460.03	689.33	348.05	799.91

* Figures in brackets indicate °/o of the total.

TABLE 6 : *The effect of burning regimes on the dry matter production in gm* of the major grass species in 1 m^2 plots in :*

(a) Hyparrhenia / Themeda grassland.

Species	Early burn		Late burn		No burn	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
H. filipendula	185.71 (57.4)	259.29 (38.1)	173.53 (51.2)	310.85 (40.1)	137.52 (38.1)	156.46 (32.1)
T. triandra	78.47 (21.5)	345.89 (51.9)	101.38 (29.6)	373.27 (48.1)	147.22 (40.8)	170.28 (35.9)
Other plants	59.09 (21.1)	60.21 (10.0)	63.48 (19.2)	90.71 (12.8)	75.62 (21.1)	147.88 (32.0)
Total	323.27	665.39	338.39	774.83	360.36	474.62

(b) Imperata grassland.

Species	Early burn		Late burn		No burn	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
I. cylindrica	186.43 (57.3)	259.00 (61.2)	229.64 (61.5)	289.89 (50.7)	289.47 (90.2)	375.04 (34.7)
T. triandra	92.72 (28.2)	128.78 (30.6)	105.70 (28.2)	224.55 (39.2)	17.78 (5.5)	10.20 (9.4)
H. filipendula	14.88 (4.6)	19.29 (3.9)	23.88 (6.1)	29.68 (5.2)	6.42 (2.0)	10.65 (9.8)
Other plants	4.45 (9.9)	21.11 (4.3)	15.27 (4.2)	27.29 (4.9)	7.19 (2.3)	12.10 (46.1)
Total	298.48	428.18	374.49	571.41	320.86	407.99

* Figures in brackets indicate % of the total.

higher in the late than early burning regimes. The grand mean dry weights were also higher in the late than early burnt areas. In the areas protected from fire, the contribution made by *H. filipendula* and *T. triandra* were reduced while those made by the other plants (being largely shrubs particularly in the ungrazed areas) were increased in the *Hyparrhenia/Themeda* grassland (Table 6 a). In the *Imperata* grassland *I. cylindrica* produced 90.2 °/o of the dry weight in the unburnt grazed area but the other plants (largely shrubs) suppressed the performance of *I. cylindrica* in the ungrazed area (Table 6 b).

(c) Spread of Imperata in natural grassland.

The rates of spread of *I. cylindrica* in a natural grassland under grazed and ungrazed conditions may be seen in Table 7. The parameters recorded were statistically greater in the ungrazed than grazed areas.

TABLE 7 : *The effect of grazing on the rate (in 18 months) of spread of Imperata cylindrica in natural Hyparrhenia/Themeda grassland.*

	Grazed.	Ungrazed.
Distance of furthest shoot from parent plant (cm.)	64.2	296
Distance of furthest tip of rhizome from parent plant (cm)	155	334
Number of tillers per plant	4.5	8.0
Weight of rhizomes (g/plant)	15.26	109.08
Rate of spread of shoot (cm./month)	3.6	16.4
Rate of spread of rhizomes (cm./month)	8.6	18.5
Rate of dry matter accumulation in rhizome (mg/plant/month)	848	6060

DISCUSSION.

The grassland of Rwenzori National Park was probably derived from previously widespread forests by man's activities (PHILLIPS, 1930 ; BUDOWSKI, 1956). Different management practices during the last several centuries reduced the original fire-climax grassland into several different grassland types (LOCK, umplubl. vegetation map of the Park). By the end of the nineteenth century much of the grassland was probably *Themeda* grassland and the shores of the lakes Idi Amin Dada, George, and the Kazinga Channel were covered with bushes dominated by *Capparis tomentosa* Lam ; *Euphorbia candelabrum* and *Securinega verosa,* Baill STANLEY, 1890) implying that the vegetation then was similar to that of today. The presence of *T. triandra* meant that regular burning which maintains it (EDWARDS, 1942 ; WEST, 1965 ; LOCK and MILBURN, 1971 ; EDROMA, 1975) must have existed for some long time till today. Bush clearing of the lake shores in 1912-13 and 1927-30 modified the lake shores and triggered gully and sheet erosions (BISHOP 1962) seen along the shores today. The erosion and degeneration of the vegetation into mosaic *Sporobolus* type were aggravated by the hippo overgrazing since the 1950's.

The Sporobolus grassland in study Area A is typical of the vegetation found along the shores of the lakes and the Kazinga Channel. Tufted tussocky grasses like *S. pyramidalis* and mat forming short (5 cm) grasses like *S. stapfianus* and *M. kunthii* (table 2 a) which are of poorer nutritive value to the herbivores are common and wide spread. Large areas of this grassland type are bare and the entire environment has become unsuitable for the germination and establishment of the richer grasses. The mosaic grassland came into existance through over population of the hippos and the resultant overgrazing initiated a vicious cycle of reduced shoot leading to reduced root system, poor flowering and seed production, and to further starvation of shoots until the plants died and became replaced by shorter and less nutritious species as observed elsewhere by BEWS (1917). Some soil characteristics developed under the overgrazing. The hard surface that characterises most of the short mosaic areas indicate little moisture penetration to deeper soil horizons, increased run-off and increased evaporation (EDROMA, 1975). In the event of the two dry seasons each year, the inadequate moisture is soon exhausted and any vegetation especially shrub and the deep rooted grasses that might have become established are killed. Although grass mortality is also high the poor grasses re-establish themselves relatively rapidly and the time required between seed germination and the development of mature plants able to produce viable seeds in their turn is short. The grasses which form the community of the *Sporobolus* grassland have fibrous shallow root systems, ease of establishment and have rapid growth and appear to be much better adapted to the local conditions in the overgrazed habitats than most shrubs and tall grasses. Their performance is maintained by grazing and in absence of grazing they become suppressed and ousted by tall growing species (ALIA, 1974).

The carrying capacity of the *Sporobolus* grassland is thus reduced by the overgrazing. In order to revert the deteriorating trend in the community it was recommented that the hippo population be reduced by cropping from 14,000 to 7,000 (BERE 1959) and thereafter regulated. This was done during early 1960's and it resulted into the improved vegetation cover in the previously mosaic and bare grounds (LAWS 1968; THORNTON 1971) and increased numbers (by immigration) of elephants, buffaloes, bushbucks and waterbucks into the Mweya Peninsula. The density of the large mammals increased from 130 to 160 per square mile while the biomass rose by 20 % to 264,735 lb /square mile (EDROMA 1974). Since the hippo cropping the hippo population has built up again and a second management control is being worked out. The overgrazed areas where fire is excluded by the scarcity of vegetation fuel, can be managed by controlling the animal numbers in the area by dispersing the population in the park and/or by scientifically - based cropping. This management policy is being practised in the Uganda National Parks.

The floristic composition of the fire-climax grassland (FIELD 1970; LOCK 1972) types (Areas B and C) is shown in Table 2. Although the *Hyparrhenia/Themeda* and *Imperata* grassland types have fewer species than the Sporobolus grassland type, they have higher plant densities and more nutritious species than that of the *Sporobolus* grassland. Under grazing and no grazing, and burning and no burning, the total populations of the plants per unit area are high throughout the year. The soil is protected and rain water penetrates to deep horizons so that even during the dry seasons some grasses are able to remain green. Grazing enables the grasslands to maintain higher plant populations while areas protected from grazing have higher densities of shrubs and fewer tall grasses. The tall grasses and shrubs suppress the short grasses by shading. The scarcity of the short grasses in the *Hyparrhenia/Themeda* and *Imperata* grassland is due to their being unable to perform vigorously and compete for the available resources when they are shaded, and the abundance of *S. pyramidalis* and the mat forming species in the overgrazed areas of the Park is attributed to the absence of the tall grasses in this zone.

The seasons have marked effect on the number and dry matter production of the grasses. The maximum number of species was recorded during the wet seasons and the minimum during the dry seasons. Although the differences in the number of species between the seasons was not marked for any one grassland type, such an effect of seasonality in grassland species distribution was recorded by KUMAR and JOSHI (1972). Plant densities and dry matter production were higher in the wet than dry seasons in all the grassland types. The bulk of the net primary production was made up of a few dominant species as found elsewhere by BLAISDELL (1958), BRAY *et al* (1959), PEARSON (1965) and SINGH (1968). But during the rainy seasons greater number of species contributed significantly to the total herbage. In other studies in the same National Park, EDROMA (1975) showed that the total plant density in the different grassland types was related to the amount of rainfall in the different months.

Burning has a marked effect on the structure and potential for dry matter production of the grassland types. Whether grazed or not burning stimulated the grasses to produce more herbage in the *Hyparrhenia/Themeda* grassland. In both burnt and grazed areas, species other than the dominant ones significantly contributed in the herbage production (Table 5 b). In the *Imperata* grassland more herbage was produced in the unburnt area rather than in the burnt one (Table 5 c), but since much of the herbage consisted of course and fibrous material which was hardly grazed by the herbivores, it was of no direct use to the animals. Leaving Imperata grassland unburnt and ungrazed resulted into gradual elimination of *I. cylindrica* by *C. afronardus*. By burning this grassland, several plant species were able to coexist and, above all, the young fresh sprouting shoots of *I. cylindrica* and *C. afronardus* being palatable at that stage, were grazed extensively.

But not all fires produce desirable effects on the structure and productivity of the grassland. The results presented on Table 6 clearly show that both *Hyparrhenia/Themeda* and Imperata grassland types produced more herbage under the late burning regime. If the areas were protected from fire the proportion of herbage made by the desirable species was suppressed as asserted by HEADY (1960). *T. triandra* and *H. filipendula* two important species in the moderately grazed grassland were maintained productive by late burning.

In Uganda uncontrolled fires are not permitted by a Decree and in the National Parks, burning is carried out under the supervision of a scientific Officer. Results here confirm what has been shown elsewhere in Uganda that the character of the moderately grazed grassland communities can be maintained by late burn, as a management policy. Studies are in progress to determine the effect of different burning intervals (e.g. annual, or once in 2 or 3 years) on the structure and performance of the grassland communities.

Observations have shown that the character of the grassland types may be affected by competition from invading species. In Rwenzori National Park, *I. cylindrica* is a weedy species which occurs in circular patches in the *Hyparrhenia/Themeda* grassland. It became noticeable in the Park just before the area was gazetted a Game Reserve in 1932. From Table 7 its rate of spread in a natural grassland under grazed and ungrazed conditions can be seen. From the original parent plant, the species sends out rhizomes in the soil and new shoots begin to appear in all directions. The results here show that *I. cylindrica* spreads significantly faster in the areas not grazed. Grazing suppresses its rate of spread. It is therefore suggested that an *Imperata* grassland should be kept green and palatable by burning. In this way herbivores are able to suppress it by grazing. Protecting *I. cylindrica* from burning and grazing leads to thickening of the grassland and eventually to the deterioration of the species followed by subsequent replacement by shrubs and trees. But in a National Park where diversity and complexity of communities need be conserved, regular early burning of *Imperata* grassland is advocated for.

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