

DISTRIBUTIONS, DENSITIES & TRENDS OF ELEPHANTS & RHINOCEROS

IN KENYA, 1977 - 1978

FROM KREMU'S AERIAL SURVEYS

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SUMMARY

Baseline information on densities, distributions and population trends of the African elephant (*Loxodonta africana*) and the black rhinoceros (*Diceros bicornis*) was obtained during KREMU's 1977 and 1978 aerial surveys of all pastoral rangelands in Kenya.

Survey methodology included a survey height of 300 ft above ground, a census strip width of 112 m on either side of the Cessna 185 aircraft and east-west transects spaced 10 km apart in 1977 (2.2% sampling intensity) and 5 km apart in 1978 (4.4% sampling intensity).

Minimum and maximum populations of elephants for all of Kenya were 59,800 - 87,600 in 1977 compared to 44,300 - 67,000 in 1978. The 1978 population was 73.5% of that in 1977 showing a significant decline in the population in one year. The ratios of live: dead elephants decreased from 51:49 in 1977 to 44:56 in 1978 providing further evidence of a declining population. All except 5,000-10,000 of these elephants were on the 500 000 km² pastoral rangelands with most occurring in the South Central, East Central-Coastal and South-East regions especially in the Hola, Ijara, Tsavo, Lamu, Mtito Andei and Jipe eco-units. Their numbers were also relatively high in the Laikipia, Meru and Mara eco-units.

The 5,000-10,000 present in the Agricultural Zone were present mainly in the Aberdare and Mt. Kenya National Parks (2,000 in each), Mt. Elgon and the Mau Forest.

Maximum populations of rhinos were 3636 in 1977 and 1142 in 1978 for the entire rangelands of Kenya. The population for the shrubby habitat of the Agricultural Zone was believed to be about 300.

The 1978 population was only 31.4% of the 1977 population indicating a drastic decline in one year. The 1978 distribution was also greatly reduced from that in 1977.

KREMU recommends that the very low and rapidly declining population of rhino presents a grave situation that warrants prompt action to arrest and reverse this trend, especially in Tsavo, Mtito Andei, Jipe, Hola and Meru eco-units. The downward trend in elephant numbers, although not as alarming as for rhino, also signals a need for increased conservation measures.

1.0 INTRODUCTION

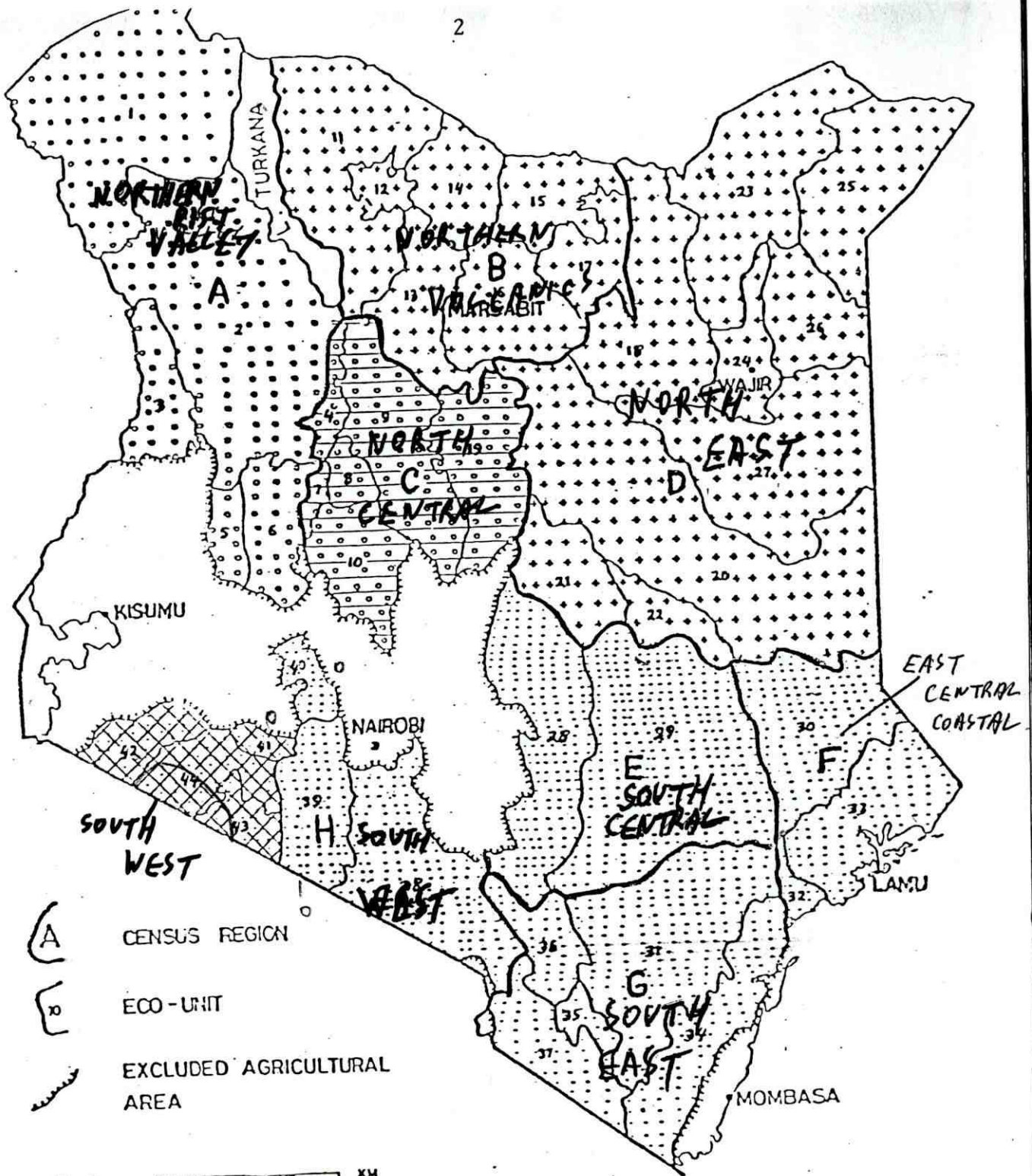
Much concern has been expressed during recent years for the welfare of African elephants (*Loxodonta africana*) and black rhinoceros (*Diceros bicornis*) in Kenya. Elephant numbers in Kenya were reported to have declined from 167,000 in 1973 to 68,425 - 71,419 in 1976/7 according to calculations by the Kenya Game Dept. and the IUCN Elephant Survey (Hillman 1977). For the Tsavo, Garissa/Lamu and Tana River ecosystems this IUCN survey showed a decrease of 55% in elephant numbers from 1973 to 1976. Hillman (op.cit.) reports that "..... direct hunting of elephants by man appears to have been the major cause of the recent reported declines. Since 1973 it can only have been illegal."

For the Agricultural Zone (Fig. 1) the East African Wildlife Society Report of the Working Group on the Distribution and Status of East African Mammals 1977 Phase I: Large Mammals, shows both elephants and rhinoceros declining. They cite heavy poaching, drought and habitat destruction as the reasons for these declines.







Dr. Ian Douglas-Hamilton is currently studying the status and trends of elephants throughout Africa under the sponsorship of the World Wildlife Fund/IUCN. His results when available will reveal population trends in Kenya relative to other African countries. KREMU is collaborating with Dr. Douglas-Hamilton on this project which is in cooperation with the Ministry of Tourism and Wildlife.

References showing actual numeric changes in populations of rhinoceros, hereafter referred to as rhinos, are difficult to find. Various technical and popular articles indicate the rhino is disappearing in Kenya, Tanzania, Uganda and the Sudan. A compilation of past and present estimates of rhinos in Kenya from various research and management agencies showed rhino populations of 16,000-20,000 in 1969 compared to 1,500 - 2,000 in 1979 (Hillman, 1979).

The purpose of this report is to present results obtained on these two important species from the Kenya Rangeland Ecological Monitoring Unit (KREMU) aerial surveys in 1977 and 1978. The results



1977-1978 AERIAL CENSUS PROGRAMME

-  77-01 (JAN-MARCH)
-  77-02 (APRIL)
-  77-03 (MAY)
-  77-04 (AUGUST)
-  77-05 (SEPTEMBER-OCTOBER)
-  77-06 (NOVEMBER)

CENSUS REGIONS

- A NORTHERN RIFT VALLEY
- B NORTHERN VOLCANICS
- C NORTH CENTRAL
- D NORTH EAST
- E SOUTH CENTRAL
- F EAST CENTRAL-COASTAL
- G SOUTH EAST
- H SOUTH WEST

cover all the rangelands (500 000 km²) or about 80% of Kenya (Fig.1). Estimates are also given for the other 20% of Kenya, known as the High Potential Agricultural Zone, which KREMU does not survey, based on information obtained from the Kenya Game Dept. and National Park Wardens.

Results are presented for each of eight Eco-Regions and for each of 44 smaller Eco-Units (Fig.1). These regions and units are separated on the basis of phyto-geographic differences and to some extent on the basis of differences in domestic and wild herbivore distributions and densities.

The Kenya government has taken strong action during the past two years to protect the welfare of wild herbivores, especially those of high trophy value such as the elephant and rhino. Hunting has been banned and a powerful anti-poaching unit has worked hard to suppress poaching.

This KREMU report compares 1977 and 1978 populations for each area of Kenya and shows trends in populations for this 2-year period. We hope these results will be useful to various Government and private conservation agencies in planning wise management and conservation of these two priceless wildlife species.

2.0 . METHODS

In 1977, all the rangelands of Kenya were surveyed along east-west aerial transects spaced 10 kilometers (km) apart. The survey height was 300 feet (ft) above ground level and the average strip width was 112 m on either side of the aircraft or 224 m for both sides. This provided a 2.2% coverage of the entire 500 000 km². The southern portion of Kenya was surveyed from January to May and the northern portion from August to November.

In 1978, the same rangelands were surveyed in exactly the same manner except that transect spacings were 5 km thus increasing the

sampling intensity from 2.2 to 4.4%. The total areas surveyed were 11 000 km² in 1977 and 22 500 km² in 1978.

Three Cessna 185 aircraft were used to fly the surveys. Each crew consisted of a pilot, a front-seat observer who recorded information on the rangelands, and two rear-seat observers who counted all livestock and wild herbivores within the census strips. The eight aerial observers (4 pairs) received intensive training in 1976 and all were involved throughout the 1977 and 1978 surveys, thus providing continuity of observers and minimising human bias during these two years. The census strips on either side of the aircraft were delineated by two rods extending back from the wing struts (Fig. 2), based on standard strip width calibration methods (Pennycuick et al 1977).

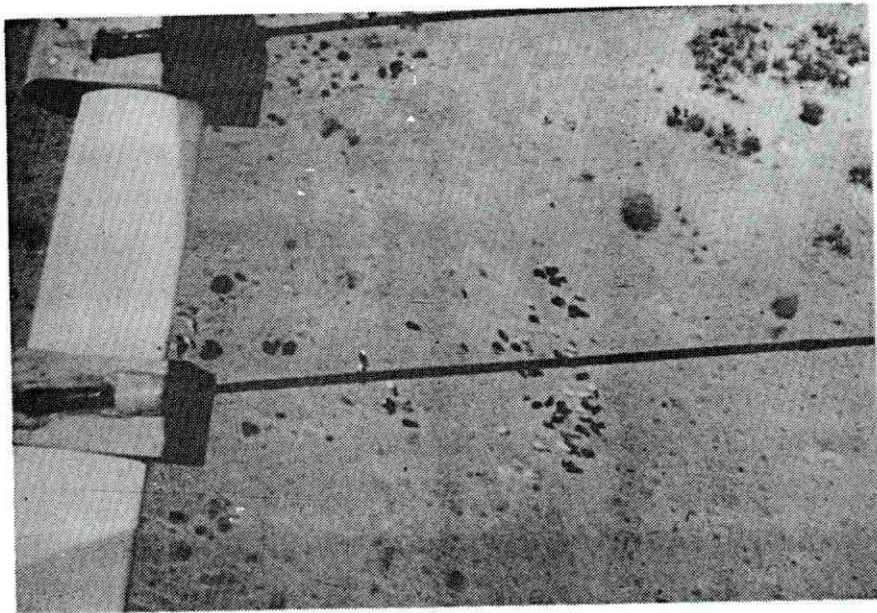


Fig. 2. Census strip method used by KREMJ showing strut rods used to define the census strip for counting herbivores.

All groups of 10 or more animals were photographed as well as counted visually. The visual counts were later corrected from counts of the photographs. All sightings were recorded on tape recorders and then transcribed to data sheets. The analysis was conducted by KREMU's Data Management Section who determined the population estimate, standard error and confidence limits for each species using Government of Kenya IBM 370 Computer at the Central Bureau of Statistics, Nairobi.

3.0 RESULTS

3.1 Elephants (*Loxodonta africana*)

3.1.1 Distributions By Eco-Regions And Eco-Units

Fig. 3 shows the 1977 and 1978 distributions of elephants throughout Kenya and the locations of major density areas. The map shows the most extensive distributions to be in the South Central, East Central-Coastal and South East eco-regions especially in eco-units 29,30,31,33,36 and 37 also known as the Hola, Ijara, Tsavo, Lamu, Mtito Andei and Jipe units. They were also quite widely distributed in eco-unit 10 (Laikipia) of the North Central region, eco-unit 21 (Meru) of the North East region and eco-unit 44 (Mara) of the South West region.

For the North West region, the northwest portion of eco-unit I (N. Turkana) was not surveyed in 1978 because of logistical problems following the loss of a second KREMU aircraft on October 13th. Thus no data was available for that unit to compare with 1977. We assume that the transitory population which periodically migrates to the Magila Range and Songot Mountain area from Kidepo Valley National Park in Uganda and were estimated to number 1,585 animals in 1977 was still using the Kenya range in 1978.

For the forested areas of the Agricultural Zone (Fig. 1), most elephants were located in the northern portion of the Aberdare Range, the Mt. Kenya Forest, Mt. Elgon and the Mau Forest. Actual numbers were not known but it was estimated that up to 10,000 elephants were in this zone, based on estimates of 2000 in each of Mt. Kenya and

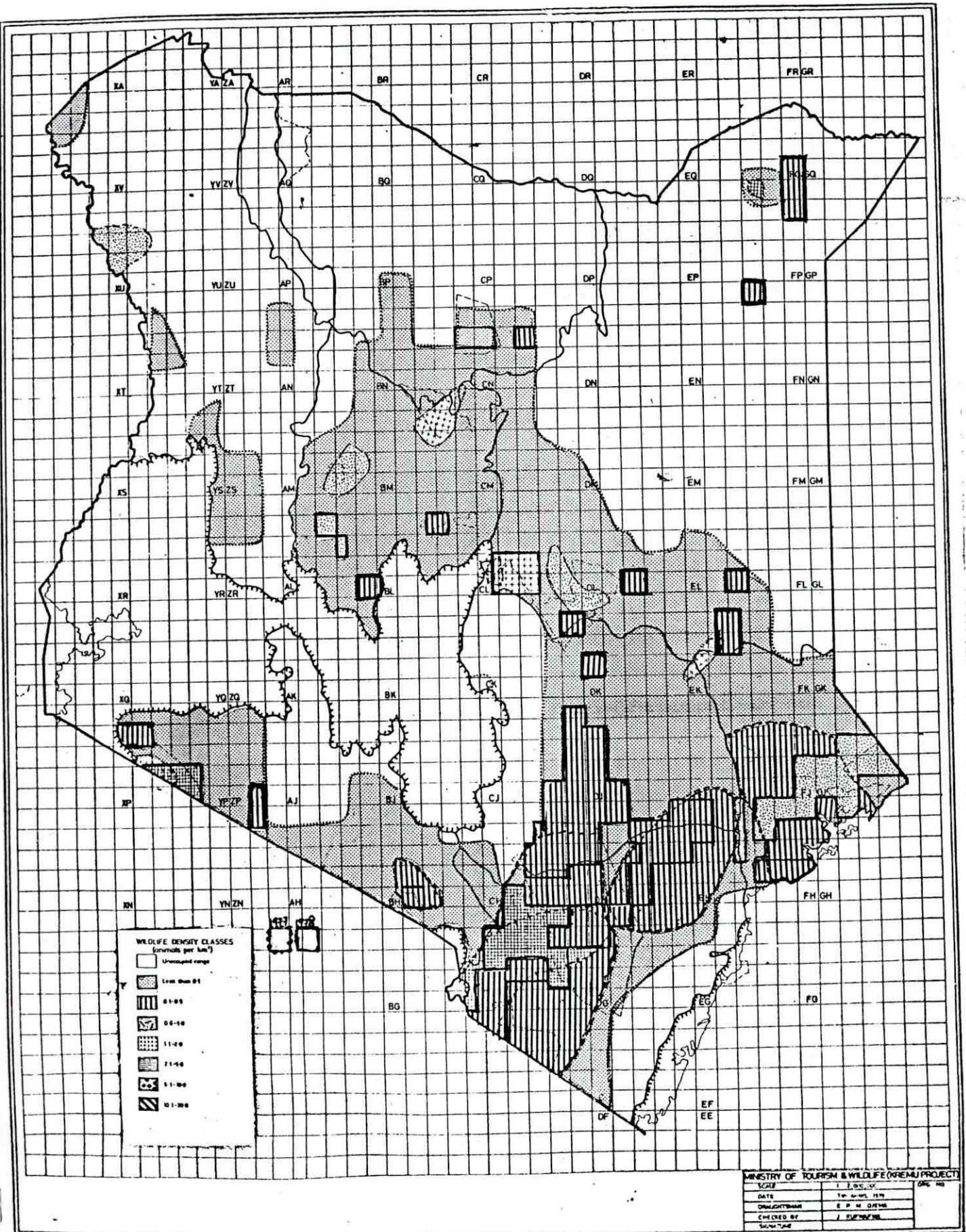


Fig. 3. 1977 and 1978 distributions and density zones for elephants throughout the rangelands of Kenya.

Aberdare National Parks (pers. comm. Park Wardens April 1979). As mentioned earlier, the E. Afr. Wildl. Soc. stated in their 1977 report that elephants were declining in the Agricultural Zone due to poaching, drought and habitat destruction.

3.1.2 Population Estimates and Trends

Table 1 shows the numbers of animals counted, uncorrected population estimates and standard errors for each eco-unit and eco-region of the rangelands of Kenya. Results are presented for both 1977 and 1978 with total numbers for the 500 000 km² rangelands given at the bottom of the table.

The greatest numbers of elephants were found in the South East region (G) where estimates were 24,485 in 1977 and 21,886 in 1978. Most were in Tsavo East and Tsavo West National Parks. Other areas with relatively high numbers were Lamu (Unit 33) with 11,167 in 1977 and 6,378 in 1978; Meru (Unit 21) with 8,312 in 1977 and 2,379 in 1978; Ijara (Unit 30) with 2,729 in 1977 and 2,032 in 1978; Laikipia (Unit 10) with 2,093 in 1977 and 1,927 in 1978 and Mara (Unit 44) with 1,272 in 1977 and 2,629 in 1978.

The 1977 population estimate for the entire pastoral region of Kenya, except the North West Region A, was 58,191 compared to 42,745 in 1978. The 1978 population estimate was 73.5 of that in 1977.

Another 1600 should be added for the North West region which was not adequately surveyed in 1978 thus giving uncorrected total population estimates of 59,800 in 1977 and 44,300 in 1978.

It must be noted that the population estimates presented in Table 1 are only estimates calculated from numbers observed along survey transects. They should rightfully be rounded-off to the nearest 10 for estimates below 1000 and to the nearest 100 for estimates above 1000. Thus an estimate of 1588 becomes 1600 and 273 becomes 270. Numbers were not rounded off in Table 1 so that

Table 1. Numbers of live and dead elephants counted, population estimates and standard errors for various eco-regions and eco-units of Kenya from 1977 and 1978 PREMU aerial surveys.

Table 3, p. 25

AREA
DENSITY
80,800
.02
0

63,150
.03
.001

38,400
.11
Lairdipia
.05

129,775
.07
.02

59,525
.05
.08

27,825
.5
.3

49,325
.5
.44

40,975
NAROK & MARA
Amboseli
.04
Mara
.08

ECO-UNIT	NUMBERS COUNTED						POPULATION ESTIMATES*						S.E.**		% LIVE/FR./BONES	
	LIVE		FRESH CAR.		BONES		LIVE		FRESH CAR.		BONES		1977	1978	1977	1978
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
NORTH WEST REGION																
1	356	0	0	0	1	0	1,585	0	0	0	0	0	101.6	-	97/0/3	-
2	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
3	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
5	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
6	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
Totals & Aves.	356	-	0	-	1	-	1,585	-	0	-	45	-	101.5	-	97/0/3	-
NORTHERN VOLCANICS REGION																
11	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
12	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
13	35	0	0	0	0	2	1,588	0	0	0	0	44	97.5	-	100/0/0	0/0/100
14	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
15	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
16	0	5	0	0	0	0	0	112	0	0	0	0	-	60.7	-	100/0/0
17	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
Totals & Aves.	35	5	0	0	0	2	1,588	112	0	0	0	44	97.5	60.7	100/0/0	71/0/29
SAMBURU-LAIKIPIA REGION																
4	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
7	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
8	19	0	0	0	1	0	869	0	0	0	46	0	60.9	-	96/0/5	-
9	16	0	4	0	57	0	710	0	189	0	2604	0	67.7	-	21/5/74	-
10	46	88	1	0	1	0	2,093	1927	51	0	51	0	93.3	75.4	96/2/2	100/0/0
19	11	0	0	0	23	46	498	0	0	0	1041	1056	50.1	-	32/0/68	0/0/100
Totals & Aves.	92	88	5	0	82	46	4170	1927	240	0	3742	1056	68.7	75.4	51/3/46	66/0/34
NORTH EAST REGION																
18	0	0	0	0	1	0	0	0	0	0	45	0	-	-	0/0/100	-
20	6	11	1	1	55	34	273	262	46	24	2505	809	98.9	60.7	10/1/89	24/2/74
21	183	102	3	0	39	21	8312	2379	129	0	1757	490	76.0	53.3	81/2/17	83/0/17
22	7	0	0	0	2	5	297	0	0	0	1146	549	90.5	-	22/0/78	0/0/100
23	13	7	0	0	3	4	576	166	0	0	144	96	67.4	97.0	81/0/19	64/0/36
24	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
25	0	5	0	0	1	1	0	149	0	0	54	30	-	98.0	0/0/100	63/0/37
26	0	4	0	0	0	1	0	104	0	0	0	26	-	97.1	-	80/0/20
27	0	0	0	0	1	14	0	0	0	0	45	390	-	-	0/0/100	0/0/100
Totals & Aves.	209	129	4	1	125	95	9458	3060	175	24	5696	2390	76.9	56.6	62/1/37	57/1/42
TANA RIVER REGION																
28	0	1	0	0	2	2	0	23	0	0	90	45	0	95.7	0/0/100	33/0/67
29	61	178	12	6	39	188	2763	4105	563	135	1597	4531	46.0	23.3	54/11/35	48/2/50
Totals & Aves.	61	179	12	6	41	190	2763	4128	563	135	1687	4576	46.0	28.7	53/11/36	48/1/51
LAMU/GARISIA REGION																
30	56	80	21	10	26	102	2729	2032	1023	257	1267	2850	41.8	36.9	54/21/25	42/5/53
32	0	2	-	1	-	13	0	41	-	21	-	269	-	92.7	-	6/13/81
33	215	290	-	8	-	43	11167	6378	-	132	-	946	18.1	30.5	-	86/1/13
Totals & Aves.	271	372	-	17	-	158	13,896	8,451	-	410	-	4065	22.8	32.4	-	68/3/29
SOUTH EAST REGION																
31	297	701	-	26	-	265	14215	15804	-	586	-	265	31.2	60.4	-	71/2/27
34	13	0	1	0	2	16	610	0	47	0	94	389	76.2	-	81/6/13	0/0/100
35	0	7	0	0	0	5	0	177	0	0	0	127	103.4	-	-	58/0/42
36	97	187	0	1	0	20	4453	4219	0	23	0	451	82.8	46.8	100/0/0	90/1/9
37	111	68	0	10	0	23	5207	1686	0	248	0	570	39.3	35.6	100/0/0	67/10/23
Totals & Aves.	518	963	-	37	-	329	24,485	21,886	-	857	-	7511	43.4	56.2	-	72/3/25
NAROK & MARA REGION																
38	13	4	-	0	-	7	559	87	-	0	-	152	66.9	97.7	-	36/0/64
39	0	0	-	0	-	0	0	0	-	0	-	0	-	-	-	-
40	0	0	-	0	-	0	0	0	-	0	-	0	-	-	-	-
41	0	0	-	0	-	2	0	0	-	0	-	50	-	-	-	0/0/100
42	0	2	-	0	-	1	0	48	-	0	-	24	-	95.8	-	67/0/33
43	0	16	-	0	-	0	0	417	-	0	-	0	-	68.1	-	100/0/0
44	29	108	-	0	-	7	1,272	2629	-	0	-	170	58.6	75.7	-	84/0/6
Totals & Aves.	42	130	-	0	-	17	1,831	3,181	-	0	-	396	82.0	75.6	-	88/0/12

ALL 500 000 KM² PASTORAL REGIONS OF KENYA

Totals & Aves.	1228	2406	21	7	248	333	58,101	42,745	973	159	11,125	8,066	-	-	51/3/16	44/1/55
							59,776		A	1,092	11,170	20,038				

the proportion of LIVE/FRESH CARCASSES/BONES-ROT PATCHES could be calculated more accurately.

The reader will also notice that population estimates for either year are not very accurate for individual eco-units due to the difficulty of accurately censusing elephants using the transect sampling method unless the sampling intensity is at least 15% and the area is stratified and sampled according to major vegetation types and density zone. The higher sampling intensity plus stratification greatly improves both the accuracy and precision of the population estimate.

The elephant is one of the most difficult herbivores in East Africa to census accurately and with high precision because it occurs in a few large herds that are non-randomly distributed (Norton-Griffiths, 1978; Western, 1976a; Western 1976b; Pennycuick et al, 1977). However, it appears that over a large region and where elephants are numerous, population estimates will be fairly precise. KREMU's estimates of 59,800 elephants in 1977 and 44,300 in 1978 are believed to be 75-90% accurate. Limited tests over the past year at Meru National Park and Mara Wildlife Reserve indicate that we are counting at least 85% of the elephants on our 112 m strips on either side of the aircraft at a survey height of 300 ft for the habitats in those two areas. Of course, in heavy woodland and bushland we may be seeing only 75% of the elephants but it is unlikely if our experienced observers are seeing any less than 75% at this narrow census strip and low survey height except for a few small areas.

Assuming that our 1977 and 1978 counts were only 75% accurate then the estimates for all the rangelands of Kenya would be 77,600 in 1977 and 57,000 in 1978. Allowing for up to 10,000 elephants in the Agricultural Zone, then the upper estimate for all Kenya would be 87,600 in 1977 and 67,000 in 1978.

Regardless of the biases in KREMU's results, the data indicate conclusively that on a nation-wide basis the population trend was downward and the 1978 population was about 75% of that in 1977. The only exceptions to this downward trend were in the South West region

3.1.3 Proportions Of Live To Dead Elephants

The proportion of live elephants to fresh carcasses and to bones - rot patches provides an index to current and past mortalities as well as to population trends.

Fig. 4 shows the proportions of live/fresh/bones - rot patches for three eco-regions and for all of Kenya in 1977 and 1978. For all of Kenya, the percent of live elephants declined from 51% to 44% while the percent of bones - rot patches increased from 46% to 55%. This indicates an increase in mortality rate from 1977 to 1978 and a downward trend in the population. This trend is quite noticeable in the South Central and South East regions as well as the Meru (No. 21) eco-unit of the North East region. Sample sizes were too small in the other eco-units to draw any definitive conclusions.

3.2 Rhinoceros (Diceros bicornis)

3.2.1 Distributions By Eco-Regions And Eco-Units

Fig. 5 shows the 1977 and 1978 distributions of rhinos throughout the rangelands of Kenya and the locations of major density areas. The maps shows they were mainly confined to the South East and South West regions, in particular eco-units 31 (Tsavo), 36 (Mtito Andei) and 37 (Jipe) in the South East and eco-unit 44 (Mara) in the South West. They were present on both the shrubby grasslands and the woodlands of Meru National Park and the adjacent Bisanadi Conservation Area in 1977. However, by March 1979 they had been virtually eliminated from all habitats except the heavy bushland and woodland areas of Meru National Park.

Our 1977 and 1978 surveys produced no sightings throughout the North West, Northern Volcanics or North Central regions. In the North East region they were observed only in eco-unit 21 (Meru),

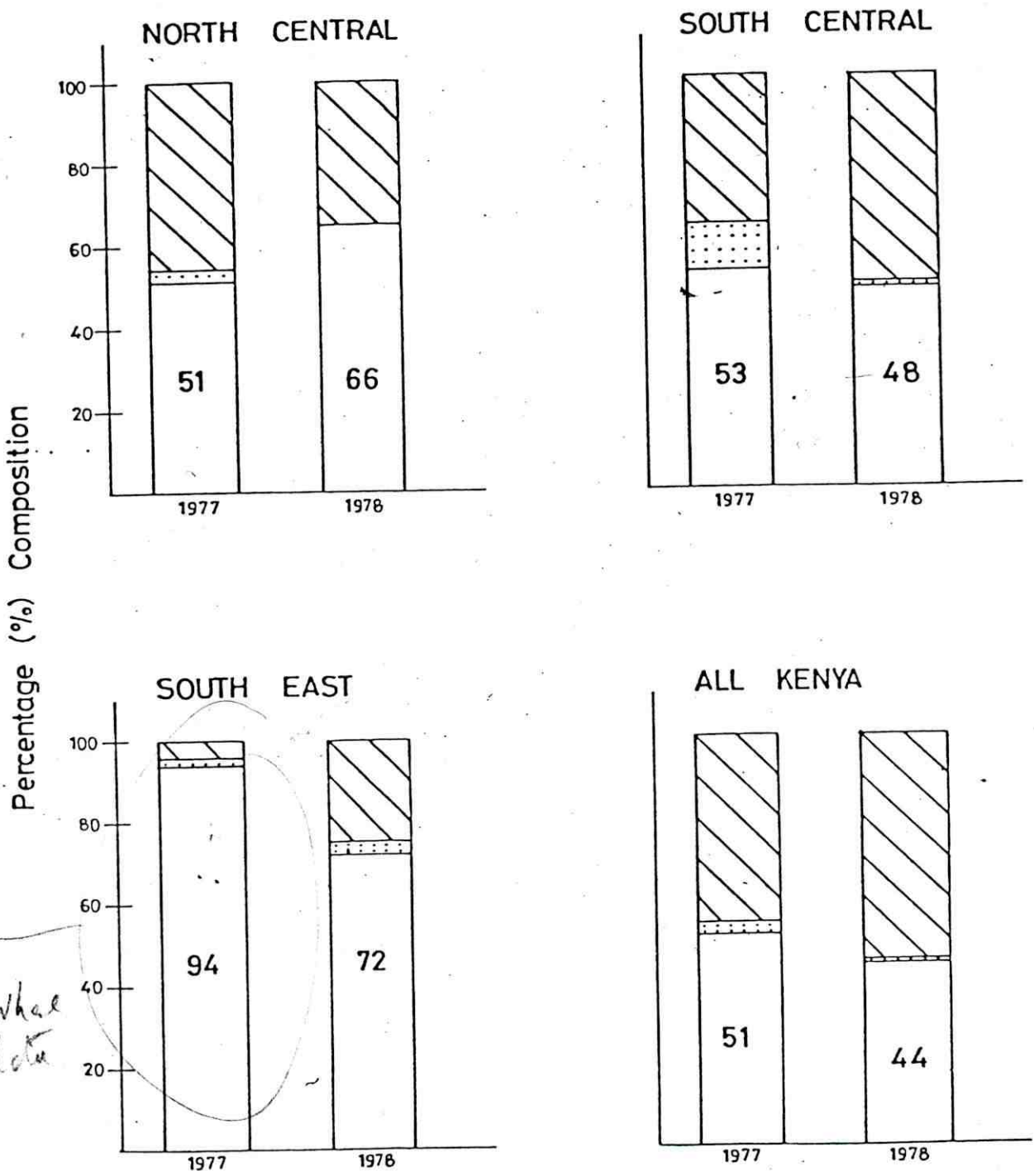
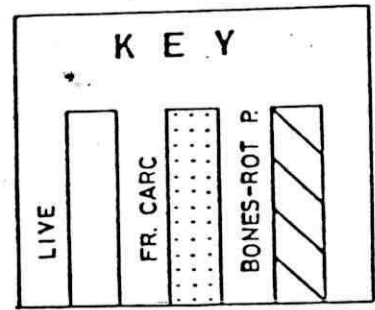


Fig. 4. Proportions of Live/Fresh Carcasses/Bones-Rot Patches of elephants in the three eco-regions and throughout Kenya, 1977 and 1978.

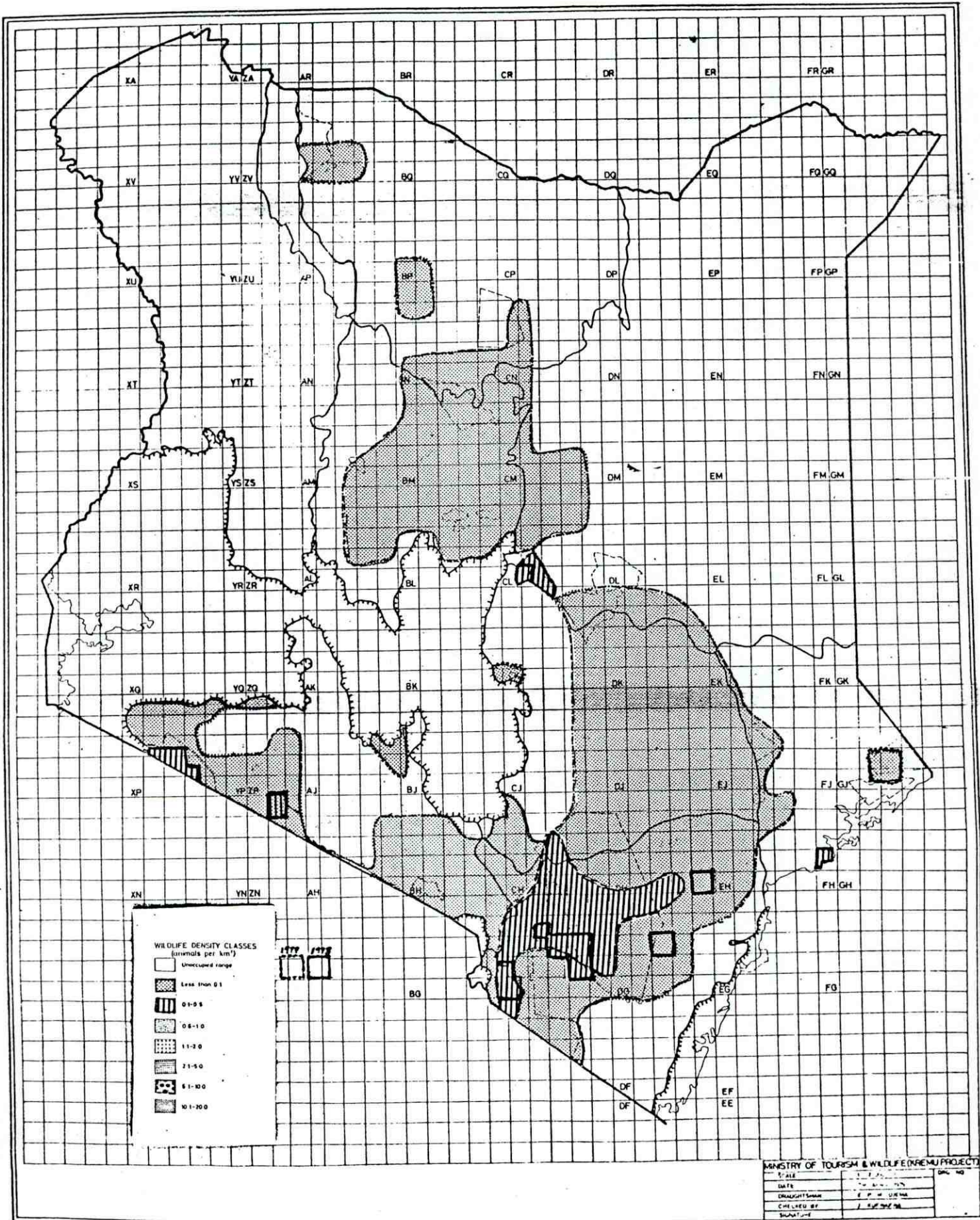


Fig. 5. 1977 and 1978 distributions and density zones for rhinos on the rangelands of

while in the South Central region they were only observed in a small portion of eco-unit 29 (Hola). They were observed in only a few locations in eco-units 30 (Ijāro) and 33 (Lamu) of the East Central-Coastal region.

They were not observed in any eco-units of the South West region except 43 (Loita) and 44 (Mara).

For the Agricultural Zone, a few are known to be present in the north portion of the Aberdares especially on the west side of Mt. Kenya and in the Mau Forest. The 1979 estimate was 40 on the Laikipia Plateau, 40 in Mt. Kenya Forest and 200 in Mt. Kenya and Aberdare National Parks (pers. comm. Park Wardens April 1979).

Fig. 5 shows a major reduction in the distribution of rhinos in 1978 compared to 1977. As of 1978 their distribution had been constricted to mainly a few localities in the national parks and wildlife reserves.

3.2.2 Population Estimates and Trends

Table 2 shows the numbers counted, population estimates (uncorrected) and standard errors for each eco-unit and eco-region as well as for the entire rangelands of Kenya. It also presents the 1978 estimates as a percentage of the 1977 estimates.

The uncorrected 1978 population estimate of 571 rhinos for all regions was only 31.4% of the 1977 estimate of 1818 animals. Although we recognize that there are considerable sampling biases involved in surveying rhinos, especially when their numbers are very low and most of those remaining have sought refuge in heavy bush cover where they are less visible, we still believe KREMU's counts and estimates reflect a pronounced decline from 1977 to 1978. They reveal that the rhino population is at a dangerously low level with the groups so small and scattered that productivity will undoubtedly be sub-normal. In many areas their numbers may be below the "threshold-for-survival" where normal productivity rates could not be achieved unless the sparse population is augmented by an introduction of animals from elsewhere.

How accurate are KREMU's population estimates and how must they be adjusted to arrive at a more correct population estimate. The two main sources of survey bias for rhinos are:

1. Counting bias, or what percentage of the animals present along the survey strips are actually counted;
2. Sampling bias, or errors in the sampling design due to the non-random distribution of rhinos and an inadequate sampling intensity.

In the first instance, we believe we count at least 75% of the rhinos on our narrow 112 m - wide strip at the 300 ft survey height for all shrubby grassland and savannah habitats. However, in bushland and woodland with greater-than 50% canopy cover we may be counting only 50% or less of the animals on the strips. This means that with the current trend of fewer animals present in the open and semi-open bushland and in shrubby grassland; and a proportionality higher percentage in the more densely wooded areas, our observability bias increases. This would result in our 1978 counts being less accurate than those in 1977.

In the second instance, we recognize that 2.2% and 4.4% sampling intensities are inadequate for determining population estimates on an eco-unit basis, although they are reasonably accurate for the larger eco-regions and on a nation-wide basis. For example, in Meru National Park and the Bisanadi Conservation Area we counted no rhinos in 1978 using a 4.45% sampling intensity. In February 1979 we surveyed the area at 5.6, 9.0 and 18.3% sampling intensities as well as a stratified survey which sampled the High Density Grassland at 17.8% intensity and the Low Density Woodland at 6.0% intensity. Again, no animals were seen at the 5.6% sampling intensity giving a population estimate of 0; whereas 4 were seen at the 9.0% intensity giving a population estimate of 44 rhinos. At the 18.3% sampling intensity, 3 rhinos were counted giving an estimate of 16 rhinos. The stratified survey (17.8 & 6.0% intensities) counted 4 rhinos giving an estimate of 34 rhinos. Probably the true population lay somewhere between 16 and 44. The 1978 population estimate for Meru

Table 2. Numbers counted, population estimates[✓] and standard errors of rhinos in various eco-regions and eco-units of Kenya from 1977 and 1978 KRMU aerial surveys.

ECO-UNIT	SAMPLING INTENSITY		NO. COUNTED (SAMPLE SIZE)		POP. ESTIMATE [✓]		STANDARD ERROR [*]		1978 EST. AS
	1977	1978	1977	1978	1977	1978	1977	1978	% OF 1977 EST.
			NORTH WEST		REGION A				
1	2.21	-	0	0	0	0	-	-	-
2	2.13	-	0	0	0	0	-	-	-
3	2.13	-	0	0	0	0	-	-	-
5	2.18	-	0	0	0	0	-	-	-
6	2.22	-	0	0	0	0	-	-	-
Totals & Aves.	2.17	-	0	0	0	0	-	-	-
			NORTHERN VOLCANICS		REGION B				
11	2.14	4.38	0	0	0	0	-	-	-
12	2.17	4.51	0	0	0	0	-	-	-
13	2.27	4.52	0	0	0	0	-	-	-
14	2.24	3.59	0	0	0	0	-	-	-
15	2.08	3.48	0	0	0	0	-	-	-
16	2.06	4.47	0	0	0	0	-	-	-
17	1.99	4.33	0	0	0	0	-	-	-
Totals & Aves.	2.14	4.18	0	0	0	0	-	-	-
			NORTH CENTRAL		REGION C				
4	2.08	-	0	0	0	0	-	-	-
7	2.18	-	0	0	0	0	-	-	-
8	2.21	-	0	0	0	0	-	-	-
9	2.16	-	0	0	0	0	-	-	-
10	2.04	-	0	0	0	0	-	-	-
19	2.33	4.17	0	0	0	0	-	-	-
Totals & Aves.	2.17	-	0	0	0	0	-	-	-
			NORTH EAST		REGION D				
18	2.23	4.40	0	0	0	0	-	-	-
20	2.33	4.20	0	0	0	0	-	-	-
21	2.33	4.58	2	0	86	0	93.0	-	0
22	2.36	4.58	0	0	0	0	-	-	-
23	2.08	4.21	0	0	0	0	-	-	-
24	2.26	4.11	0	0	0	0	-	-	-
25	1.87	3.34	0	0	0	0	-	-	-
26	2.27	3.86	0	0	0	0	-	-	-
27	2.21	3.59	0	0	0	0	-	-	-
Totals & Aves.	2.22	4.10	2	0	86	0	93.0	-	0
			SOUTH CENTRAL		REGION E				
28	2.22	4.50	0	0	0	0	-	-	-
29	2.32	4.46	2	0	86	0	73.2	-	0
Totals & Aves.	2.27	4.48	2	0	86	0	73.2	-	0
			EAST CENTRAL-COASTAL		REGION F				
30	2.05	4.28	1	0	49	0	100.0	-	0
32	2.06	4.84	0	0	0	0	-	-	-
33	1.93	4.55	0	2	0	44	-	100.0	200+
Totals & Aves.	2.01	4.56	1	2	49	44	100.0	100.0	89.8
			SOUTH EAST		REGION G				
31	2.21	4.44	18	7	815	158	35.7	39.2	19.4
34	2.13	4.11	1	0	47	0	100.0	-	0
35	1.98	3.95	0	0	0	0	-	-	-
36	2.18	4.43	6	1	275	23	70.9	95.7	8.4
37	2.13	4.03	7	5	328	124	46.0	77.4	37.8
Totals & Aves.	2.13	4.19	32	13	1,465	305	46.7	59.0	20.8
			SOUTH WEST		REGION H				
38	2.33	4.61	0	0	0	0	-	-	-
39	2.30	4.74	0	0	0	0	-	-	-
40	2.12	4.57	0	0	0	0	-	-	-
41	2.03	3.97	0	0	0	0	-	-	-
42	2.13	4.13	0	0	0	0	-	-	-
43	2.06	3.84	0	2	0	52	-	100.0	200+
44	2.28	4.11	3	7	132	170	65.1	47.6	128.8
Totals & Aves.	2.18	4.28	3	9	132	222	65.1	59.9	168.2
			ALL OF 500 000 KM ²		PASTORAL REGIONS OF KENYA				
Totals & Aves.	-	-	40	24	1818	571	-	-	31.4

* Standard error as a % of population estimate.

✓ Uncorrected population estimates not adjusted for accuracy.

eco-unit should therefore be corrected upwards from 0 to about 35. Similar adjustments may have to be made for eco-units 29, 30 and 34. Considering both biases discussed above, we believe KREMU's 1977 and 1978 surveys produced estimates that were 50 - 75% of the true populations. This means that the corrected maximum populations were 3636 in 1977 and 1142 in 1978. Certainly, the population is critically low and the trend is rapidly downward. Six, and probably 10, of the 44 eco-units still contain rhinos but several of these will be devoid of rhinos within the next year if the current trend continues.

The decline seems to be just as rapid within the National Parks such as Meru and Tsavo (see eco-units 21 and 31 in Table 2) as in non-park areas. This pronounced decline is apparently of recent origin as Goddard (1970) showed that the population in Tsavo was stable during the 1960's.

The number present in the Agricultural Zone is estimated to be about 300 based on estimates by Park Wardens (pers. comm. April 1979).

4.0 CONCLUSIONS & RECOMMENDATIONS

Aerial surveys of all Kenya rangelands (500 000 km²) in 1977 and 1978 by KREMU showed that both elephants and rhinos were declining in numbers. Minimum - maximum numbers of elephants for these rangelands were 59,800 - 87,600 in 1977 and 44,300 - 67,000 in 1978. An additional 5,000 - 10,000 occurred in the wooded regions of the Agricultural Zone. For all of Kenya, KREMU's population estimates were:

	<u>Minimum</u>	<u>Maximum</u>
1977	64,800	97,600
1978	49,300	77,000

The 1978 population on the rangelands was **73.5%** as high as in 1977 based on those regions where comparable counts were available for both years. Greatest numbers occurred in the South East region where

uncorrected population estimates were 24,500 in 1977 and 21,900 in 1978. Most of these animals were in Tsavo East and Tsavo West National Parks. Other eco-units with relatively high numbers were Lamu, Ijara, Laikipia and Mara.

The ratios of live: dead elephants decreased from 51:49 in 1977 to 44:56 in 1978 providing further evidence of a declining population. Eco-regions showing the greatest reduction in numbers were the North Central, North East and East Central-Coastal regions, especially within the Meru, Lamu and Jipe eco-units.

The 1978 rhino population was only 34.1% of that in 1977 for all Kenya rangelands. Population estimates for all of Kenya were:

	<u>Minimum</u>	<u>Maximum</u>
1977	2118	3936
1978	871	1442

All but about 300 were outside the Agricultural Zone.

Most rhinos were confined to the South East and South West regions, in particular the Tsavo, Mtito-Andei, Jipe and Mara eco-units. Greatest decreases were occurring in the Tsavo, Mtito Andei, Jipe, Hola and Meru eco-units. Their distributions were greatly constricted in 1978 compared to 1977 and few remained on savannah and shrubby grassland ranges.

On the basis of KREMJ's 1977 and 1978 aerial survey data we make the following recommendations:

1. Increased management and research on these two important species to find ways of stopping and ultimately reversing the drastic downward trend in population and constrictions in their distributions.
2. Increased inter-disciplinary collaboration in planning and implementing programmes for preventing the annihilation of rhinos and elephants over large areas of their former range

and for maximising their numbers in harmony with multiple land-use objectives.

3. As poaching is cited as the major factor responsible for these population declines, a more efficient means of controlling poaching must be found. Hopefully, the new anti-poaching units will be effective in achieving this goal.
4. Prime ranges for elephant and rhino must be delineated and a multi-disciplinary land-use programme drawn up for these critical areas in order to optimise the distribution and abundance of these important species while maximising multiple-use objectives.

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R E F E R E N C E S

- Hillman, A.K.K. (1977) IUCN elephant survey and conservation programme. Interim report on status of elephants in Kenya, 1977.
- Hillman, A.K.K. (1979) Past and present estimates of rhinoceros numbers in Kenya. Compiled by Hillman A.K.K. for the IUCN African Rhino Group, Elephant Survey and Conservation Programme and the Kenya Rhino Action Group.
- Goddard, J (1970) Age criteria and vital statistics of a black rhinoceros population. *E. Afr. Wildl. J.* 8, 105-121.
- Norton-Griffiths, M. (1978) Counting animals. Handbook No. 1 2nd edition, ed. by J.J.R. Grimsdell. Serengeti Ecological Monitoring Programme. African Wildlife Leadership Foundation, Nairobi.
- Pennycuik, C.J., Sale, J.B., Stanley Price, M. & Jolly, G.M. (1977) Aerial systematic sampling applied to censuses of large mammal populations in Kenya. *E. Afr. Wildl. J.* 15, 139-146.
- Western, D. (1976a) An aerial method of monitoring large mammals and their environment, with a description of a computer program for survey analysis. Project Working Document 9, UNDP/FAO Kenya Wildlife Management Project (KEN/71/526), Nairobi.
- Western, D. (1976b) The distribution of animals in relation to resources. Handbook No. 2, ed. by J.J.R. Grimsdell and H.T. Russell. Serengeti Ecological Monitoring Programme. African Wildlife Leadership Foundation, Nairobi.