HERBIVORE DYNAMICS IN SOUTHERN NAROK, KENYA

JOHN G. STELFOX,[1] Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya
DONALD G. PEDEN, Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya
HELMUT EPP,[2] Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya
ROBERT J. HUDSON, Department of Animal Science, University of Alberta, Edmonton, Alberta T6G 2P5, Canada
SUSAN W. MBUGUA, Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya
JASPAT L. AGATSIVA, Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya
CHARLES L. AMUYUNZU, Kenya Rangeland Ecological Monitoring Unit, Box 47146, Nairobi, Kenya

Abstract: Monthly counts of large herbivores on the rangelands of southern Narok District were conducted by the Kenya Rangeland Ecological Monitoring Unit (KREMU) from December 1978 to November 1979. At that time these rangelands supported year-long herbivore populations of 132/km² representing a biomass of 160 kg/ha. The Mara Plains, particularly the area protected as the Masai-Mara National Reserve, served as a critical dry season range. During the peak of the dry season (Jul), the resident population of 100,000 blue wildebeest (*Connochaetes taurinus*) was supplemented with large migratory herds from the Serengeti which increased total numbers to >800,000. Burchell's zebras (*Equus burchelli*) and Thomson's gazelles (*Gazella thomsoni*) were less migratory but moved seasonally through the Mara, Siana, and Loita range units.

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The rangelands of southern Narok District are among the most important and productive in Kenya. A combination of relatively high rainfall, relatively low evaporation, and mainly volcanic soils give this area high forage production potential (Pratt and Gwynne 1977:55–60). This area also supports the greatest densities of wild and domestic herbivores in Kenya with a year-long average in 1979 of 132 animals/km² (Andere 1980).

Parts of Narok, particularly the Mara Plains, provide dry season range for the Serengeti migratory herbivore population, especially wildebeest and zebra. These plains are used heavily between late June and October, and both the duration and intensity of grazing in the Mara have increased noticeably as this migratory population has expanded since the mid-1960's (Sinclair and Norton-Griffiths 1979:7). Therefore, the future of this unique and spectacular migratory complex hinges on the availability and productivity of the Mara as well as that of the wet-season range in Tanzania.

The introduction of rinderpest about 90 years ago eliminated the majority of cattle (*Bos indicus*), African buffalo (*Syncerus caffer*), and wildebeest. By 1962, rinderpest had disappeared and populations responded with wildebeest increasing about 10% annually (Sinclair 1979). Part of this increase evidently was caused by higher precipitation in the 1970's, especially during the dry season.

Increasing competition for forage between wildlife and livestock, plus the potential for transmission of diseases, have been of concern to pastoralists and resource planners. In this context KREMU set out to measure the monthly populations and distributions of livestock and wildlife for a 1-year period extending from December 1978 to November 1979. This report is a summary of these activities and a comparison of these findings with previous studies.

This study represents a team effort. Aerial biologists involved in the study were M. Mugambi, M. Ngatia, and J. W. Kufwafwa. Aerial observers were B. B. Raburu and S. Sikawa. The aircraft were piloted by A. M. Stepanowich and B. G. Pratt. E. W. Kabaru, J. K. Chemjor, and G. N. Kiilu assisted with preparation of tables and figures. Special acknowledgment is given to S. N. Nganga for supervising the statistical analyses. Critical reviews of the original reports upon which this manuscript was prepared were provided by M. Norton-Griffiths, D. Western, and P. Kuchar J. Naiguran, warden of Mara National Reserve, provided insight into regional land use conflicts. W. E. Stevens and D. K. Andere, project manager and co-manager, respectively, organized the project and provided administrative and logistic support.

[1] Present address: Canadian Wildlife Service, #1000-9942-108 Street, Edmonton, Alberta T5K 2J5, Canada.

[2] Present address: Canada Centre for Remote Sensing, c/o Saskatchewan Research Council, Saskatoon, Saskatchewan S7N 0X1, Canada

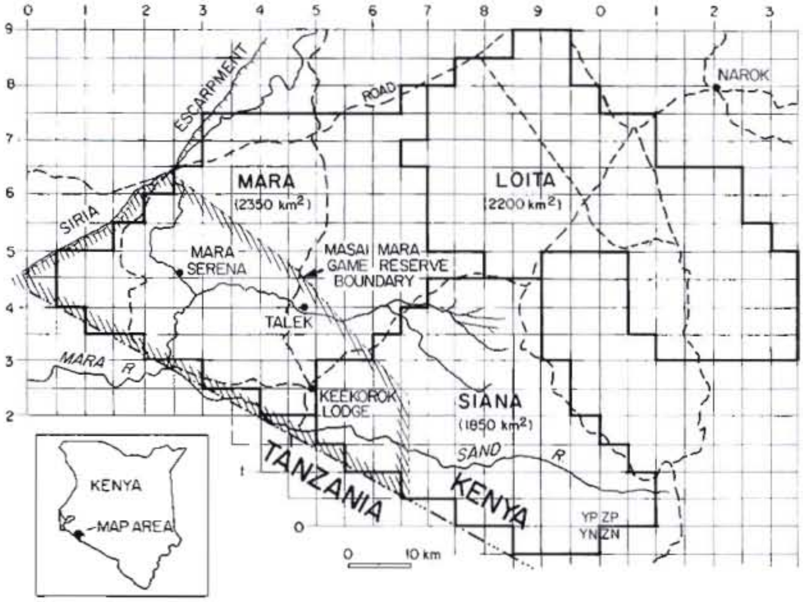

Fig. 1. The 3 range units on the Narok Study Area, Kenya.

STUDY AREA

Narok District is located in southwestern Kenya. The rangelands of the southern part of the district are bounded on the east by the Rift Valley, on the southwest by the Kenya–Tanzania border, and on the northwest by the Siria Escarpment. This area is roughly triangular in shape, covering an area of approximately 7,500 km², of which 6,400 km² were surveyed.

Three range units differing from a biogeographic and climatic standpoint can be recognized (Fig. 1): (1) Mara—a 2,350 km² *Themeda* grassland in the western portion of the study area, (2) Loita—a 2,200 km² dwarf-shrub and whistling thorn (*Acacia drepanolobium*) grassland of the Loita Plains, and (3) Siana—a 1,850 km² area of hills and plains supporting *Croton* bush and several other woody species interspersed with grasslands. Twelve main habitat types are represented in the study area (Table 1).

Rainfall is associated loosely with movement of the low pressure Intertropical Convergence Zone (Brown and Cocheme 1973, Norton-Griffiths et al. 1975). The annual distribution of rainfall is bimodal with the main rains from March to May and a minor peak during November–December. The main dry period is from mid-June to mid-October with a lesser dry season during January–February. Often this short dry season is absent or less noticeable, as during this study.

Local variations in topography, such as high mountains and escarpments plus orographic and diurnal effects, play a major role in rainfall patterns within the study area. There is a sharp increase in rainfall with altitude in the Loita Hills and the Siria Escarpment. The main rain shadow encompasses the Loita Plains and part of the Siana Plains, with a mean normal rainfall of approximately 400 mm.

METHODS

Numbers and Distributions of Herbivores

Aerial surveys were made monthly from December 1978 to November 1979 following a protocol designed by Norton-Griffiths (1978:22). Transects oriented in an east-west direction were flown at 5-km intervals at a height of 91 m above ground level (agl). Two observers occupying the rear section of a Cessna 185 aircraft counted animals appearing between 2 rods attached to the wing struts. The field of vision between these rods projected a census strip that was calibrated by flying repeatedly across ground markers of known spacing. The survey strip (total of both sides of the aircraft) was 244 m which gave a sampling intensity of 4.9%.

Numbers of animals within survey strips on

Table 1. Rangeland habitats in Narok District, Kenya, 1978–79.

Habitat type	Area (km^2)	Dominant species
Grassland	650	*Themeda triandra* *Hyparrhenia rufa*
Dwarf-shrub grassland	1,769	*Acacia drepanolobium* *Themeda triandra*
Shrubby grassland	1,487	*Acacia gerrardi* *Themeda triandra*
Bushy grassland[a]		*Tarchonanthus camphoratus* *Themeda triandra*
Wooded grassland	397	*Balanites aegyptica* *Themeda triandra*
Grassy shrubland[a]		Similar to shrubby grassland—dense shrub cover
Dwarf shrubland[a]		*Acacia drepanolobium* *Hyparrhenia rufa*
Shrubland	155	*Tarchonanthus camphoratus* *Commiphora schimperi* *Croton dichogamus*
Tall shrubland	231	*Croton dichogamus* *Euclea divinorum*
Shrubby riverine	187	*Acacia xanthophloea* *Euclea divinorum*
Wooded riverine	126	*Acacia xanthophloea* *Warbugia ugandensis*
Woodland[a]		*Olea africana* *Euclea divinorum*

[a] Small widely scattered habitats too small to accurately estimate area from satellite imagery. Collectively, they account for 1,398 km^2 of the 6,400-km^2 study area.

either side of the aircraft for each 5-km transect segment were counted and recorded into tape recorders. Groups of animals >10 in number also were photographed and later counted with the aid of a 10× binocular microscope.

Each 5-km transect segment (rather than the entire transect) was considered an observation. Although this departure from tradition likely resulted in greater autocorrelation among observations, tests on KREMU's data indicated that this was not serious. Animal counts from the 2 observers on either side of the aircraft were summed and recorded on the basis of Universal Transverse Mercator grids to the nearest 25-km^2 unit.

Population estimates (PE) and standard errors (SE) were calculated using a modification (Peden 1981) of Jolly's Method 1 (Jolly 1969) in which SE's were expressed as a percent of the PE. Formulas used to estimate PE and SE were:

$$PE = N\bar{y},$$

and

$$SE = \sqrt{\frac{N(N-n)s^2}{n}},$$

where $\bar{y}$ is the sample mean, s^2 is the sample variance, n is the sample size, and N is the number of observations required to give complete coverage of the study area.

Tests of visibility bias on the Mara indicated that counting efficiency was 70–80% for wild herbivores and 80–90% for livestock (Stelfox and Peden 1981:69–83). Therefore, density and biomass estimates presented here should be corrected upwards by about 1.33× for wildlife and 1.18× for livestock.

Environmental Parameters

During aerial surveys an observer occupying the front seat of the aircraft recorded vegetation cover, height, greenness, and phenology and the availability of free water. As with animal counts, these data were recorded for each 5-km segment of the transects.

Monthly indices of herbage volume were calculated by multiplying the percent of a unit within each height class by the corresponding height class mean. These products were summed to obtain a weighted monthly value. Means for each height class were I = 0.25 m, II = 0.75 m, and III = 1.25 m. Herbaceous greenness was indexed by multiplying the percent of a unit containing a given greenness class by the corresponding greenness class (I, II, or III). These products then were summed as for height. Greenness classes were I = dry brown, II = green patches, and III = uniform green. Water bodies counted within a unit were totaled for each ecosystem for each month. Water abundance Classes I–V represented actual numbers of water bodies; Class VI referred to ≥6 water bodies (a value of 10 was used as the $\bar{x}$ for this class). Percentages of each unit that were burnt were averaged for each block of 4 units to give values for each 10 × 10-km unit/month. The classes were 0 = none, L = 1–25%, and H = >25%.

Proportions of each unit comprised of each of the 12 major habitats found in the study area were estimated from maps. These habitat categories were developed using vegetation physiognomic characteristics (primarily vegetation height and canopy cover) that could be recog-

Table 2. Average herbivore populations[a] on Narok rangelands, Kenya, December 1978–November 1979.

Species	$\bar{x}$ unit wt (kg)	Mara (2,350 km²)	Loita (2,200 km²)	Siana (1,850 km²)	Total study area (6,400 km²)
Wild grazers					
Blue wildebeest	123	165,000	49,000	22,000	236,000
Burchell's zebra	200	38,000	19,000	13,000	70,000
African buffalo	450	19,000	400	4,900	25,000
Kongoni	125	2,900	600	2,200	5,800
Topi	100	29,000	500	1,100	31,000
Thomson's gazelle	15	45,000	29,000	10,000	85,000
Wart hog (*Phacochoerus aethiopicus*)	45	3,300	300	1,100	4,800
Total		303,000	98,000	55,000	457,000
Wild browsers					
Giraffe (*Giraffa camelopardalis*)	750	1,800	1,200	1,500	4,500
African elephant	1,725	800	0	400	1,200
Black rhinoceros		11	0	0	11
Total		2,600	1,200	1,900	5,700
Wild mixed feeders					
Grant's gazelle	40	2,800	13,000	2,400	18,000
Impala	40	27,000	8,500	23,000	58,000
Eland	340	1,800	1,900	600	4,800
Total		31,000	24,000	26,000	81,000
Total (wild herbivores)		337,000	123,000	83,000	543,000
Livestock					
Cattle	180	52,000	61,000	58,000	171,000
Sheep and goats	23	30,000	57,000	34,000	120,000
Donkey	150	1,000	4,200	2,000	7,400
Total		83,000	122,000	94,000	299,000
Total (all herbivores)		420,000	245,000	177,000	842,000

[a] Minimum populations uncorrected for visibility bias.

nized from a light aircraft flying at 90–120 m agl (Pratt et al. 1966:369–382).

Animal-Habitat Association

Differences in habitat selection among herbivore species during each of 4 periods were tested by analysis of variance. Results were summarized as tabular means of environmental parameters and habitat proportions associated with sightings of each species. The basic case was a 25-km² unit assigned to the species with the greatest abundance relative to its mean for the entire study area. Divergence of these means from grand means for the entire study area was taken as evidence for selectivity.

RESULTS

Average Annual Herbivore Populations

Year-long average population sizes of wild and domestic herbivores illustrate the intensive use of the study area (Table 2). Of the average monthly estimate of 842,000 animals (132/km²), wild herbivores comprised 64% and livestock 36%. Wildebeest were the most abundant species (28%), followed by cattle (20%), sheep and goats (14%), and Thomson's gazelle (10%). Zebra, impala (*Aepyceros melampus*), topi (*Damaliscus lunatus*), buffalo, and Grant's gazelle (*Gazella granti*) each made up <10% of the total population.

Average biomass density for the entire study area was approximately 160 kg/ha. Because of differences in body size, biomass distribution among species differed from population numbers. Dominant herbivores in terms of relative biomass were cattle (30%), wildebeest (28%), zebra (14%), and buffalo (11%).

The Mara was most heavily stocked with an average of 420,000 herbivores (179/km² [236 kg/ha]). Because most of the Mara range unit lies within the Masai-Mara National Reserve, livestock accounted for only 9 animals/km² (44

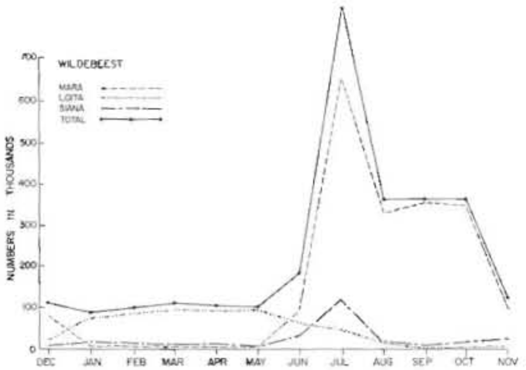

Fig. 2. Monthly blue wildebeest populations occupying the Mara, Loita, and Siana plains in southwestern Kenya, December 1978–November 1979.

kg/ha), but densities averaged 151/km² in that portion lying outside the reserve. Wild grazers (mainly wildebeest, zebra, and buffalo) comprised 66% of the total biomass while cattle contributed 17% for the entire range.

The Loita supported the largest numbers of livestock annually (55/km² [58 kg/ha]). The density of wild herbivores averaged 56/km² (59 kg/ha). The greatest biomass contribution came from cattle (42%), wildebeest (23%), zebra (14%), and sheep and goats (5%).

The Siana supported 49 livestock/km² and 45 wild herbivores/km² for a biomass of 124 kg/ha. Numerically dominant herbivores were cattle (33%), sheep and goats (19%), impala (13%), wildebeest (13%), and zebra (7%).

Monthly Distributions

Although most herbivores made only local movements, relative and absolute use of the Mara, Loita, and Siana range units by wildebeest, zebra, and Thomson's gazelles showed pronounced monthly changes (Fig. 2). The resident population of about 100,000 wildebeest was supplemented with large migratory herds reaching a peak of >800,000 in July. Although numbers declined 1 month later, migratory remnants remained until November. Because the greatest dry season influx of wildebeest came from Tanzania, nse of the Mara and Siana plains was synchronized, but by far the most important range unit was the Mara. In contrast, use of the Loita by wildebeest declined at the peak of the migration.

Zebras also moved into the study area reaching a peak of >115,000 in June (Fig. 3). A larger proportion of the zebra population remained

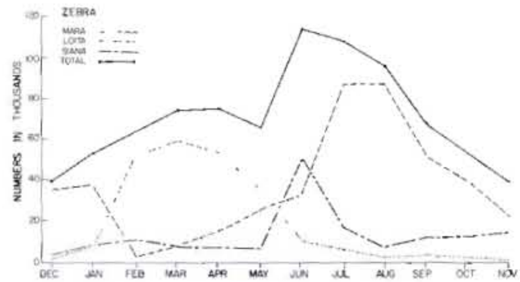

Fig. 3. Monthly Burchell's zebra populations occupying the Mara, Loita, and Siana plains in southwestern Kenya, December 1978–November 1979.

in the study area throughout the year but showed a seasonal rotation through the 3 range units. The main wet season range occupied from February to May was the Loita. Zebra passed through the Siana in June on their way to the main dry season range in the Mara where they stayed from July to October.

Use by Thomson's gazelles was heaviest in January. Populations declined during peak use by wildebeest and zebra during June–October, then increased in November (Fig. 4). Both the Tanzanian Serengeti and the wheat-growing areas north of the Loita appeared to provide late dry-season range adjacent to the study area during the Jnne–October period. Relative use of the Mara, Loita, and Siana did not vary markedly throughout the year except that the Loita tended to be more important during July.

Habitat Selection

Patterns of habitat use by individual species were examined for 4 periods of the year (Table 3): (1) wet season (Apr–May), (2) peak of the wildebeest migration (Jun–Jul), (3) dispersal of the migratory species (Aug–Sep), and (4) stabilization of distributions of nonmigratory

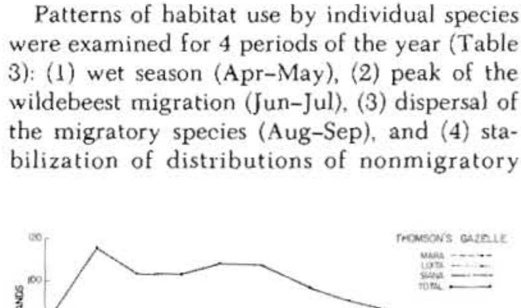

Fig 4. Monthly Thomson's gazelle populations occupying the Mara, Loita, and Siana plains in southwestern Kenya, December 1978–November 1979.

Table 3. Proportional use and description of habitat types for selected wildlife species on the Narok rangelands, Kenya, March–November 1979.

	Burchell's zebra				Blue wildebeest				Thomson's gazelle				Study area (proportion or $\bar{x}$)			
	Mar–Apr	Jun–Jul	Aug–Sep	Oct–Nov	Mar–Apr	Jun–Jul	Aug–Sep	Oct–Nov	Mar–Apr	Jun–Jul	Aug–Sep	Oct–Nov	Mar–Apr	Jun–Jul	Aug–Sep	Oct–Nov
Habitat type																
Grassland	0.03	0.17	0.23	0.13	0.02	0.18	0.20	0.17	0.11	0.11	0.08	0.11	0.10	0.10	0.11	0.11
Dwarf-shrub grassland	0.59	0.09	0.12	0.06	0.65	0.23	0.25	0.19	0.30	0.57	0.38	0.43	0.27	0.27	0.25	0.29
Shrubby grassland	0.16	0.27	0.27	0.38	0.05	0.18	0.22	0.19	0.19	0.15	0.22	0.12	0.20	0.20	0.20	0 20
Wooded grassland	0.02	0.15	0.11	0.09	0.00	0.12	0.12	0.14	0.04	0.03	0.03	0.05	0.06	0.06	0.06	0 05
Dwarf shrubland	0.02	0.00	0.00	0.02	0.01	tr[a]	0.03	0.01	0.02	0.01	0.01	0.00	0.01	tr	0.01	0.01
Shrubland	0.18	0.28	0.20	0.22	0 30	0.25	0.14	0 27	0.27	0 12	0.26	0.27	0.31	0.32	0.29	0.29
Tall shrubland	0.01	0.03	0.02	0.05	0 02	0.02	0.01	0.02	0.05	0.01	0.02	0.03	0.04	0.04	0.03	0.03
Shrubby riverine	0.03	0.03	0.03	0.03	0 02	0.02	0 02	0.04	0.05	0 04	0 02	0.03	0.03	0.03	0.03	0.03
Wooded riverine	0.01	0.01	0.03	0.03	0.02	0.04	0 03	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Environmental descriptors[b]																
Herbage vol	15.13	31 57	37.92	32.88	14.17	30.62	38.02	35.69	15.95	24.79	33.52	30.57	22 87	28 09	34 10	29.96
Herbage greenness	2.61	1.64	1.43	1.54	2 40	1.58	1.54	1.55	2.40	1.71	1.55	1.28	2.39	1.72	1.40	1.32
Low-woody green	3 14	2.31	2.53	2 54	3 17	2.11	2.54	2 55	3.38	2.39	2.67	2.15	3.41	2.77	2.74	2.52
High-woody green	2.63	1.49	2.20	2.87	1.93	1.37	2.71	1.93	3.52	2.10	2.44	1.35	3.26	1.60	2.48	1.84
Burns	0.10	3 59	0.33	1.41	0.00	3 03	0.36	0.34	0.00	2.36	2.66	1.54	0.13	1.66	2.93	2.07
River	0.50	0.44	0.33	0.33	0.31	0.39	0.57	0.21	0.38	0.26	0.14	0.09	0.57	0.36	0.24	0.20
Pools	1.37	1.77	1.63	0.97	1.86	1.42	1.14	0.52	1.72	1.61	0.28	0.17	2.07	1.39	2.66	0.48

[a] tr = <0 01

[b] Scores weighted by relative representation of habitats

Table 4. Population estimates of wild herbivores for the Mara and Loita plains, Kenya, 1961–1979.

Species	1961[a] (May)	1974[b] (May)	1977[c] (May)	1979[c] (May)	1979[c] (Jun)
Blue wildebeest	17,817	84,710	84,700	101,700	819,500
Burchell's zebra	20,567	20,412	34,600	65,200	107,800
Topi	4,111	5,082	17,900	31,500	25,500
African buffalo	5,934	10,882	34,200	30,000	31,500
Kongoni	721	850	5,300	8,900	5,000
Thomson's gazelle		11,936	63,300	106,500	90,500
Grant's gazelle		5,204	8,800	19,900	18,500
Impala		8,692	53,900	59,200	51,800
Eland	750	1,168	4,700	8,500	4,600
African elephant	455	1,012	1,200	700	500
Black rhinoceros	54	84	100	0	0
Totals[d]	50,409	124,200	182,700	246,500	1,277,700
Totals[e]	—	150,032	308,700	432,100	1,438,500

[a] Stewart and Talbot (1962).
[b] This study.
[c] S. Taiti, unpubl. rep., Kenya Wildl. Cons. Manage. Dep., Nairobi, 1974.
[d] Excluding gazelle and impala.
[e] Including gazelle and impala.

species (Oct–Nov). Comparisons of species-specific means for each environmental gradient or habitat proportion with means for the entire study area reveal patterns of selection. Although data were collected for 9 of the most abundant wild herbivores, attention is drawn to the 3 migratory species: wildebeest, zebra, and Thomson's gazelle. Because environmental gradients were used differently by nonmigratory species, such as buffalo and giraffe, the migrants differed mainly in their use of different habitat types.

Wet Season.—March–April was a period of pasture growth following the main rainy season and prior to the influx of migratory wildebeest. Significant differences ($P < 0.05$) among herbivore species were found for all environmental gradients except burns and proportions of all habitats except dwarf shrublands and wooded riverine categories. During this period of relaxed competition wildebeest, zebra, and Thomson's gazelle differed little in their response to environmental gradients, but slight differences in habitat use were evident. Wildebeest were restricted largely to dwarf-shrub grasslands and shrublands. Use of the former implied preference because use exceeded availability 2-fold. Zebra showed a similar pattern, whereas Thomson's gazelles tended to use a wider variety of habitat types roughly in proportion to their relative availabilities.

Wildebeest Migration.—June–July was characterized by a massive influx of wildebeest. Relative to the previous period, wildebeest and particularly zebra greatly reduced use of dwarf-shrub grasslands and increased use of shrubby grasslands and wooded grasslands. Both species used areas supporting higher herbage volumes than gazelles. Thomson's gazelles intensified use of dwarf-shrub grasslands with a corresponding decrease in use of shrublands.

Peak Wildebeest Density.—With the influx of the main migratory populations during August–September, wildebeest and zebra intensified their apparent preference of grasslands but made significant use of other grassland categories as well as shrublands. Thomson's gazelles tended to move to shrubby grasslands and shrublands although preference still was shown for dwarf-shrub grassland.

Wildebeest Emigration.—During October–November, wildebeest used areas with high herbage volume. Zebra seemed to move from grasslands to shrubby grasslands, whereas Thomson's gazelles moved from shrubby grasslands to dwarf-shrub grasslands.

DISCUSSION

Population Trends

Although inevitable problems of standardization of counting methodology may preclude detailed analysis, increases in estimated populations have been so regular and large that general conclusions are possible (Table 4). Comparing May populations, there were an estimated 18,000 wildebeest in 1961 compared to 102,000 in 1979. For the 8 wildlife species that can be compared for these 2 periods—wildebeest, zebra, topi, buffalo, kongoni (*Alcelaphus buselaphus*), common eland (*Taurotragus oryx*), African elephant (*Loxodonta africana*), and black rhinoceros (*Diceros bicornis*)—the 1979 population of 246,500 was 4.9× greater than in 1961. Elephant numbers remained similar, whereas rhinoceros declined to the point where none were seen in 1979.

In the 1960's, few migratory wildebeest and zebra from Tanzania entered tbe Mara during the dry season (Pennycuick 1975). However, by 1979 large numbers grazed the Mara and western portion of the Siana from late June to late October. This migration increased wildebeest numbers from 102,000 to 820,000 and zebra numbers from 65,000 to 108,000 between May and July. This increase of 761,000 wildebeest and zebra as a result of immigration from Tanzania gave a total population 24× greater than in 1961 (Stewart and Talbot 1962).

High rates of increase appear to be partly due to eradication of rinderpest and improved moisture regimes. Although rapid increases have occurred throughout the entire Serengeti Ecosystem (Sinclair and Norton-Griffiths 1982), a contributing factor, at least for wildebeest, appears to be greater use of the northern part of the migratory circuit. The total Serengeti population increased 276% between 1961 and 1974 (Sinclair 1979), whereas use of the Mara plains increased 375% during the same period.

Range Use by Wild Herbivores

A number of wild species respond to environmental change by migration; others exploit a finer grain of environmental heterogeneity with more localized movements. One of tbe most striking migratory systems is the 1,500-km circuit of wildebeest around the Serengeti-Mara Ecosystem. From December to March, wildebeest occupy the southeastern shortgrass plains where calving takes place. During April–June, they gradually move northwestward to the north Serengeti and Masai-Mara where they remain from July to September. During the October–November migration, herds return to the southeastern plains.

This pattern is somewhat simplified because timing and extent depends upon rainfall. Also, there are resident populations and more subtle local movements. Results of monthly surveys suggest that the nonmigratory population of wildebeest numbers perhaps 100,000. However, migratory behavior may be stimulated in drier years. There also was evidence that the Loita serves as a wet season dispersal area for 50,000–80,000 animals.

The other 2 migratory species in this area are zebra and Thomson's gazelle. In general, they use the shortgrass plains during the wet season and longgrass plains during the dry season, but movements are not as synchronized nor as striking as wildebeest.

Movements of zebra tended to be more local. In addition to use of the Serengeti, this study indicated the Loita was an important dispersal area during the wet season (Feb–May) that was used by 50,000–60,000 individuals. Influx from Tanzania onto the Mara during June–August involved a comparable number. The Siana was used in June while the main concentration of zebra in the Mara occurred in July and August at the time of peak occnpancy by wildebeest.

Over the entire Serengeti ecosystem occupational patterns of zebra and wildebeest are highly correlated (Maddock 1979). Zebra tend to lead the grazing succession. This was confirmed by KREMU's monthly counts, but the pattern of use of the 3 range units does not suggest a strong interdependence of the 2 species.

Thomson's gazelle appear to exploit a finer grain of environmental heterogeneity. Except for a major emigration of 60,000 animals during September–October (presumably to Tanzania and north of the study area), monthly use of all 3 ecosystems was relatively stable. There was little evidence that they followed movements of large grazers to capitalize on short, open range structure as suggested by McNaughton (1976). However, intensive use by both domestic and wild herbivores over the entire ecosystem has left few areas with dense grass cover avoided by gazelles.

Future

With increasing wildlife populations Masai pastoralists face increasing competition for forage and water. Disease risk, particularly from wildebeest and buffalo, is high and increasing. At the same time, range for livestock grazing, especially during the dry season, is declining. Cultivation, particularly wheat farming, now occurs in areas formerly used by pastoralists. This has resulted in a concentration of livestock on the Loita Plains and apparent overgrazing. Development schemes, which include plans to settle the Masai people on individually owned ranches and establish parks in the Nguruman and Loita Hills, will exacerbate land use conflicts in the Narok District. This will almost certainly influence this wildlife spectacle and place a premium on integrated land use planning.

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