

UNGULATE POPULATION ESTIMATES FOR H.G.R. AND
N. CORRIDOR FOR JULY 1978, BASED ON
FOOT AND HELICOPTER COUNTS

by

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INTRODUCTION

This study was planned as an interim measure to provide improved population estimates for the ungulates in H.G.R. and the N. Corridor, as approximate population sizes were required for the determination of game removal figures over the next three years. By investigating the repeatability and reliability of both total foot and total helicopter counts it was possible to obtain two estimates of population size. Previously, population estimates have been based on helicopter counts using subjectively-defined accuracy categories. It is known that the helicopter undercounts a number of species (Melton 1978a), but insufficient information on conversion factors is available. Many of the aspects included in this report require further investigation, and it is intended to use much of the raw data presented here in the proposed census evaluation study.

METHODS

Total foot counts and total helicopter counts were conducted over the period 4th - 25th July 1978 in H.G.R. and the N. Corridor. These were a co-operative effort between research and management staff.

Foot counts

A total of 17 foot counts were conducted in 12 areas (see Fig. 1), and all of these except No. 23 Nzimane, were also counted by helicopter.

The selection of areas depended on two major criteria, namely the ease of counting and the representative nature of the vegetation. The former was necessary to obtain a reliable indication of repeatability and the relationship between foot and helicopter counts, and the latter to allow crude extrapolation of animal densities to the entire reserve. In practice, the ease of counting depended on the accessibility of the area, the presence of physical barriers to movement (e.g. fences, deep rivers) and good visibility strips on the periphery (e.g. roads, open ridges) to allow animals breaking out of the area to be seen.

The strategy was to enclose the areas as far as possible before counting began by using a mobile main line (M) and secondary lines consisting of one or two wings (W) and a static

end line (E). The arrangement of the lines varied considerably between areas, but that used in the Hidli-Gontshi area (3) shown in Fig. 2 acts as a good example. In this case, 74 counters (4 Officers and 70 game guards, technical assistants, labourers and togt workers) were used. The most reliable

HELICOPTER COUNTING BLOCKS

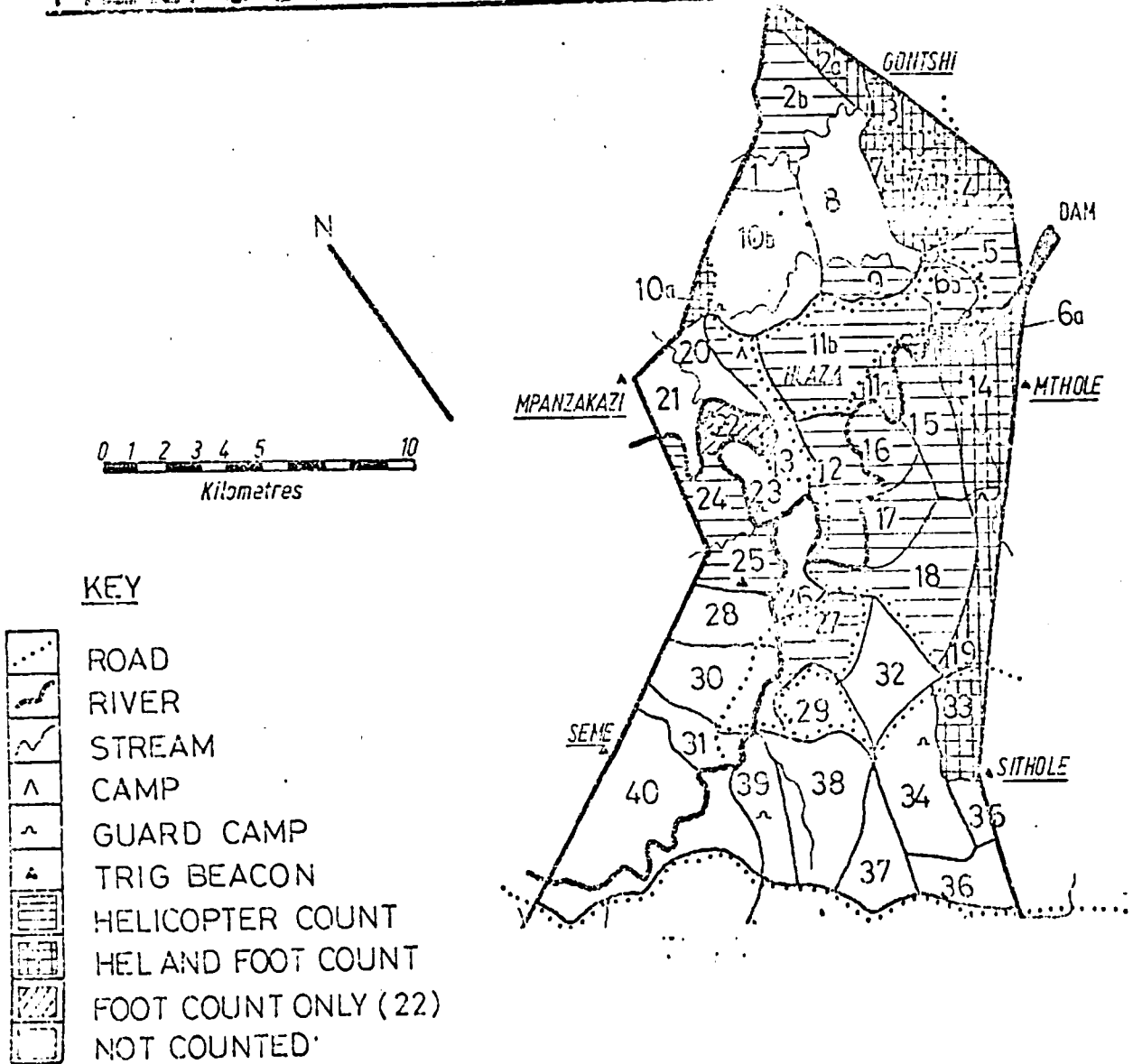


Figure 1. Areas in H.G.R. counted by foot and helicopter in July 1978.

observers were spaced evenly along the lines. The end line (E) of 12 counters was positioned on the northern boundary along the service track to Gontshi outpost and continued to the fence. Each 'E' counter was given a set distance of road to his left and right to watch, and only animals passing out of the area within this visibility strip were recorded. The main line of 54 counters was strung out in a straight line over Hidli between the lower Magangeni tourist road and the eastern fence, using a mean spacing of about 28 metres. Radios were carried by M1, M27 and M54. Animals passing out of the area through the line to the left and right of each counter were recorded accordingly on a

form bearing drawings of the more common species. The first counter in the wing, W1, formed an extension from M1 to the road, and the wing itself (W1-W8) was formed in a northerly direction along the road at right angles to the main line. The wing only counted those animals passing out of the area between themselves and the counter in front. The wing was dynamic, in that individual spacing varied according to visibility, the object being to maintain the greatest possible distance between observers while staying in visual contact. In this case, wing length varied between about 600 m and 1000 m in length.

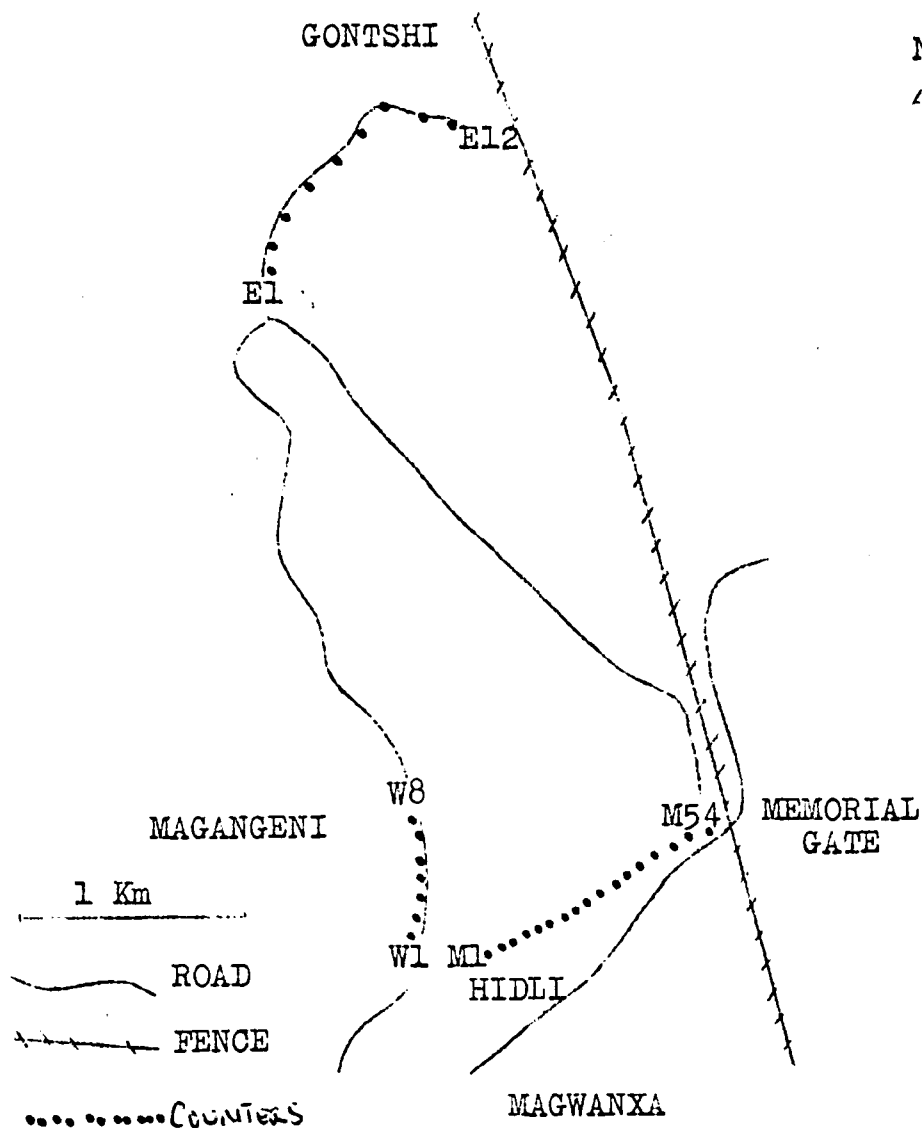


Figure 2. Arrangement of counting lines used for a foot count of Area 3, Hidli-Gontshi, in July 1978.

The main line progressed slowly through the area, halting only if a break occurred or one part of the line fell behind. Maintenance of the line was achieved by radio contact and personal communication between successive counters. At the end of each count the counters were questioned and their recordings checked with those of the adjacent counters, and any discrepancies

corrected while memories remained fresh.

Helicopter counts

The 29 areas counted using the helicopter are shown in Fig. 1. Of these, 6 areas were each counted three times to investigate

repeatability. The remaining areas selected were either priority game removal areas (current or proposed) or were also covered by ground counts. Complete coverage of each area was achieved by flying parallel strips. Areas were flown at various times of the day, but where a comparison with foot counts was required, the timing was regulated to correspond with that of the foot counts; and where counts were repeated, timing was kept the same from one count to the next.

Definitions

Game counts can only be justified if they are either reliable or at least repeatable. A reliable count provides an accurate estimate of the actual population size; while a repeatable one may not be as accurate, but will be sufficiently consistent between successive counts to indicate trend.

The Tolerance Index for a given species was based on its response to the main line of counters during foot counts. Species intolerant of the main line ran ahead and tended to move out of the area through the secondary lines where the spacing was much greater; while more tolerant species tended to pass through the main counting line. The Tolerance Index for a given species was therefore the percentage of those counted which passed through the main line.

The conversion factor (C.F.) for a particular species is the factor by which the helicopter count total must be multiplied to give an approximation of the actual population size. Therefore:

Population size = helicopter count total X conversion factor.

RESULTS AND DISCUSSION

Foot counts

Foot counts were conducted in 12 areas (4 663 ha) representing 17,3 % of H.G.R. and the N. Corridor (see Fig. 1). The numbers of ungulates recorded in each area are presented with other relevant data in Appendices 1 - 12. These data are used later for extrapolating ungulate densities to the whole reserve.

Reliability

It is important to identify which species were accurately counted by foot counts to allow evaluation of the helicopter count and extrapolation of results over the whole reserve. However, in the absence of known population sizes this assessment had to be made subjectively, based on observations made during counting.

In the present series of counts, the following possible sources of error were identified:

(1) Application of method. Rugged topography and dense vegetation made it difficult to keep the line straight and intact. However constant radio communication between count supervisors kept the possible undercounting and overcounting errors to a minimum.

(2) Observers. Many observers were illiterate. A rigid control system to check recordings was initiated (see Methods); and very few incorrect observations were made. Most mistakes were corrected immediately the count was over.

(3) Animal behaviour. The only significant sources of error were considered to result directly from the intrinsic physical and behavioural characteristics of the species themselves, such as body size, herd size, colouration, response to disturbance (running, freezing, use of burrows) and activity patterns (diurnal/nocturnal) in association with the use of dense vegetation.

Table 1 presents Tolerance Indices (see Definitions) in ascending order for the various species counted in the 15 counts which used both main and secondary lines; relevant physical and behavioural characteristics of the species are also included. Giraffe, mountain reedbuck and steenbok were not included, as sample sizes were too small (i.e. $N < 20$).

To facilitate discussion on the reliability of the counts, the species have been divided into (a) intolerant (main line $< 50\%$) and (b) tolerant species ($> 50\%$).

(a) Intolerant species (zebra, kudu, buffalo). These are large, highly mobile herd animals with large overlapping home ranges. Observations showed that they sometimes move up to 1,0 km ahead of the main counting line before breaking out through the secondary lines. The very large herd size and aggressive nature of the buffalo disrupted the organisation of the counting line at times, but not sufficiently to invalidate the counts.

(b) Tolerant species. These are of variable body size, but either are territorial or have small home ranges. They were only pushed a short distance before breaking back through the main counting line. Detection by observers varied as follows:

(i) Large body size and/or herd size (s.l. rhino, black rhino, wildebeest, impala). They were easily counted breaking through the line. However, black rhinos caused serious disruption (temporarily) of the line, resulting in poor counts for that species.

(ii) Medium to small body size; in family groups or solitary. The counts of nyala and warthog were considered to be accurate. They generally flushed noisily and were sufficiently large to be seen. Adverse weather conditions causing warthog to retreat to burrows were not experienced. The remaining species were either small, mainly nocturnal and rested in very dense bush (bushpig, bushbuck) or very small and often froze to avoid detection until counters were very close (red duiker, grey duiker). Once disturbed, red duiker flushed quietly and some could have passed through the line undetected, while grey duiker flushed noisily and were easily observed.

Table 1. Tolerance Indices and relevant physical and behavioural characteristics of ungulates observed in 15 foot counts in H.G.R.

Species	N	Tolerance index	Body size	Group structure	Spatial organisation
Zebra	387	21 %	Large	Herd	Large home range
Kudu	60	38 %	Large	Herd	Large home range
Buffalo	531	43 %	Large	Herd	Large home range
Wildebeest	519	64 %	Large	Herd	Territorial
Black rhino	26	65 %	Large	Fam/sol *	Territorial
Impala	2123	65 %	Medium	Herd	Territorial
Nyala	3042	67 %	Medium	Fam/sol *	Small home range
Warthog	769	81 %	Medium	Fam/sol *	Small home range
S.l. rhino	111	82 %	Large	Fam/sol *	Territorial
Red duiker	103	84 %	Small	Fam/sol *	Territorial ?
Bushpig	24	87 %	Medium	Fam/sol *	? Home range
Grey duiker	129	89 %	Small	Fam/sol *	Territorial
Bushbuck	47	91 %	Medium	Fam/sol *	Territorial

* Fam./sol. = Family or solitary

The conclusions are that the foot counts gave reliable results for most species shown in Table 1: grey duiker, red duiker and bushbuck (in descending order of reliability) were possibly all slightly undercounted: while bushpig were severely undercounted and black rhino were over or undercounted.

Repeatability

An indication of the repeatability of the foot counts was obtained by counting five areas twice, these were Nos. 3 Hidli-Gontshi, 4 Magwanxa, 7a Magangeni, 7b Qholwana-Nqunqulu and 33 Sithole. A period of 4-13 days was left between counts of any particular area to allow the population to redistribute following the disturbance caused by the first count.

Table 2 presents the numbers of ungulates₂ recorded on the two sets of counts, and the results of the Chi² test for variation between samples. The Null hypothesis was that successive counts were equal, so count totals were used as the observed values, and the mean of the two counts as the expected. The count for a particular species was considered to be repeatable if the Chi² test gave a non-significant result (P > 0,05), and not repeatable if the result was significant (P < 0,05 to P < 0,001).

Table 2. Numbers of ungulates recorded in repeated foot counts of areas 3, 4, 7a, 7b and 19 in H.G.R. in July 1978.

Species	Numbers counted			Significance	
	N1	N2	Mean	Chi ²	Probability
S.l. rhino	59	45	52	1,88)
Zebra	132	165	148,5	3,67)
Kudu	22	13	17,5	2,31)
Bushbuck	11	11	11	0)
Bushpig	10	14	12	0,66) P > 0,05 NS
Grey duiker	43	39	41	0,20)
Nyala	1076	1100	1088	0,27)
Red duiker	19	14	16,5	0,76)
Buffalo	290	166	228	33,72	P < 0,001 SS
Impala	686	916	801	33,02	P < 0,001 SS
Wildebeest	206	123	164,5	20,94	P < 0,001 SS
Warthog	357	306	331,5	3,92	P < 0,05 S
Giraffe	0	3	1,5	-)
Mtn reedbuck	4	2	3	-) Small samples
Black rhino	5	11	8	-)

SS : highly significant
 S : significant
 NS : not significant

Table 2 shows that the counts could be regarded as:

(a) repeatable for zebra, kudu, nyala, s.l. rhino, red duiker, bushpig, grey duiker and bushbuck (all P > 0,05). These species do not form very large herds, so that chance movements across counting area boundaries would have a minimal effect.

(b) not repeatable for buffalo, wildebeest and impala (all P < 0,001) and possibly warthog (P < 0,05, but P = 0,05 at only Chi² 3,84). The highly significant result for buffalo, wildebeest and impala is due to their habit of forming large herds, so that one or two chance movements across counting area boundaries can drastically alter the number present in the area.

Although these counts were not repeatable in the sampling area of 2 263 ha (approximately 8,4 % of the reserve), they would become repeatable if the area covered was increased, thereby eliminating error due to chance movements. Further study is needed to determine the minimum size of sampling areas for repeatability.

Helicopter counts

The numbers of ungulates counted from the helicopter in the 29 areas (see Fig. 1) are compared with the results obtained in 1976 in Appendix 13.

Repeatability

Six areas were counted three times (see Methods) to investigate repeatability, with each set of counts being done on alternate days between 12-16th July. The areas counted were nos. 2a Gontshi-Sikhalasomoya, 3 Hidli-Gontshi, 7a Magangeni, 7b Qholwana-Nqunqulu, 4 Magwanxa, and 5 Maphumulo. The total area counted each time was 2 568 ha, representing 9,5 % of the reserve.

Table 3. Numbers of ungulates recorded in repeated helicopter counts of areas 2a, 3, 4, 5, 7a and 7b in H.G.R.

Species	Numbers counted				Significance		
	N1	N2	N3	Mean	Chi ²	Probability,	Repeatability
S.l. rhino	26	26	23	25	0,24)	P > 0,05 NS	Repeatable
Nyala	208	202	196	202	0,36)		
Buffalo	67	83	160	103,3	46,91)	P < 0,001 SS	Not
Wildebeest	117	52	123	97,3	31,57)		
Warthog	132	135	254	173,7	55,18)		
Impala	424	372	465	420,7	10,11)	P < 0,01 S	Repeatable
Zebra	101	65	104	70	10,47)		
Kudu							
Mtn reedbuck	10	6	11	9	-)		
Waterbuck	0	2	0	0,7	-)		
Black rhino	4	7	6	5,7	-)	Small	
Bushbuck	2	1	1	1,3	-)	samples	
Bushpig	6	0	0	2	-)		
Grey duiker	2	2	0	1,3	-)		
Red duiker	2	0	0	0,7	-)		

Table 3 presents the results of the three sets of counts, N1, N2 and N3; and the statistical significance applying to the variation observed between them for each species. Species with mean count totals of less than 10 were not tested.

Only two species gave repeatable results ($P > 0,05$), namely s.l. rhino and nyala. Of the remainder, the non-repeatability for buffalo, wildebeest, zebra and impala could possibly be explained by chance daily movements out the area. This error is likely however to be less than experienced on foot counts, as the helicopter counted all the areas of one set in a single day, and the combined areas approximated home range areas for the more mobile species (buffalo, zebra, wildebeest). The high variability between the warthog counts (132, 135, 254) cannot be explained by shifts in distribution.

Numerous factors may affect the accuracy and repeatability of helicopter counts, but counting speed (Melton 1968b) and weather conditions are considered to be particularly important.

(i) Counting speed. Melton (1968b) suggested that an increase in counting time results in an increased count total, at least in impala, nyala and warthog. An attempt was therefore made to standardise the counting speed over the three sets of counts. In practice, this was not successful, as times for N1, N2 and N3 were 159 min, 132 min and 173 min respectively. Reference to Table 3 shows that impala numbers were lower in the N2 count as expected, but this was not the case for nyala and warthog. Zebra and wildebeest numbers were also depressed in N2, but weather conditions may have been involved.

(ii) Weather conditions. The overall counting conditions for counts N1, N2 and N3 were good, fair and good respectively. Open-habitat species seek shelter in adverse weather conditions, and this factor could possibly account for the low N2 counts for wildebeest and zebra, although conditions were far from extreme. Whether s.l. rhino, buffalo and warthog are less responsive to fluctuating weather conditions requires investigation.

The sampling strategy of counting a limited number of isolated or semi-isolated areas in a non-continuous manner was clearly inadequate to determine repeatability, and no firm conclusions can be drawn. However the inexplicable variation in the warthog counts suggests the operation of an as-yet unknown variable, supporting Melton's (1978b) view that this type of count is susceptible to such errors.

Relationship between helicopter and ground counts

Conversion factors

Table 4 presents the percentages of the foot count totals seen from the helicopter for each species, based on 15 foot and helicopter counts of the same areas.

Interpretation of the relationships shown in Table 4 should take into account the reliability of the foot count on which the helicopter percentage is based, and the reaction of the particular species to the helicopter itself. The only foot counts considered unreliable were those for black rhino and bushpig (see Foot Counts - Reliability). Regarding tolerance of the helicopter, it seems logical that species which tend to run from the helicopter such as wildebeest, zebra and buffalo, may be undercounted by a method which samples fairly small areas at different points in time, such as was the case here. This

implies that such undercounting might not take place during a normal helicopter count when areas are counted successively to form a very large counting unit.

Therefore the most acceptable relationships were those obtained for species reliably counted on foot and which do not show a continuous running response to the helicopter. Only for these species are conversion factors (see Definitions) given in Table 4.

Table 4. Relationship between numbers counted on 15 foot and 15 helicopter counts in H.G.R. in July 1978.

Species	Totals		Helicopter as % foot count	Conver- sion factor	Remarks
	Foot	Helicopt			
Impala	1844	847	46 %	2,2)	
Kudu	54	23	43 %	2,3)	reliable foot
Warthog	778	285	37 %	2,7)	counts
Nyala	2912	530	18 %	5,6)	
Grey duiker	96	6	6 %	16,7)	possible under-
Bushbuck	49	2	4 %	25,0)	count on
Red duiker	102	1	1 %	100,0)	foot
Black rhino	22	22	(100 %)		Poor ground count
Wildebeest	474	247	(52 %))	Intolerant of
Zebra	348	181	(52 %))	Helicopter
S.l. rhino	106	51	(48 %)	(2,1)	??
Mtn reedbuck	14	5	(36 %)		Small sample
Bushpig	24	7	(24 %)		Poor ground count
Buffalo	525	107	(20 %)		Intolerant of helicopter
Giraffe	3	0	(0 %)		Small sample

Effect of vegetation density on helicopter counts

For each species, the percentage seen from the helicopter varied between counting areas. It might be expected that a lot of the variation could be accounted for by differences in aerial visibility, with greater percentages being seen in the more open areas. This was investigated by dividing the 11 areas counted by both methods into subjective aerial visibility categories (S.A.V.C.), namely moderate, poor and very poor (Whateley, pers. comm.). Each foot count was regarded as one sample, so in areas where two foot and three helicopter counts were conducted, the mean helicopter count was used for comparison. Table 5 shows

that no clear relationship exists between aerial visibility and the percentage counted from the helicopter for these species, with the exception of s.l. rhino. This result may be explained by the fact that each species has a fairly well defined habitat preference, and it is the visibility of that species within the preferred vegetation types which is relevant, rather than the extent of the vegetation type in the area. The practical implication of this finding is that at least for the purpose of this investigation, a correction factor may be applied to the helicopter count total for a given species, without having to take into account differences in vegetation.

Table 5. Percentages of ground counts seen from the helicopter in three aerial visibility strata in H.G.R.

	SUBJECTIVE AERIAL VISIBILITY CATEGORY								
	Moderate (N = 4)			Poor (N = 9)			Very poor (N = 3)		
	Foot N	Hel. N	Hel. as % foot	Foot N	Hel. N	Hel. as % foot	Foot N	Hel. N	Hel. as % foot
S.l. rhino	32	19	59%	69	32	46%	5	0	0%
Impala	362	249	69%	1434	561	39%	48	37	77%
Kudu	7	0	0%	47	23	49%	0	0	-
Bushbuck	3	1	33%	37	1	3%	9	0	0%
Bushpig	9	0	0%	15	6	40%	0	0	-
Grey duiker	16	2	12%	74	3	4%	6	1	17%
Nyala	404	70	17%	2284	428	19%	224	32	14%
Warthog	155	43	28%	595	234	39%	28	8	29%
Red duiker	7	0	0%	40	1	2%	55	0	0%
Buffalo	261	22	8%	255	85	33%	9	0	0%
Wildebeest	58	16	28%	415	247	60%	1	0	0%
Zebra	93	38	41%	253	143	57%	2	0	0%
Reedbuck	3	0	0%	11	5	45%	0	0	-
B. rhino	0	1	Inf.	21	19	90%	1	2	200%

Cost of counts

A detailed breakdown of expenses incurred during the counts is presented in Appendix 14. These are presented as the average per count, derived from a single count of each of the 11 areas which were counted both by foot and helicopter (see Fig. 1). Mean counting area size was 401 ha, and the distribution of the areas throughout the reserve was fairly representative as far as helicopter ferry time and distance travelled by road are concerned.

The foot counts were 2,9 times more expensive than those from the helicopter, with mean costs per count of R157 and R54 respectively.

Population estimates

Population estimates, which are presented in Table 6, were obtained in three ways.

(A) Extrapolation from 1976 helicopter count. For each species for which a conversion factor was available (see Table 4), the 1976 helicopter count total was multiplied by the conversion factor. This corrected 1976 total was then extrapolated through to 1978 by applying approximate increment rates and subtracting game removals. For the purpose of obtaining these estimates it was assumed that the counts for buffalo, giraffe, s.l. rhino, wildebeest and zebra were entirely accurate.

(B) Extrapolation from 1978 foot counts. The reserve was divided into animal density strata (high, moderate, low) for each species on the basis of the 1976 helicopter count. It was justified to assume that these were true animal density strata, and not just reflections of differences in vegetation density, as it had been shown earlier (see Table 5) that there was no clear relationship between vegetation density and the percentage of animals seen from the helicopter. The assumption was made that the distribution of animals in 1976 and 1978 was the same. The areas foot counted in 1978 were then assigned to the various strata. A species density was then calculated for the areas counted on foot within each stratum, and this density applied to the whole stratum to give a population size. Combination of the results obtained in the three strata constituted the overall population estimate. The helicopter counts of bushbuck, bushpig and grey duiker were too small to allow stratification, so for these species the mean density recorded in all the foot counts was extrapolated to the whole reserve without stratifying.

(C) Local knowledge. Records of the less-well represented species are kept by research, and these were used as population estimates where required.

The final population estimates for each species, shown in Table 6, are subject to a number of constructional errors. The more important are (i) the conversion factors may vary between helicopter counts (although in this study the 'A' values shown in Table 6 may be taken as minimum population estimates, as the 1976 helicopter count was only regarded as 'fair' compared with 'good' for 1978), (ii) increment rates in H.G.R. are not accurately known for most species, and (iii) some density strata were under or over-represented in the foot samples (ideally a 25 % random sample should be used within each stratum).

The final estimates shown in Table 6 were interpreted in terms of animal units (A.U.'s), and an overall stocking rate was calculated of 1 A.U. per 3,9 hectare. Macdonald (pers. comm.) estimated the actual carrying capacity (C.C.) of the reserve by lumping vegetation communities into the following: (i) forest (5432 ha, C.C. = 1 A.U./40 ha), (ii) closed woodlands with Enteropogon or Dactyloctenium grass cover (7568 ha, 1 A.U./10 ha), (iii) open to closed woodlands and scrub-invaded

TABLE 6. Population estimates of ungulates in H.G.R. and N. Corridor for July 1978 from 3 sources.
 Key: () Unstratified; * based on bushbuck:nyala of 1:55; N.C. none counted
 [] Estimate too high; ** Hitchins unpublished.

SPECIES	(A) Extrapolation from 1976 hel. count			(B) Foot count stratification	(C) Local knowledge	Final Estimate	A.U. equivalent	No. of A.U.'s
	C.F	Inc. rate	Estimate	Estimate	Estimate			
BUFFALO	-	10%	1160	[1600]	-	1300	1,0	1300
GIRAFFE	-	?	48	Small sample	-	50	0,6	83
S.L. RHINO	-	9.5%	220	250	-	235	0,4	588
WILDEBEEST	-	5%	920	1250	-	1100	2,0	550
ZEBRA	-	5%	550	[950]	-	600	1,8	333
HIPPO	-	?	N.C.	N.C.	1-3	2	0,6	3
IMPALA	2,2	15%	4800	7850	-	6350	6,1	1041
KUDU	2,3	10%	360	210	-	290	2,5	116
CM. REEDBUCK	-	?	Small sample	N.C.	20	20	4,9	4
MT. REEDBUCK	-	?	"	Small sample	50	50	8,1	6
WATERBUCK	-	?	"	N.C.	30	30	2,0	15
BLACK RHINO	-	?	C.F. ?	Inaccurate count	200 **	200	0,7	286
BUSHBUCK	25	0%	150	(220) *	-	190	6,4	30
BUSHPIG	-	?	N.C.	(70)	-	70	4,9	14
GREY DUIKER	16,7	0%	Small sample	(500)	-	500	20,8	24
NYALA	5,6	15%	6000	11950	-	9000	4,0	2250
STEENBOK	-	?	Small sample	Small sample	10	10	17,6	1
WARTHOG	2,7	15%	2100	2100	-	2100	7,7	273
RED DUIKER	100	0%	346	346	-	270	17,6	15
KLIPSPRINGER	-	?	N.C.	N.C.	0	0	-	-
TOTAL								6932 A.U.

grasslands with good quality grazing (12 556 ha, 1 A.U./6 ha) and (iv) open grassland, montane and vlei (1080 ha, 1 A.U./3 ha). The overall carrying capacity was estimated as 1 A.U. per 7,96 ha.

ACKNOWLEDGEMENTS

This investigation was a co-operative effort of research and management personnel. S/R Henwood organised the many game guards and labourers used in ground counts; Warden Meiklejohn, Technician Whateley and Lt Birkenstock assisted with the counts, as did T/A's Fakude, Khomo and A. Khanyile. Technician Whateley and Warden Meiklejohn were responsible for the helicopter counts. Much of the data processing was undertaken by Lt Birkenstock, while Mrs E.K. Brooks and Mrs F. Whateley shared the typing.

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APPENDIX 1. COUNT DATA FROM AREA 2a, GONTSHI-SIKHALOSOMOYA (369ha, S.A.V.C.=poor)

SPECIES	Foot (5 July)				Helicopter(12,14,16 July)					
	N	Main Line	Sec Lines	% by Sec. lines	ha	N1	N2	N3	N	% of foot
BUFFALO	65	44	21	32%	0,18	16	27	36	26	40%
HIRAFFE	0				→	0	0	0	0	-
S.L. RHINO	1	1	0	0%	0,01	1	0	0	0,3	30%
WILDEBEEST	100	100	0	0%	0,27	36	6	56	33	33%
ZEBRA	60*	34	26	40%	0,16	29	16	24	23	38%
IMPALA	19	16	3	16%	0,05	2	12	11	8	42%
UDU	0				-	2	0	7	3	INF.
REEDBUCK(C&M)	2m	2m	0	0%	0,01	0	0	0	0	0%
ATERBUCK	0				-	0	0	0	0	-
LACK RHINO	4	2	2	50%	0,01	1	0	0	0,3	7%
BUSHBUCK	14	14	0	0%	0,04	1	0	1	0,6	4%
BUSHPIG	0				-	0	0	0	0	-
REY DUIKER	10	9	1	10%	0,03	0	0	0	0	0%
NYALA	161	157	4	2%	0,44	18	31	38	29	18%
TEENBOK	0				-	0	0	0	0	-
ARTHOG	53	52	1	2%	0,14	25	8	4	12	23%
RED DUIKER	12	12	0	0%	0,03	1	0	0	0,3	3%

* Total 60 Zebra excludes a further 28 actually counted on the walk, moved in from Area 3.

APPENDIX 2. COUNT DATA FOR AREA 3, HIDLI-GONTSHI (446ha, S.A.V.C.=poor)

SPECIES	Foot (5 July)				Foot (18 July)				Foot (Mean)			Helicopter(12,14,16 July).				
	N	Main Line	Sec. Lines	% by Sec. Lines	N	Main Line	Sec. Lines	% by Sec. Lines	\bar{N}	% by Sec. Lines	P/ha	N1	N2	N3	\bar{N}	% of foot
BUFFALO	38	12	26	68%	19	0	19	100%	28,5	79%	0,06	0	0	5	1,7	6%
GIRAFFE	0			→	0				0	-		0	0	0	0	-
S. L. RHINO	10	10	0	0%	3	8	0	0%	9	0%	0,02	1	6	9	5,3	59%
WILDEBEEST	40	38	2	5%	18	28	20	42%	44	25%	0,10	34	3	16	17,7	40%
ZEBRA	39	5	34	87%	41	6	35	85%	40	86%	0,9	14	16	17	15,7	39%
IMPAIA	167	109	58	35%	331	167	164	50%	249	45%	0,56	97	98	147	114	46%
KUDU	1	1	0	0%	0			-	0,5	0%		0	6	0	2	400%
REEDBUCK	0			-	0				0	-		0	0	0	0	-
WATERBUCK	0			-	0				0	-		0	0	0	0	-
BLACK RHINO	2	2	0	0%	4	2	2	50%	3	33%		0	0	0	0	0%
BUSHBUCK	1	1	0	0%	2	2	0	0%	1,5	0%		0	0	0	0	0%
BUSHPIG	0			-	4	4	0	0%	2	0%		0	0	0	0	0%
GREY DUIKER	2	1	1	50%	2	2	0	0%	2	25%		0	1	0	0,3	15%
NYALA	290	225	65	22%	335	156	179	53%	312,5	39%	0,70	50	37	38	41,7	13%
STEENBOK	0				0				0	-		0	0	0		-
WARTHOG	107	100	7	7%	82	79	3	4%	94,5	5%	0,21	33	33	94	53,3	56%
RED DUIKER	9	9	0	0%	5	5	0	0%	7	0%	0,02	0	0	0	0	0%

APPENDIX 3. COUNT DATA FOR AREA 4, MAQWANXA (574ha, S.A.V.C.= moderate)

SPECIES	Foot(7 July)				Foot (18 July)				Foot (Mean)			Helicopter(12,14,16 July).				
	N ₁	Main Line	Sec. Lines	% by Sec. Lines	N ₂	Main Line	Sec. Lines	% by Sec. Lines	\bar{N}	% by Sec. Lines	ρ /ha	N ₁	N ₂	N ₃	\bar{N}	% of foot
BUFFALO	134	103	31	23%	66	39	27	41%	100	29%	0,17	9	0	54	21	21%
GIRAFFE	0	-	-	-	0	-	-	-	0	-	-	0	0	0	0	-
S. L. RHINO	14	14	0	0%	12	11	1	8%	13	32.8%	0,02	12	6	11	9,7	75%
WILDEBEEST	16	15	1	6%	13	2	11	85%	14,5	41.4%	0,03	8	4	10	7,3	50%
ZEBRA	37	4	33	89%	42	16	26	62%	39,5	74.7%	0,07	25	11	28	21,3	54%
IMPALA	144	126	18	12%	170	94	76	45%	157	29.9%	0,27	62	64	58	61,3	39%
KUDU	3	2	1	33%	4	1	3	75%	3,5	57.1%	-	0	0	0	0	-
REEDBUCK(C&M)	3m	3m	0	0%	0	-	-	-	1,5	0%	-	0	0	0	0	-
WATERBUCK	0	-	-	-	0	-	-	-	-	-	-	0	0	0	0	-
BLACK RHINO	0	-	-	-	0	-	-	-	-	-	-	0	0	0	0	-
BUSHBUCK	2	2	0	0%	1	1	0	0%	1,5	0%	-	1	0	0	0,3	20%
BUSHPIG	4	4	0	0%	5	5	0	0%	4,5	0%	-	0	0	0	0	0%
GREY DUIKER	4	4	0	0%	3	2	1	33%	3,5	14.3%	-	0	0	0	0	0%
NYALA	167	154	13	8%	187	146	41	22%	177	15.3%	0,31	31	19	27	25,7	15%
STEENBOK	0	-	-	-	0	-	-	-	-	-	-	0	0	0	0	-
WARTHOG	42	31	11	26%	59	39	20	34%	50,5	30.7%	0,09	14	5	29	16	32%
RED DUIKER	4	4	0	0%	1	1	0	0%	2,5	0%	2,5	0	0	0	0	0%

APPENDIX 4. COUNT DATA FOR AREA 6a, MANZIBOMVU CONFLUENCE (59ha, S.A.V.C.=very poor)

SPECIES	Foot (4 July)				Helicopter (13 July)		
	N	Main Line	Sec. Lines	% by Sec. lines	/ha	N	% of foot count
BUFFALO	0				-	0	-
GIRAFFE	0				-	0	-
S. L. RHINO	0				-	0	-
WILDEBEEST	0				-	0	-
ZEBRA	0				-	0	-
IMPALA	19	N/A	N/A	0,32	0,32	22	116%
KUDU	0				-	0	-
REEDBUCK(C&M)	0				-	0	-
WATERBUCK	0				-	0	-
BLACK RHINO	0				-	0	-
BUSHBUCK	1	N/A	N/A	0,02	0,02	0	0%
BUSHPIG	0				-	0	-
GREY DUIKER	0				-	0	-
NYALA	31	N/A	N/A	0,53	0,53	9	29%
STEENBOK	0				-	0	-
WARTHOG	4	N/A	N/A	0,07	0,07	3	75%
RED DUIKER	0				-	0	-

APPENDIX 5. COUNT DATA FOR AREA 7a, MAGANGENI (148ha, S.A.V.C. = moderate)

SPECIES	Foot (7 July)			Foot (19 July)			Foot (Mean)			Helicopter(12,14,16,July)		
	N	Main Line	Sec. Lines	N	Main Line	Sec. Lines	N	Main Line	Sec. Lines	N	Main Line	Sec. Lines
BUFFALO	25	11	14	36	0	36	30,5	82%	0,21	7	6	0
GIRAFFE	0	-	-	-	-	0	0	-	-	0	0	0
S. L. RHINO	5	3	2	0	1	1	3	33.3%	0,02	1	0	0,3
WILDBEEST	28	13	15	0	1	14.5	51.7%	0,10	2	2	3	2,3
ZEBRA	14	0	14	0	-	7	100%	0,05	2	0	6	2,7
IMPALA	39	0	39	6	3	24	93.8%	0,16	84	39	20	47,7
KUDU	0	-	-	-	-	0	-	-	0	0	0	0
REEDBUCK(C&M)	0	-	-	-	-	0	-	-	0	0	0	0
WATERBUCK	0	-	-	-	-	0	-	-	0	0	0	0
BLACK RHINO	0	-	-	-	-	0	-	-	0	1	0	0,3
BUSHBUCK	0	-	-	-	-	0	-	-	0	0	0	0
BUSHPIG	0	-	-	-	-	0	-	-	0	0	0	0
GREY DUiker	4	3	1	2	3	4,5	33.3%	0,03	2	0	0	0,7
NYALA	24	6	18	25	8	25	52%	0,17	14	6	2	7,3
SLEENBOK	0	-	-	0	-	0	-	-	0	0	0	0
WARFHOG	31	15	16	27	13	27	53.7%	0,18	9	15	9	11
RED DUiker	2	1	1	1	-	1	50%	-	0	0	0	0

APPENDIX 6, COUNT DATA FOR AREA 7b, QHOIWANA-NQUNQULU (537ha, S.A.V.C.= poor)

SPECIES	Foot (6 July)				Foot (17 July)				Foot (Mean)			Helicopter(12,14,16 July)				
	N	Main Line	Sec. Lines	% by Sec. Lines	N	Main Line	Sec. Lines	%by Sec. Lines	N	% by Sec. Lines	ρ /ha	N ₁	N ₂	N ₃	\bar{N}	% of foot
BUFFALO	66	0	66	100%	33	2	31	94%	49,5	98%	0,09	25	39	56	40	81%
GIRAFFE	0	-	-	-	0	-	-	-	0	-	-	0	0	0	0	-
S. L. RHINO	14	9	5	36%	14	9	5	36%	14	36%	0,03	11	6	3	6,7	48%
WILDEBEEST	52	22	30	58%	36	11	25	71%	44	62.5%	0,08	17	12	22	17	39%
ZEBRA	29	4	25	86%	41	0	41	100%	35	94.3%	0,07	31	17	26	24,7	71%
IMPALA	198	152	46	23%	284	89	195	69%	241	50%	0,45	126	109	198	144,3	60%
KUDU	11	0	11	100%	3	0	3	100%	7	100%	0,01	5	0	4	3	43%
REEDBUCK(C&M)	0	-	-	-	0	-	-	-	0	-	-	0	0	0	0	-
WATERBUCK	0	-	-	-	0	-	-	-	0	-	-	0	0	0	0	-
BLACK RHINO	3	1	2	67%	6	5	1	17%	4,5	66.7%	-	3	6	6	5	111%
BUSHBUCK	7	6	1	17%	8	8	0	0%	7,5	6.7%	0,01	0	0	0	0	0%
BUSHPIG	6	6	0	0%	5	2	3	60%	5,5	27.3%	0,01	6	0	0	2	36%
GREY DUIKER	11	10	1	9%	3	2	1	33%	7	14.3%	0,01	0	1	0	0,3	4%
NYALA	429	215	214	50%	378	161	216	57%	403,5	53.3%	0,75	68	85	63	72	18%
STEENBOK	0	-	-	-	0	-	-	-	0	-	-	0	0	0	0	-
WARTHOG	155	101	54	35%	133	113	20	15%	144	25.7%	0,27	44	58	107	69,7	48%
RED DUIKER	4	4	0	0%	8	6	2	25%	6	16.7%	0,01	0	0	0	0	0%

APPENDIX 7, COUNT DATA FOR AREA 10a, MAWANE FOREST (104ha, S.A.V.C.= very poor)

SPECIES	Foot (19 July)					Helicopter (15 July)	
	N	Main Line	Sec. Lines	% by Sec Lines	/ha	N	% of foot count
BUFFALO	0	-	-	-	-	0	-
GIRAFFE	0	-	-	-	-	0	-
S. L. RHINO	0	-	-	-	-	0	-
WILDEBEEEST	0	-	-	-	-	0	-
ZEBRA	0	-	-	-	-	0	-
IMPALA	0	-	-	-	-	0	-
KUDU	0	-	-	-	-	0	-
REEDBUCK(C&M)	0	-	-	-	-	0	-
WATERBUCK	0	-	-	-	-	0	-
BLACK RHINO	0	-	-	-	-	0	-
BUSHBUCK	7	5	2	29%	0,07	0	0%
BUSHPIG	0	-	-	-	-	0	-
GREY DUIKER	1	1	0	0%	-	0	0%
NYALA	75	20	55	73%	0,72	0	0%
STEENBOK	0	-	-	-	-	0	-
WARTHOG	1	1	0	0%	-	0	0%
RED DUIKER	54	41	13	24%	0,52	0	0%

APPENDIX 8, COUNT DATA FOR AREA 11a, SISUZE (195ha, S.A.V.C.= very poor)

SPECIES	Foot (4 July)					Helicopter (12 July)	
	N	Main Line	Sec. Lines	% by Sec. Lines	/2/ha	N	% of foot count
BUFFALO	9	9	N/A	N/A	0,05	0	0%
GIRAFFE	0	-	-	-	-	0	-
S. L. RHINO	5	5	N/A	N/A	0,03	0	0%
WILDEBEEEST	1	1	N/A	N/A	0,01	0	0%
ZEBRA	2	2	N/A	N/A	0,01	0	0%
IMPALA	29	29	N/A	N/A	0,15	15	52%
KUDU	0	-	-	-	-	0	-
REEDBUCK(C&M)	0	-	-	-	-	0	-
WATERBUCK	0	-	-	-	-	0	-
BLACK RHINO	1	1	N/A	N/A	0,01	2	200%
BUSHBUCK	1	1	N/A	N/A	0,01	0	0%
BUSHPIG	0	-	-	-	-	0	-
GREY DUIKER	5	5	N/A	N/A	0,03	1	20%
NYALA	118	118	N/A	N/A	0,61	23	19%
STEENBOX	0	-	-	-	-	0	-
WARTHOG	23	23	N/A	N/A	0,12	5	22%
RED DUIKER	1	1	N/A	N/A	0,01	0	0%

APPENDIX 9, COUNT DATA FOR AREA 14, MTHOLE (988ha, S.A.V.C.=poor)

SPECIES	Foot (21 July)					Helicopter(13 July)	
	N	Main Line	Sec. Lines	% by Sec. Lines	P/ha	N	% of foot
BUFFALO	3	2	1	33%	-	0	0%
GIRAFFE	0	-	-	-	-	0	-
S. L. RHINO	4	4	0	0%	-	0	0%
WILDEBEEST	41	34	7	17%	0,04	63	154%
ZEBRA	7	7	0	0%	0,01	2	29%
IMPALA	187	172	15	8%	0,19	56	30%
KUDU	17	17	0	0%	0,02	2	9%
REEDBUCK(C&M)	8 _m	8 _m	0	0%	0,01	5 _m	63%
WATERBUCK	0	-	-	-	-	0	-
BLACK RHINO	2	2	0	0%	-	7	350%
BUSHBUCK	3	3	0	0%	-	0	0%
BUSHPIG	0	-	-	-	-	0	-
GREY DUIKER	13	13	0	0%	0,01	0	0%
NYALA	372	345	27	7%	0,38	103	28%
STEENBOK	1	1	0	0%	-	0	0%
WARTHOG	31	31	0	0%	0,03	25	81%
RED DUIKER	1	1	0	0%	-	0	0%

APPENDIX 10, COUNT DATA FOR AREA 19, NTABAMPHLOPE-GUNJANENI (558ha, S.A.V.C.=poor)

SPECIES	Foot (20 July)				Foot (24 July)				Foot (Mean)			Helicopter(15 J	
	N	Main Line	Sec. Lines	% by Sec. Lines	N	Main Line	Sec. Lines	% by Sec. Lines	N	% by Sec. Lines	ρ /ha	N	% of foot
BUFFALO	27	11	16	59%	12	0	12	100%	19,5	71.8%	0,03	5	26%
GIRAFFE	0	-	-	-	3	0	3	100%	1,5	100%	-	0	0%
S. L. RHINO	16	14	2	13%	10	5	5	50%	13	26.9%	0,02	4	31%
WILDEBEEEST	70	62	8	11%	45	4	41	91%	57,5	42.6%	0,10	55	96%
ZEBRA	13	0	13	100%	41	0	41	100%	27	100%	0,05	28	104%
IMPALA	138	109	29	21%	122	80	42	34%	130	27,3%	0,23	23	17%
KUDU	7	2	5	71%	6	0	6	100%	6,5	84.6%	0,01	8	123%
REEDBUCK(C&M)	1 _m	1 _m	0	0%	2 _m	2 _m	0	0%	1,5 _m	0%	-	0	0%
WATERBUCK	0	-	-	-	0	-	-	-	0	-	-	0	-
BLACK RHINO	0	-	-	-	1	1	0	0%	0,5	0%	-	1	200%
BUSHBUCK	1	1	0	0%	0	-	-	-	0,5	0%	-	0	0%
BUSHPIG	0	-	-	-	0	-	-	-	0	-	-	0	-
GREY DUIKER	22	22	0	0%	26	22	4	15%	24	8.3%	0,04	0	0%
NYALA	166	102	64	38%	174	103	71	41%	170	39.7%	0,30	40	24%
STEENBOK	0	-	-	-	0	-	-	-	0	-	-	0	-
WARTHOG	22	22	0	0%	9	7	2	22%	15,5	6.5%	0,03	9	58%
RED DUIKER	0	-	-	-	0	-	-	-	0	-	-	0	-

APPENDIX 11, COUNT DATA FOR AREA 22, NZIMANE (255ha, S.A.V.C.=moderate)

SPECIES	Foot Count (25 July)				
	N	Main Line	Sec. Lines	% by Sec. Lines	/ha
BUFFALO	3	3	0	0%	0,01
GIRAFFE	0	-	-	-	-
S. L. RHINO	0	-	-	-	-
WILDEBEEEST	1	1	0	0%	-
ZEBRA	0	-	-	-	-
IMPALA	205	205	0	0%	0,80
KUDU	0	-	-	-	-
REEDBUCK(C&M)	0	-	-	-	-
WATERBUCK	1	1	0	0%	-
BLACK RHINO	4	2	2	50%	0,02
BUSHBUCK	0	-	-	-	-
BUSHPIG	0	-	-	-	-
GREY DUIKER	2	2	0	0%	0,01
NYALA	105	102	3	3%	0,41
STEENBOK	0	-	-	-	-
WARTHOG	9	9	0	0%	0,04
RED DUIKER	0	-	-	-	-

"NOT COUNTED BY HELICOPTER"

APPENDIX 12, COUNT DATA FOR AREA 33, SITHOLE (430ha, S.A.V.C.=poor)

SPECIES	Foot (20 July)				P/ha	Helicopter(13 July)	
	N	Main Line	Sec. Lines	% by Sec. Lines		N	% of foot count
BUFFALO	4	0	4	100%	0,01	0	0%
GIRAFFE	0	-	-	-	-	0	-
S. L. RHINO	2	2	0	0%	5	3	150%
WILDEBEEST	28	0	28	100%	0,07	11	39%
ZEBRA	23	4	19	83%	0,05	6	26%
IMPALA	110	52	58	53%	0,26	50	45%
KUDU	8	0	8	100%	0,02	0	0%
REEDBUCK(C&M)	0	-	-	-	-	0	-
WATERBUCK	0	-	-	-	-	0	-
BLACK RHINO	0	-	-	-	-	1	INF.
BUSHBUCK	1	0	1	100%	-	0	0%
BUSHPIG	0	-	-	-	-	0	-
GREY DUIKER	11	10	1	9%	0,03	1	9%
NYALA	153	121	32	21%	0,36	27	18%
STEENBOK	0	-	-	-	-	0	-
WARTHOG	12	10	2	17%	0,03	7	58%
RED DUIKER	1	1	0	0%	-	0	0%

APPENDIX 13, Numbers of ungulates counted by helicopter in each counting area over the period 12-16 October 1978.

HEL. BLOCK	BUFFALO	GIRAFFE	S. L. RHINO	W. BEEST	ZEBRA	IMPALA	KUDU	M. REEDBCK	BL. RHINO	BUSHBUCK	G. DUIKER	NYALA	STEENBOK	WARTHOG	R. DUIKER
2a	26,3	0	0,3	32,7	23	8,3	3	0	0,3	0,7	0	29	0	12,3	0,3
b	28	0	0	0	12	1	5	0	0	1	0	51	0	5	1
3	1,7	0	5,3	17,7	15,7	114	2	0	0	0	0,3	41,7	0	53,3	0
4	21	0	9,7	22	21,3	61,3	0	0	0	0,3	0	25,7	0	16	0
5	10	0	0,3	20,3	2,7	44,7	1	0,3	0	0,3	0	26,3	0	11,3	0,3
6a	0	0	0	0	0	22	0	0	0	0	0	9	0	3	0
b	0	0	1	3	0	36	0	0	0	0	1	68	0	9	0
7a	4,3	0	0,3	2,3	2,7	47,7	0	0	0,3	0	0,7	7,3	0	11	0
b	40	0	6,7	17	24,7	44,3	3	0	5	0	0,3	72	0	69,7	0
9	61	0	0	23	3	40	2	0	0	0	0	36	0	19	0
11a	0	0	0	0	0	15	0	0	2	0	1	23	0	5	0
b	99	0	0	25	3	68	1	0	2	0	0	94	0	21	0
12	20	0	0	1	0	150	3	0	4	1	0	135	0	5	1
14a	0	0	0	15	2	45	1	5	5	0	0	73	0	8	0
b	0	0	0	48	0	11	1	0	2	0	0	30	0	17	0
15	3	0	5	22	6	60	2	0	0	0	0	57	0	6	0
16	0	0	0	0	0	21	0	0	0	0	0	10	0	0	0
17	0	0	2	1	0	26	0	0	0	0	0	21	0	2	0
18	15	0	6	2	0	21	0	0	0	0	0	22	0	4	0
19	5	0	4	55	28	23	8	0	1	0	0	40	0	9	0
24	43	0	0	1	8	237	0	0	0	0	0	56	0	10	0
25	12	0	1	1	17	72	0	0	1	1	0	49	0	7	0
26	2	0	5	2	4	39	0	0	4	0	0	29	0	3	0
27a	4	3	0	19	2	20	5	0	2	0	0	43	0	3	0
b	0	4	2	0	0	0	1	0	0	0	0	18	0	0	0
33	0	0	3	11	6	50	0	0	1	0	1	27	0	7	0
1978 TOTALS	394	7	52	341	181	1377	38	5	26	4	4	1093	0	317	3
(1975 TOTALS)	(390)	(1)	(72)	(457)	(312)	(1070)	(66)	(3)	(42)	(4)	(1)	(636)	(0)	(531)	(2)
REMAINDER '78															
10a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13a	1	0	0	0	0	7	0	0	0	0	0	15	0	0	1
20a	5	0	0	0	5	0	0	0	0	1	0	21	0	0	0

≠ NOT COMPARABLE WITH 1976 COUNT

APPENDIX 14, Breakdown of costs involved in foot and helicopter counts

The following breakdown is based on expenses incurred in conducting single counts in each of the 11 areas counted both on foot and helicopter.

FOOT COUNTS

Mean daily costs were as follows :

Salaries and Wages :		R	c
Officers (1 P/O or S/PO, 3 S/R or R)	4 at R14.50	58.00	
Game guards and T/A's	20 at R 3.28	66.00	
Labourers	26 at R 2.52	66.00	
Togt	15 at R 1.00	15.00	
Driver	1 at R 5.21	5.00	
Vehicles			
Seven ton truck	100 Km at 40c/Km.	40.00	
L.D.V.(x2)	total 80 Km at 20c/Km.	<u>16.00</u>	
			266.00

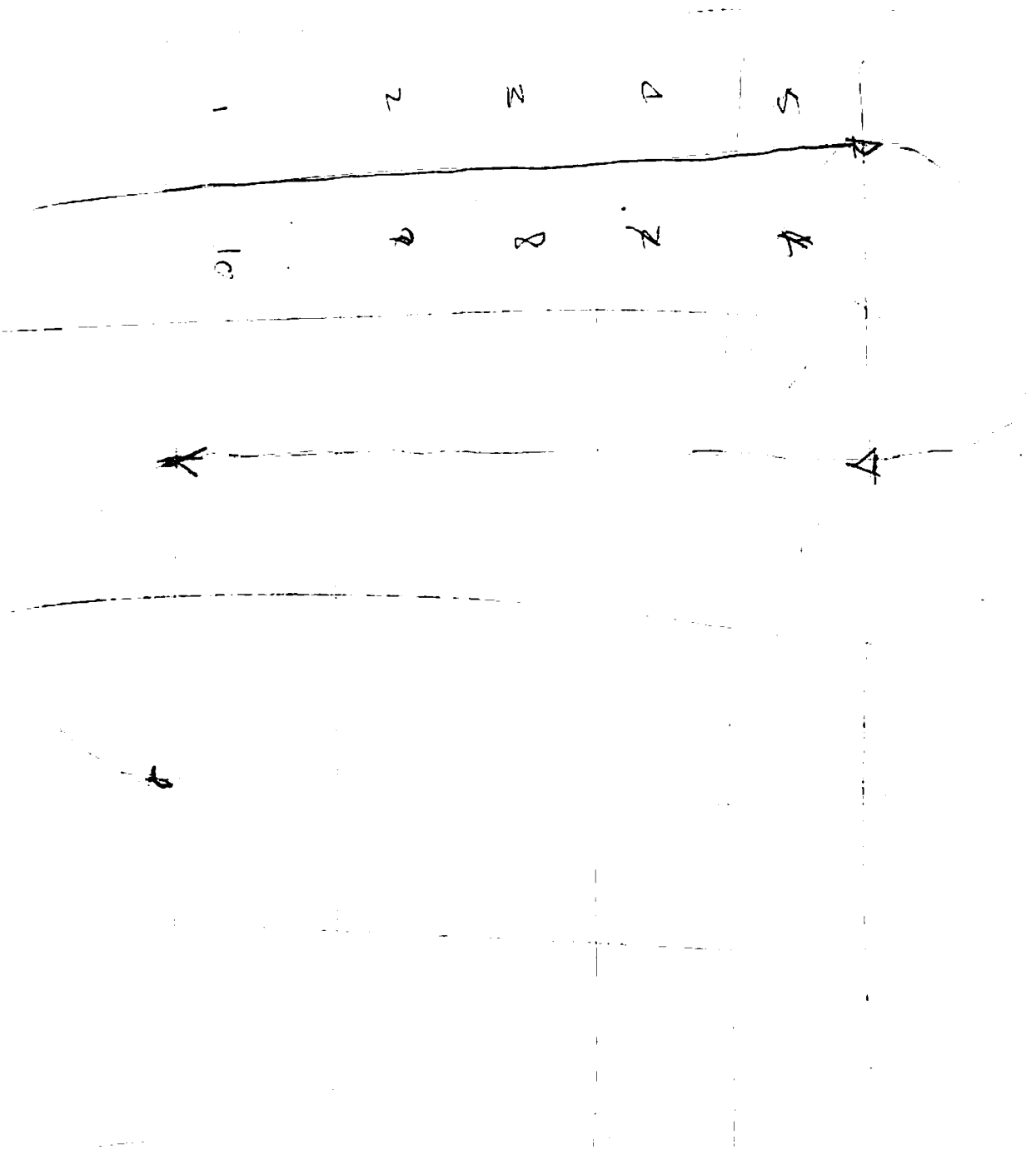
Eleven counts were completed in $6\frac{1}{2}$ days, giving a mean cost per foot count of R157

HELICOPTER COUNTS

Helicopter time :

Counting	276 min.)	} at R100/h [*]	545.00
Ferry	51 min.)		
Salaries:			
Two observers	total $1\frac{1}{2}$ days at R30/day	45.00	
Vehicles:			
L.D.V. carrying fuel	30Km. at 20c/Km.	<u>6.00</u>	
(* includes helicopter fuel)			Total 596.00

Eleven counts costing R596.00 gives a mean cost per helicopter count of R54



100
30
50