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1982 PROFESSIONAL OFFICERS' MEETING

AT OKAUKUEJO

PROGRESS REPORT OF THE BIOLOGIST (ETOSHA)

REPORT No. 1

TOTAL AERIAL CENSUS OF ETOSHA NATIONAL PARK

N 18/1/2/1

FIRST TOTAL CENSUS OF ETOSHA USING A HELICOPTER AND FIXED-WING AIRCRAFT

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This report is dedicated to the memory

of our colleagues who died on

the 1st of June 1982, during the census

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1 INTRODUCTION

Animal counts, using aircraft, commenced at Etosha National Park in 1968 (Ebedes et al; 1970). These early censusses were incomplete, due largely to time constraints. In 1973 a helicopter was used for the first time to count animals at Etosha (Joubert et al; 1973). Although it was limited to areas where animals concentrated, it proved the superiority of a helicopter above a fixed-wing aircraft in regard to visibility, speed and manoevreability. These factors are critical on the open plains of Etosha, where animals occur in large aggregations and tend to concentrate around perennial waterholes. Further counts by helicopter were undertaken between 1974 - 78 (Berry, 1980).

In 1982 it was decided to attempt the first total census of Etosha, using aircraft. The main reason for this was the fact that between 1979 and 1982 Etosha had been subjected to the worst drought on record (c. 80 years) and it was essential to establish baseline data of animal numbers and distribution. These data are required to manage Etosha, since its boundaries are no longer natural and several other man-made factors such as artificial water-points and abnormal disease levels have a major influence on animal populations.

2 METHODS

2.1 The object of a total count is to locate and record every single animal in a census zone (Norton - Griffiths, 1978). Consequently, a total count attempts to take a 100% sample and there is therefore no sample error in the final estimate of numbers. However, sources of bias do exist in total counts, namely, failing to search the whole area, failing to see all the animals, and failing to count all the animals which are sighted, accurately. It is thus our assumption that the total count we undertook is an underestimation of the actual animal numbers present at Etosha. This becomes apparent when we consider that animals occurring in herds may be undercounted by as much as 30% (Norton - Griffiths, 1978) and that some species such as springbok and kudu may be undercounted by 50% and more.

2.2 We also differentiated between "accuracy" and "precision" of counting as follows. Accuracy is used to indicate that we could estimate the actual population of a species very closely. For example, if 100 individuals actually occurred and we consistently counted 90 or more, the count was considered to be accurate. The only species which we consider to have been accurately counted were zebras, gemsbok, hartebeest, eland, wildebeest, elephant and ostrich. By precision, we mean that an animal species is consistently undercounted even although it is by a big margin. For example, if 100 individuals actually occurred and we consistently counted in the region of 50, the count was considered to be precise. In our opinion species which were precisely counted were giraffe, springbok and rhino. Species which could not be counted accurately or precisely are probably kudu, impala, steenbok, duiker, warthog and the carnivores.

2.3 We divided Etosha into a total of 60 blocks (Fig. 1). A fixed-wing aircraft, seating six persons, was assigned to census 30 blocks in which animals occurred in relatively small numbers. A helicopter, seating three persons, was assigned to count 30 blocks where animals occurred in relatively large numbers.

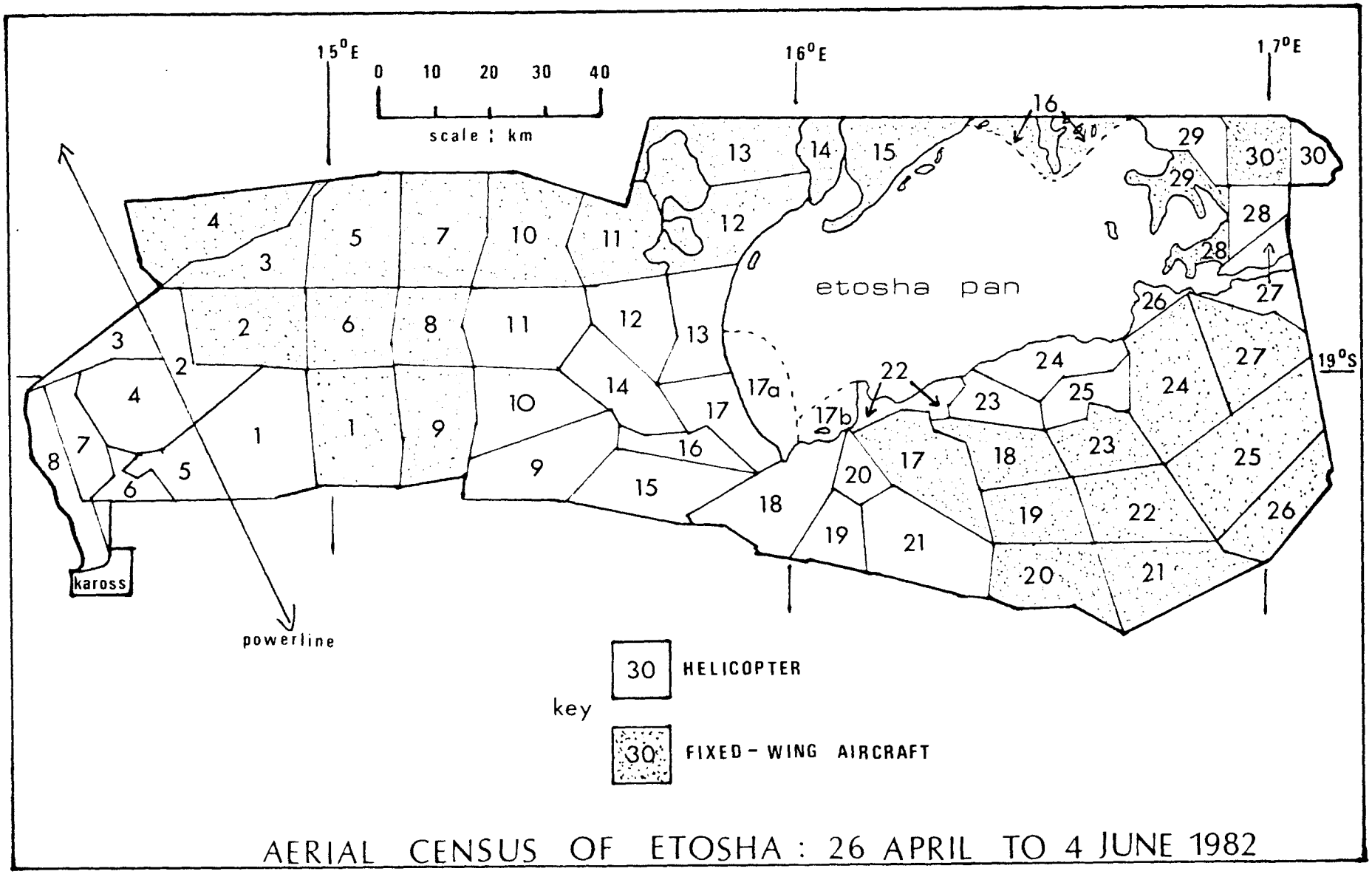

FIG. 1 : Division of Etosha into 60 blocks for the purpose of an aerial census of the total area

2.4 In the fixed-wing aircraft, the pilot and navigator plotted the course and assisted in locating animals. Animal numbers were recorded by four persons, sitting two abreast so that two scanned the area to the left and two scanned the area to the right of the aircraft. All animals seen were recorded on count sheets mounted on clipboards. The aircraft maintained a height of about 100m at a speed of about 200km/h. It flew parallel transects in each block spaced approximately 1km apart. This meant that the left hand side and the right hand side observers each scanned a strip about 500m wide.

2.5 In the helicopter the pilot and two observers sat abreast. The pilot navigated and assisted in locating animals. One observer was responsible for scanning the area to the left of the helicopter and the second observer concentrated on the right hand side area. All animals counted were recorded on tapes which were transcribed onto count sheets after each day's censussing. The helicopter flew at a height of about 60m above the open plains and increased this to about 90m over bush and woodland. Flying speed was approximately 80km/h. Parallel transects of about 1 km in width were flown in all blocks except block numbers 6, 7 and 8 (Fig. 1) where the transects were narrower.

2.6 In both aircraft the following data were recorded during each flight:
total flying time
time spent counting in each block
direction of transects
direction of movement
temperature
windspeed and direction
cloudcover
visibility
vegetation type

2.7 Censussing was done between 08h00 and 13h00, except in blocks 7 and 8 where the helicopter also flew during the afternoon and in blocks 28 and 29 where the fixed-wing flew during the afternoon. Censussing was restricted from Mondays to Fridays.

2.8 In addition, the fixed-wing aircraft undertook separate surveys of the Etosha Pan to locate animals which may have moved onto the pan.

2.9 During the census the fixed-wing aircraft was used to count the number of fence breakages occurring along the boundary.

2.10 In three blocks (open plains and pan, Mopane shrub and woodland, Acacia/Terminalia sandveld) the fixed-wing and helicopter carried out simultaneous counts to determine whether differences existed between type of aircraft used.

3 RESULTS

3.1 The totals for each species counted are given in Table 1 and a comparison is made with a previous census.

3.2 Mean group size, range in group size and its standard deviation are shown for the major species in Table 2.

3.3 A comparison between the fixed-wing and helicopter counts is made in Table 3.

3.4 Predominant vegetation types occurring in each census block are shown in Fig. 2.

3.5 The recorded number of seasonal pans, pools and gravelpits containing rain water in the census blocks are shown in Fig. 3.

3.6 Distribution maps for 12 major species are given in Figs. 4 to 15.

3.7 The number and distribution of elephant carcases found are presented in Fig. 16.

3.8 Fence breaks recorded are shown in Fig. 17.

TABLE 1: Number of animals and birds counted during the total census of April - June 1982 (198 hours flown) and the partial census of July 1974 (50 hours flown).

SPECIES	DATE	
	July 1974	April - June 1982
Burchell's zebra	14 417	7970
Hartmann's zebra	410	2665
Springbok	7 008	1 6011
Gemsbok	2 031	5081
Wildebeest	3 300	2195
Giraffe	835	1184
Kudu	913	1041
Eland	84	692
Red Hartebeest	232	396
Steenbok	25	240
Black-faced Impala	91	93
Roan Antelope	0	19
Grimm's Duiker	3	11
Damara Dik-Dik	8	0
Klipspringer	5	0
Warthog	58	328
Black Rhino	22	121
Elephant	825	2202
Elephant carcases	-	54

Table 1: continued

SPECIES	DATE	
	July 1974	April - June 1982
Lion	80	38
Leopard	2	2
Cheetah	0	2
Black-backed Jackal	69	99
Spotted Hyaena	18	6
Brown Hyaena	0	4
Bat-eared Fox	10	56
Aardwolf	0	9
Honey Badger	2	4
Porcupine	2	2
Baboon	15	20
Ostrich	676	1 835
Marabou Stork	-	130
Vultures	48	348
Eagles	43	68
Secretary Bird	19	37
Kori Bustard	128	45
Ludwig's Bustard	-	2
Crowned Crane	-	2
Blue Crane	88	49
Guineafowl	2 120	60
Pelicans	1 712	81
Flamingos	187 000	5 (flocks)
Temporary rainwater pans	66	1 010

TABLE 2: Mean group size, range and standard deviation of the major species counted at Etosha (April to June 1982).

Species	No. of observations (n)	Mean group size	Range	± SD
Burchell's zebra	511	18	1-643	47
Hartmann's zebra	365	7	1- 80	8
Springbok	916	17	1-740	45
Gemsbok	1 232	4	1- 96	7
Wildebeest	276	8	1-200	21
Giraffe	392	3	1- 21	3
Kudu	360	3	1- 15	2
Eland	51	14	1-160	29
Hartebeest	100	4	1- 20	4
Impala	6	14	3- 28	11
Warthog	164	2	1- 5	1
Rhino	78	1,6	1- 3	0,6
Elephant	245	9	1- 91	12
Lion	8	5	1- 9	3
Ostrich	417	4	1- 36	4

TABLE 3: Comparison between the helicopter and fixed-wing aircraft when counting census blocks simultaneously.

Block	Predominant vegetation type	Species	Helicopter	Fixed-wing aircraft	Fixed-wing as percentage of helicopter
22	Open pan, grassland, mopane forest	Burchell's zebra	1 775	677	38
		Springbok	1 918	550	29
		Gemsbok	40	8	20
		Wildebeest	154	70	45
		Total units	3 887	1305	34
23	Mopane scrub and woodland	Burchell's zebra	15	11	73
		Gemsbok	3	9	300
		Giraffe	2	2	100
		Kudu	29	4	14
		Hartebeest	9	33	350
		Steenbok	2	1	50
		Warthog	1	2	200
		Elephant	70	66	95
		Ostrich	14	7	50
		Total units	145	135	93
28	Acacia/ Terminalia thickets and forest	Burchell's zebra	123	78	63
		Springbok	1	0	∝
		Gemsbok	28	18	64
		Wildebeest	33	62	188
		Giraffe	64	67	105
		Kudu	73	65	89
		Warthog	1	2	200
		Rhino	1	1	100
		Elephant	176	168	96
		Total units	500	461	92

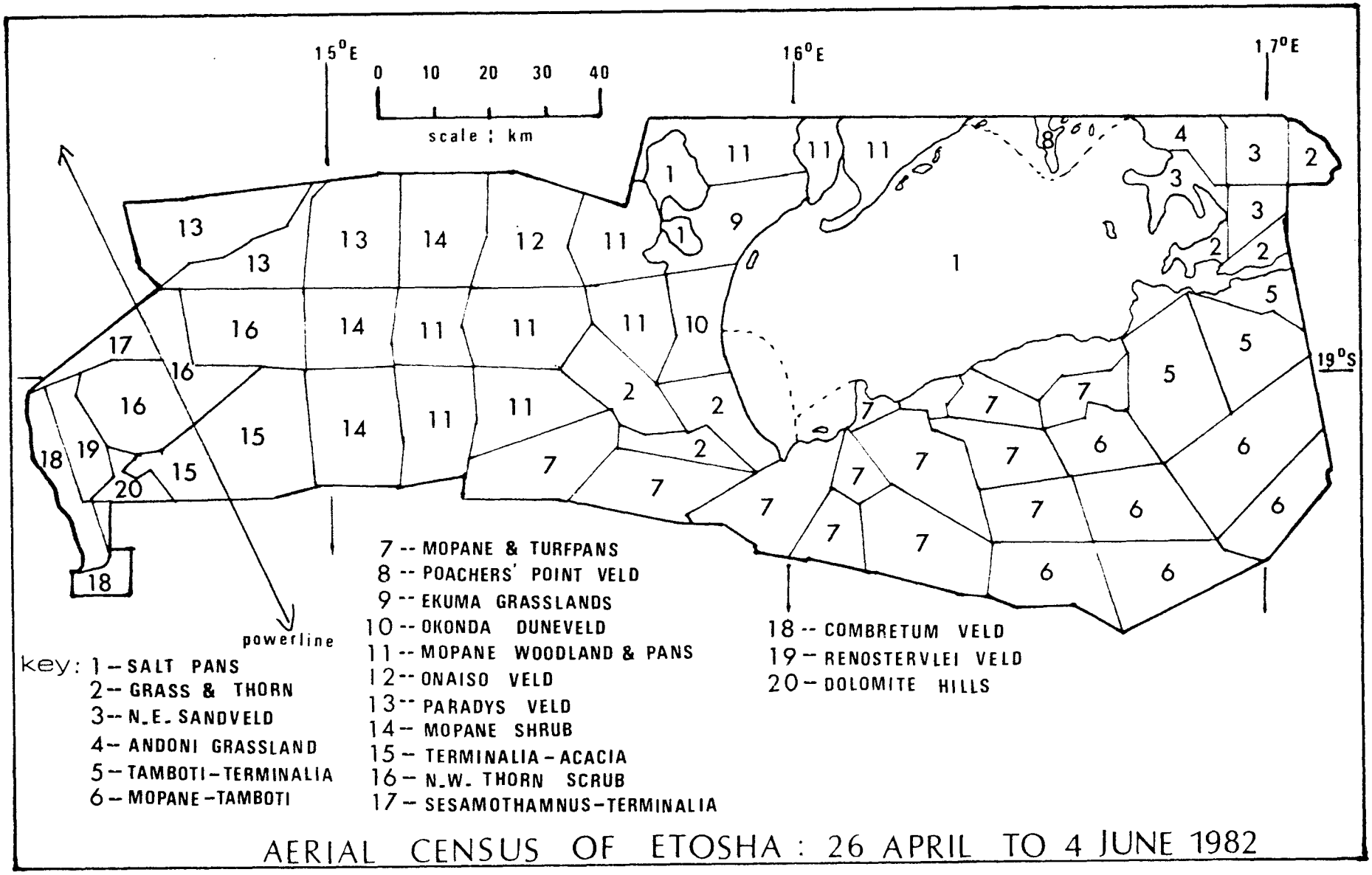

FIG. 2 : **PREDOMINANT** TYPES OF VEGETATION ENCOUNTERED IN THE CENSUS BLOCKS (ACCORDING TO LE ROUX, 1980)

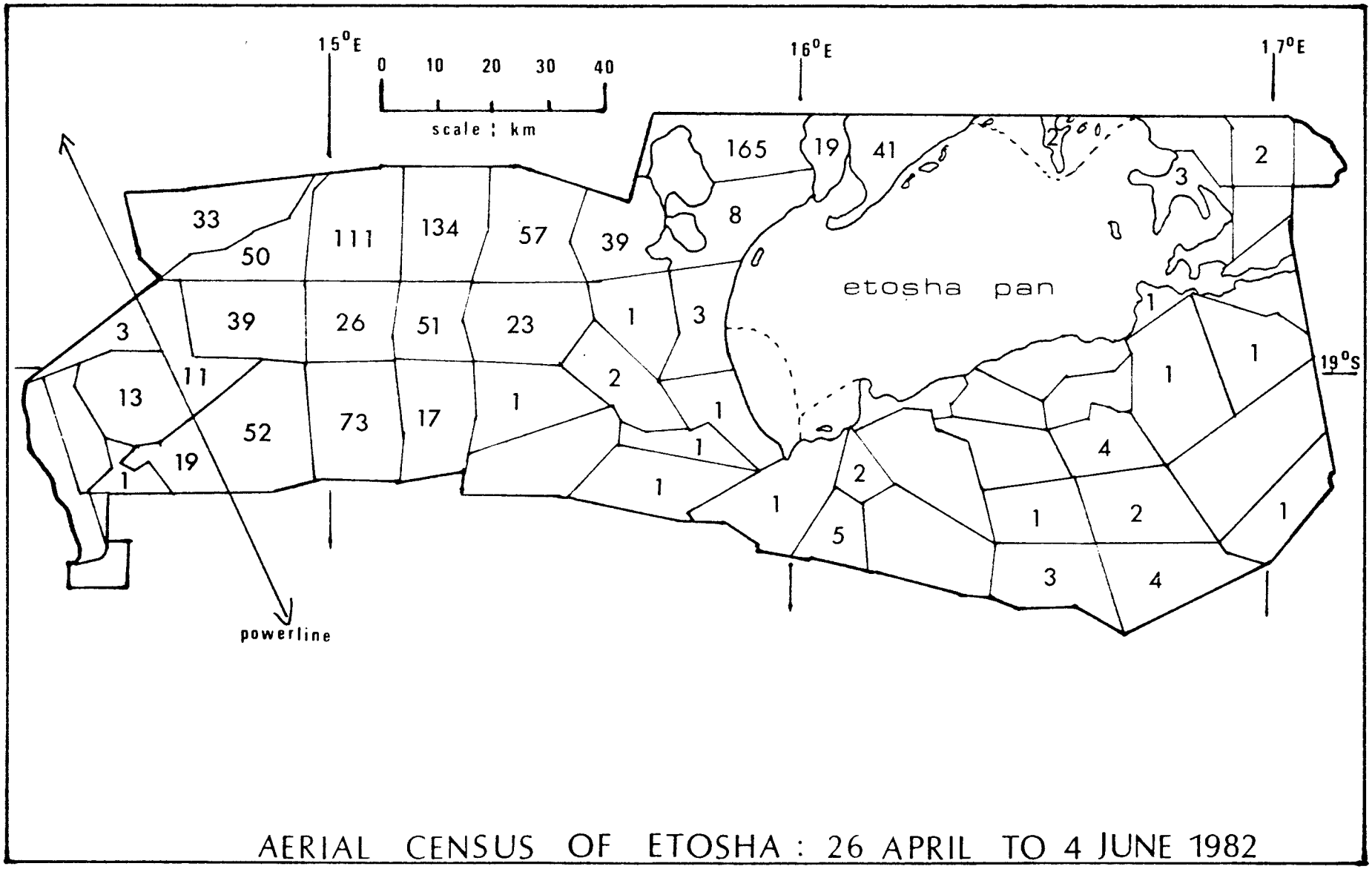

FIG. 3 : NUMBER OF SEASONAL PANS, POOLS AND GRAVEL PITS CONTAINING RAINWATER IN THE CENSUS BLOCKS.

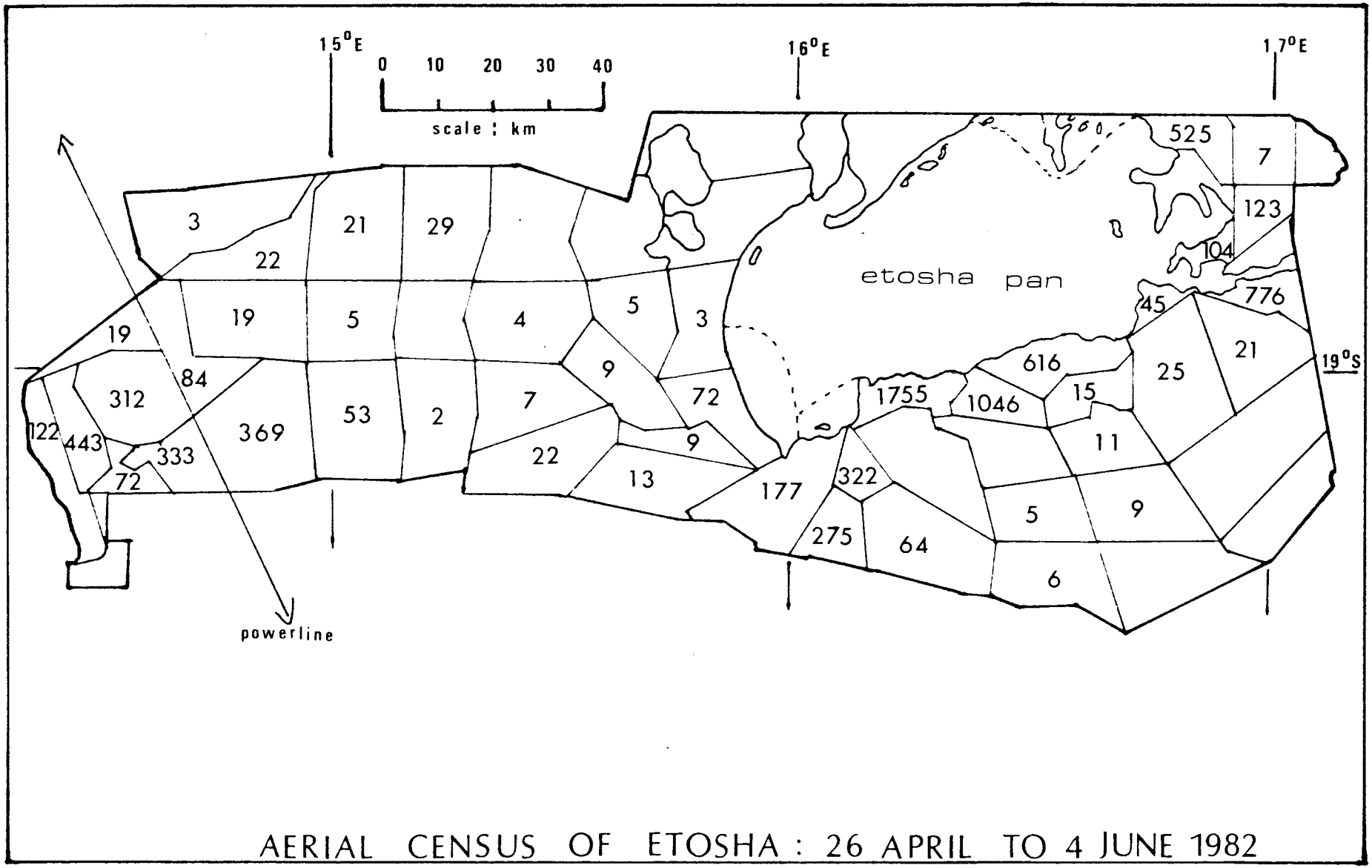

FIG. 4 : DISTRIBUTION AND NUMBERS OF BURCHELL'S ZEBRA RECORDED PER CENSUS BLOCK.

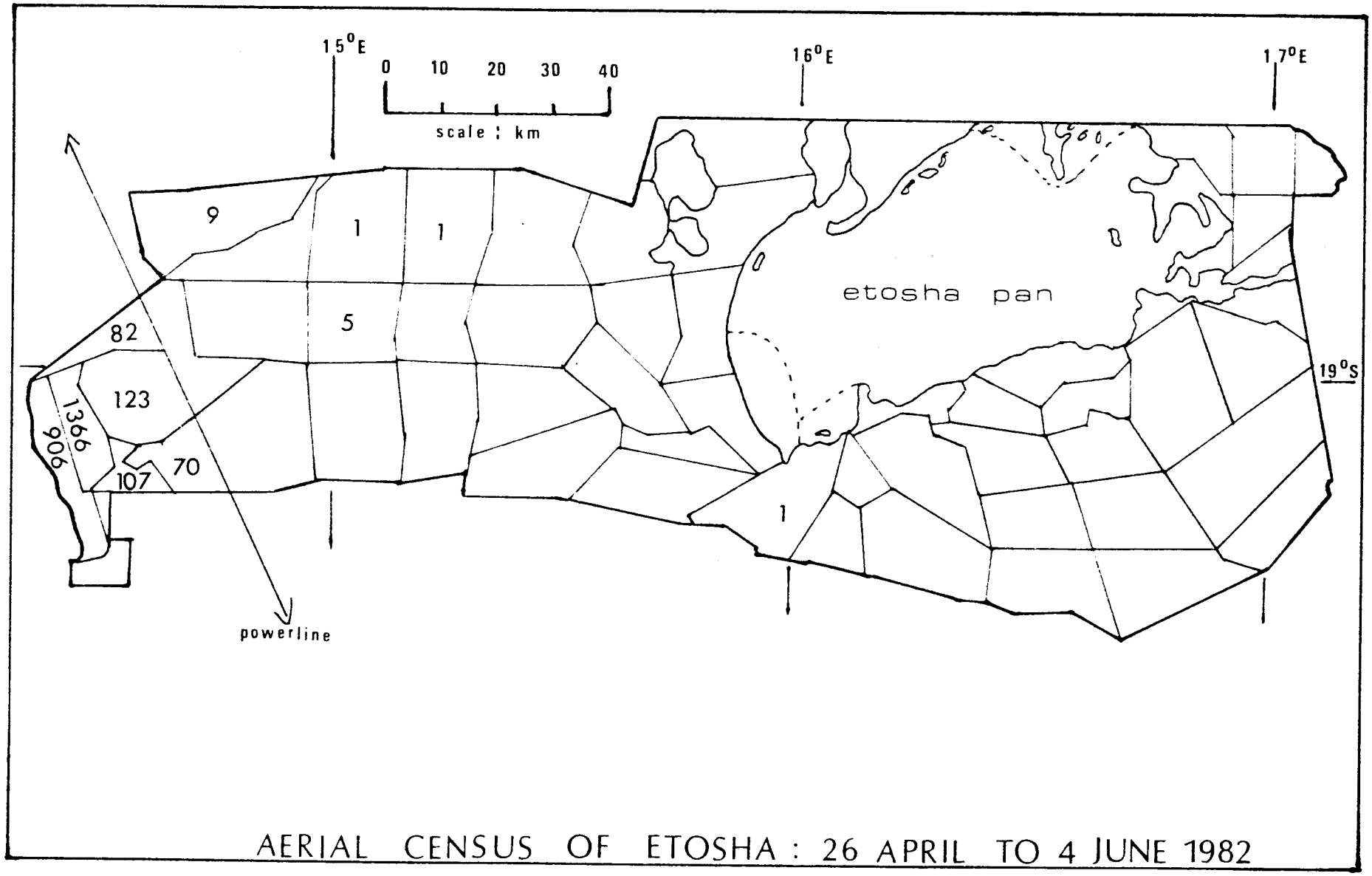

FIG. 5 : DISTRIBUTION AND NUMBERS OF HARTMANN'S ZEBRA RECORDED PER CENSUS BLOCK.

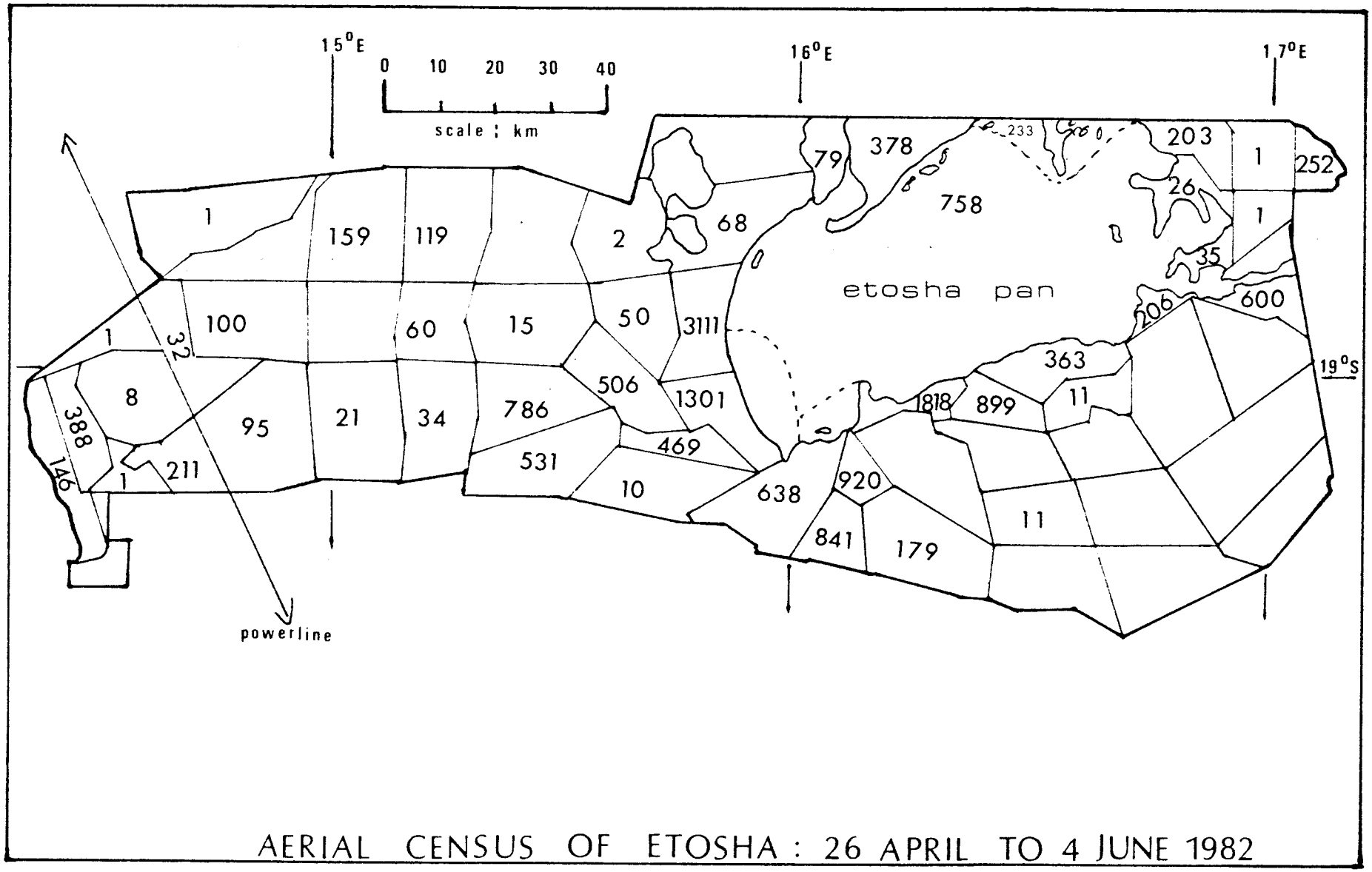

FIG. 6 : DISTRIBUTION AND NUMBERS OF SPRINGBOK RECORDED PER CENSUS BLOCK.

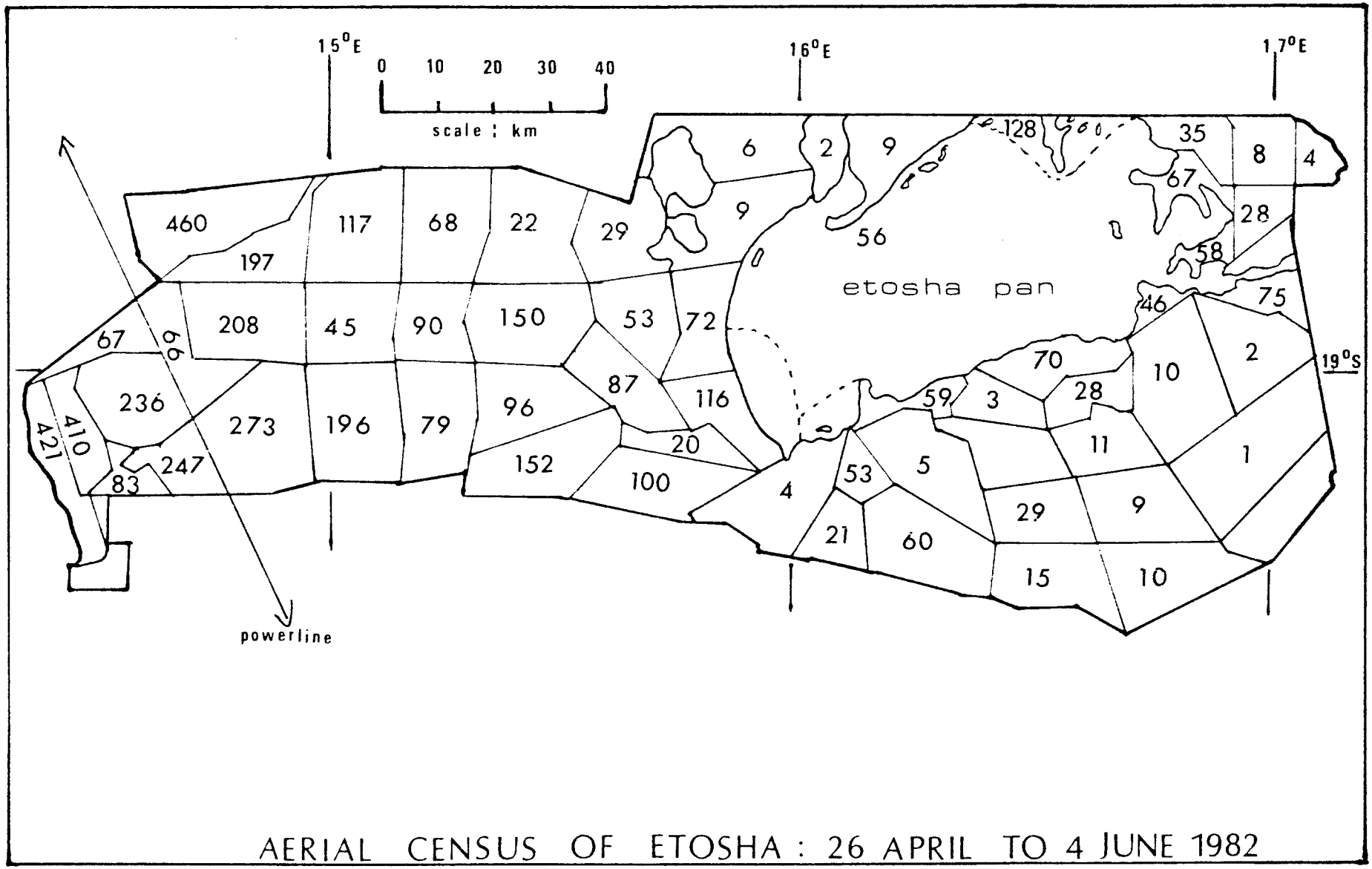

FIG. 7 : DISTRIBUTION AND NUMBERS OF GEMSBOK RECORDED PER CENSUS BLOCK.

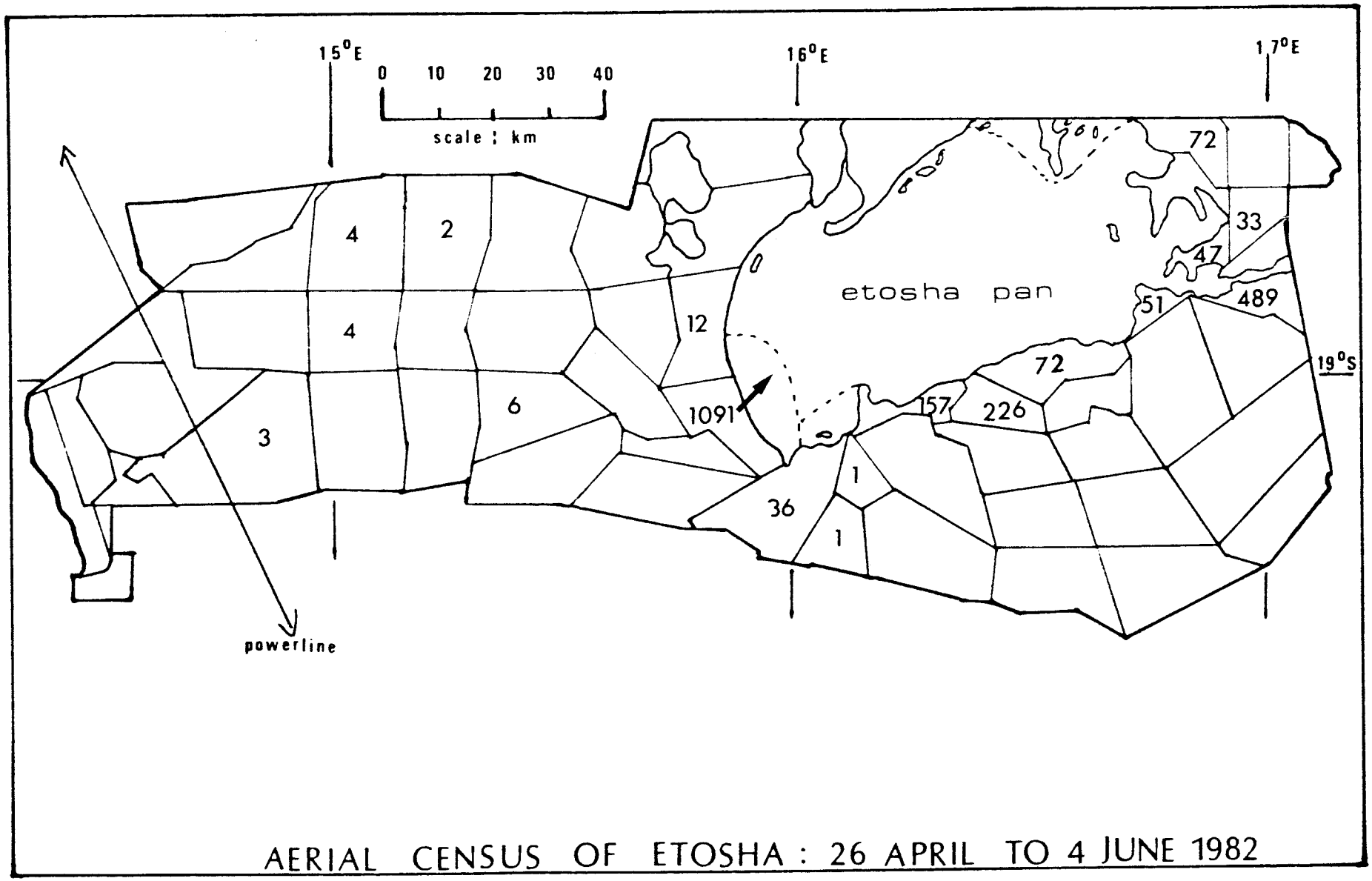

FIG. 8 : DISTRIBUTION AND NUMBERS OF BLUE WILDEBEEST RECORDED PER CENSUS BLOCK.

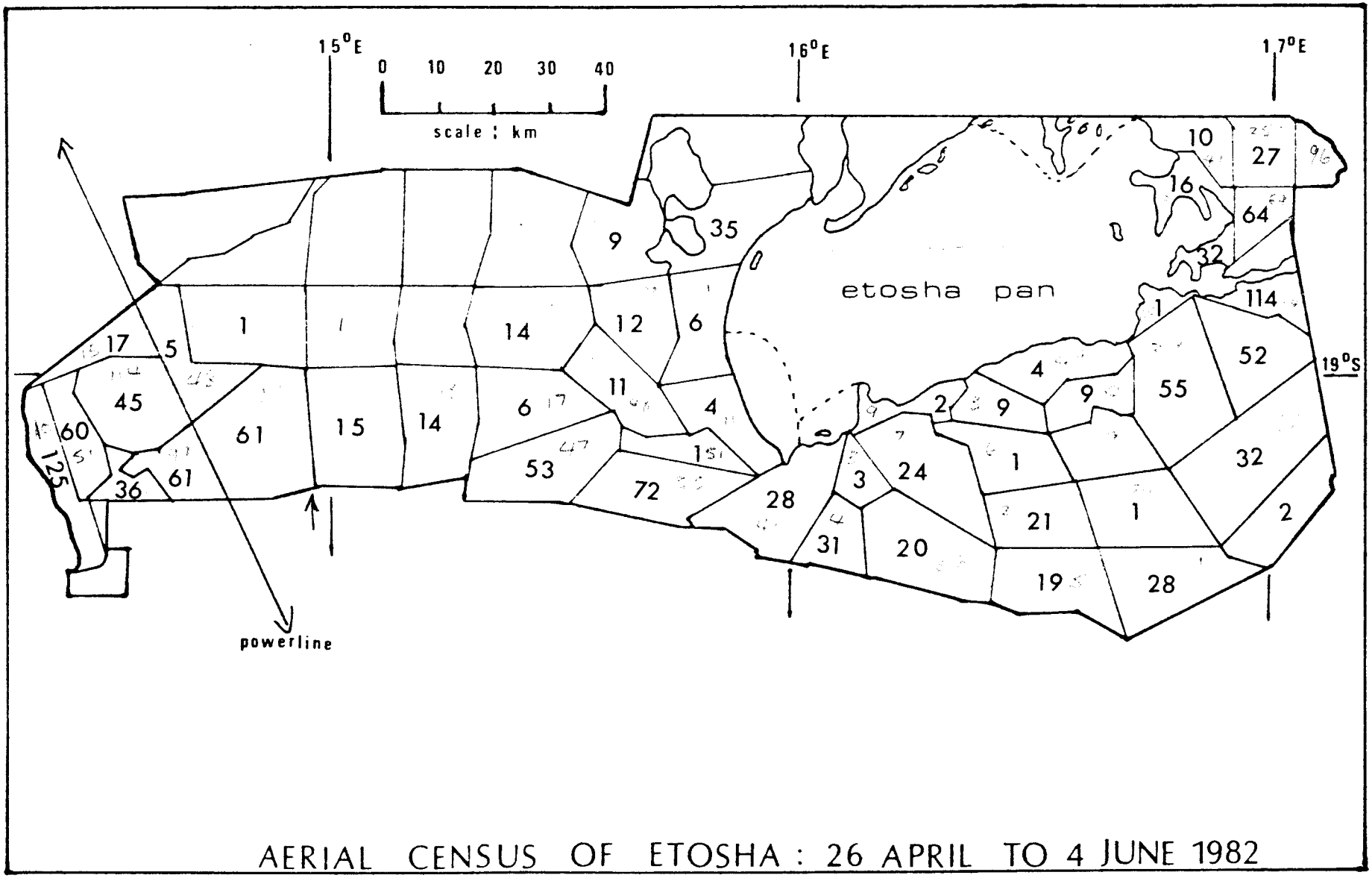

FIG. 9 : DISTRIBUTION AND NUMBERS OF GIRAFFE RECORDED PER CENSUS BLOCK.

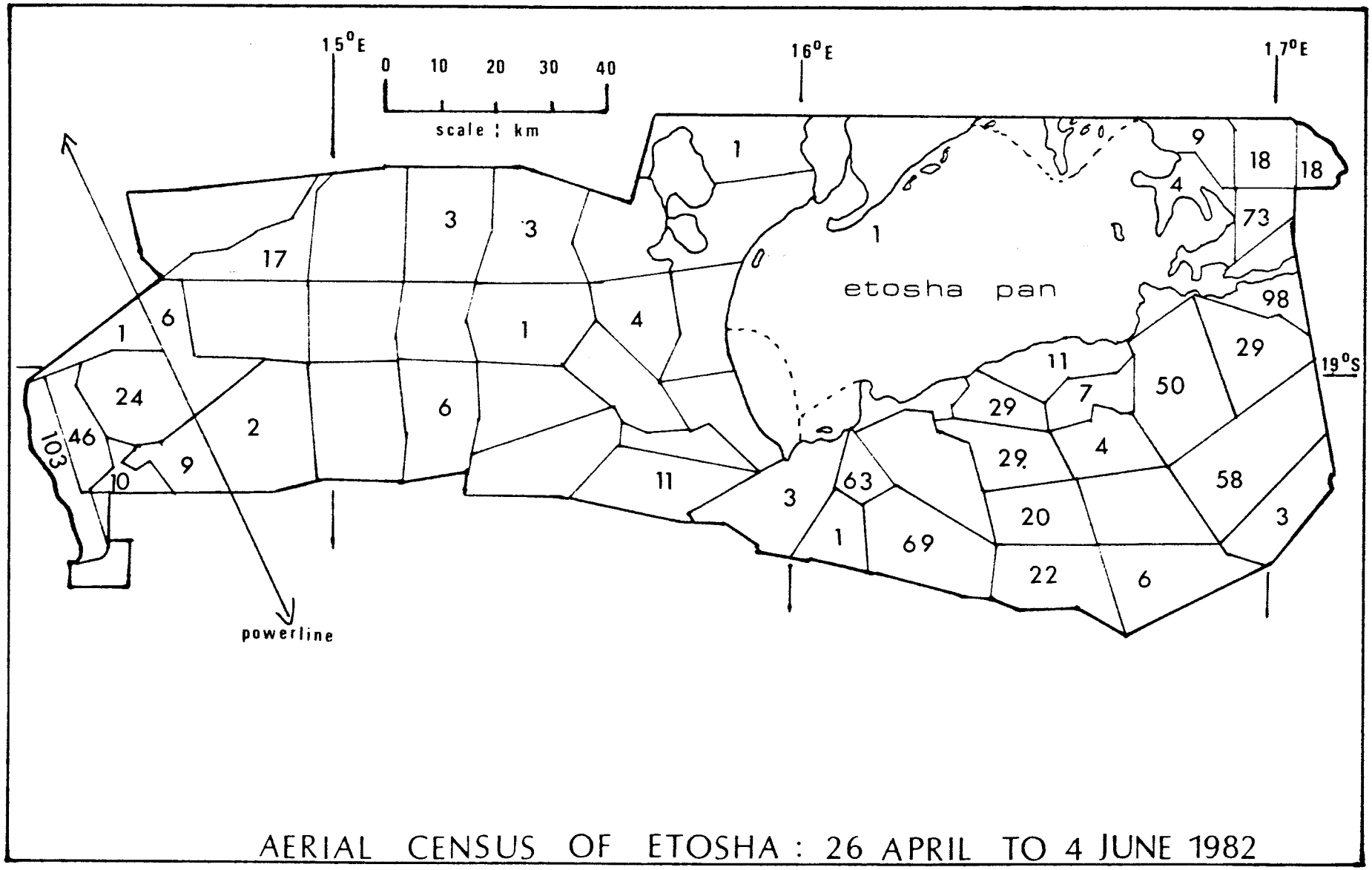

FIG. 1C : DISTRIBUTION AND NUMBER OF KUDU RECORDED PER CENSUS BLOCK.

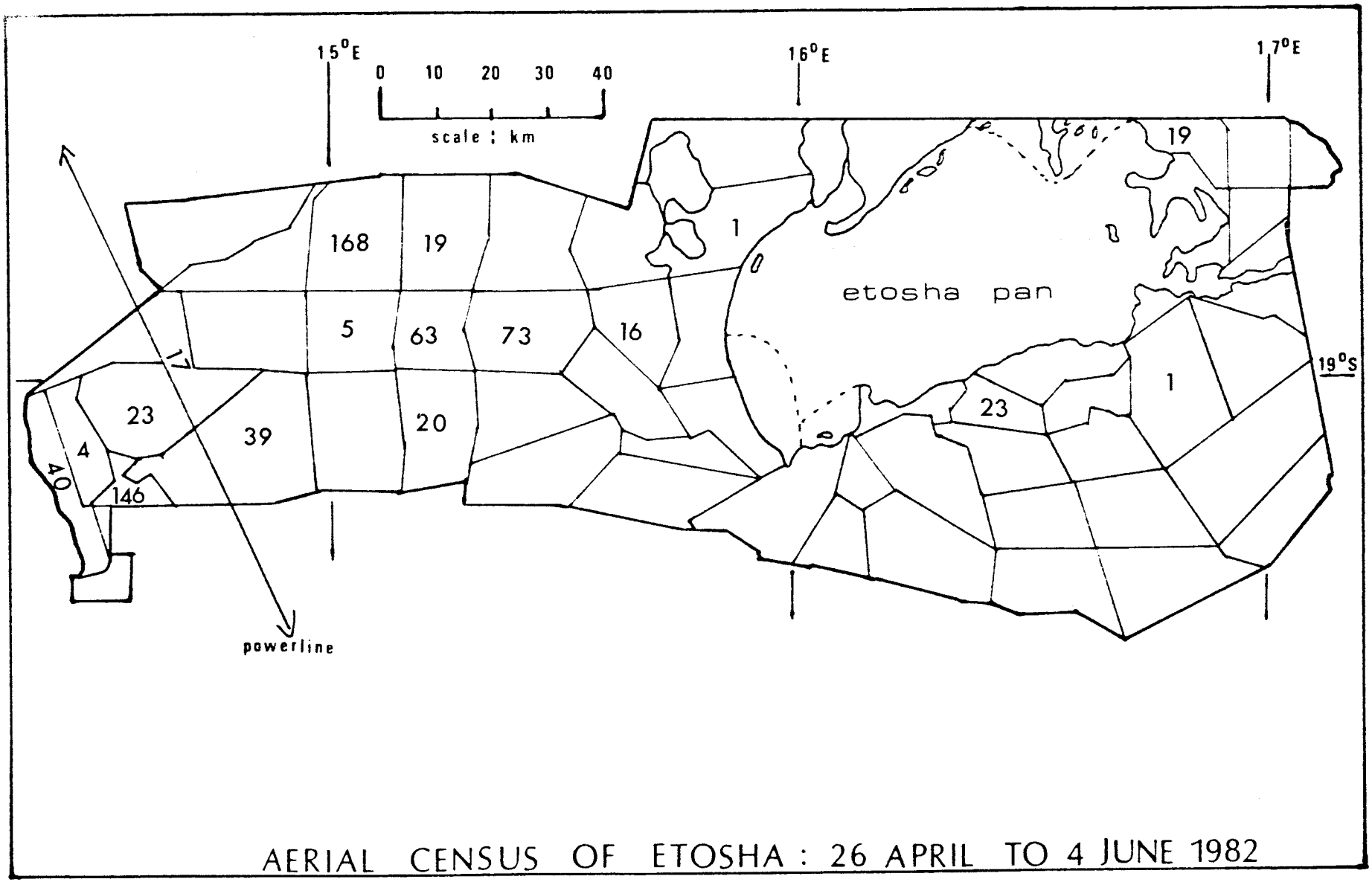

FIG. 11 : DISTRIBUTION AND NUMBERS OF ELAND RECORDED PER CENSUS BLOCK.

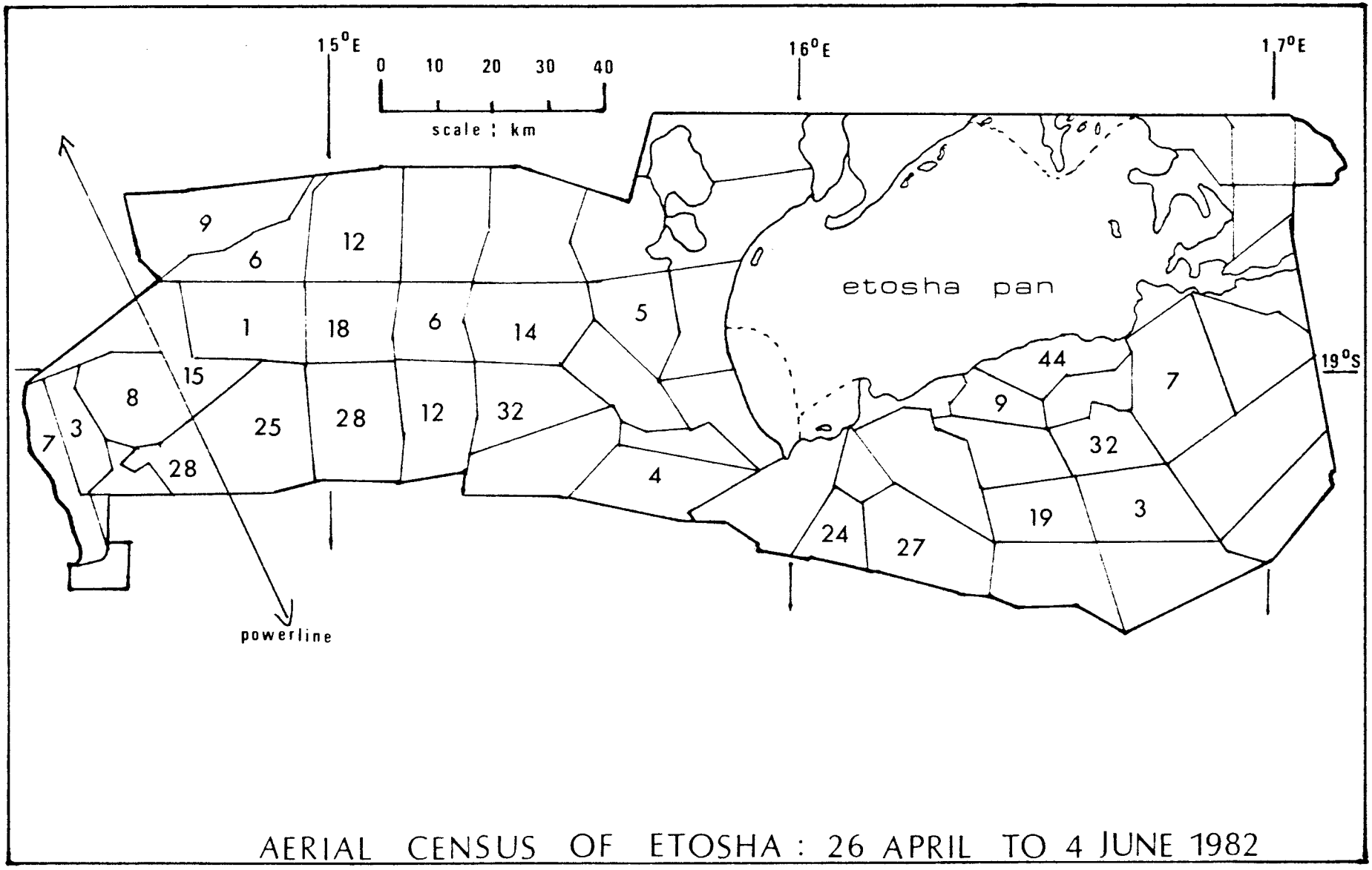

FIG. 12 : DISTRIBUTION AND NUMBERS OF RED HARTEBEEST RECORDED PER CENSUS BLOCK.

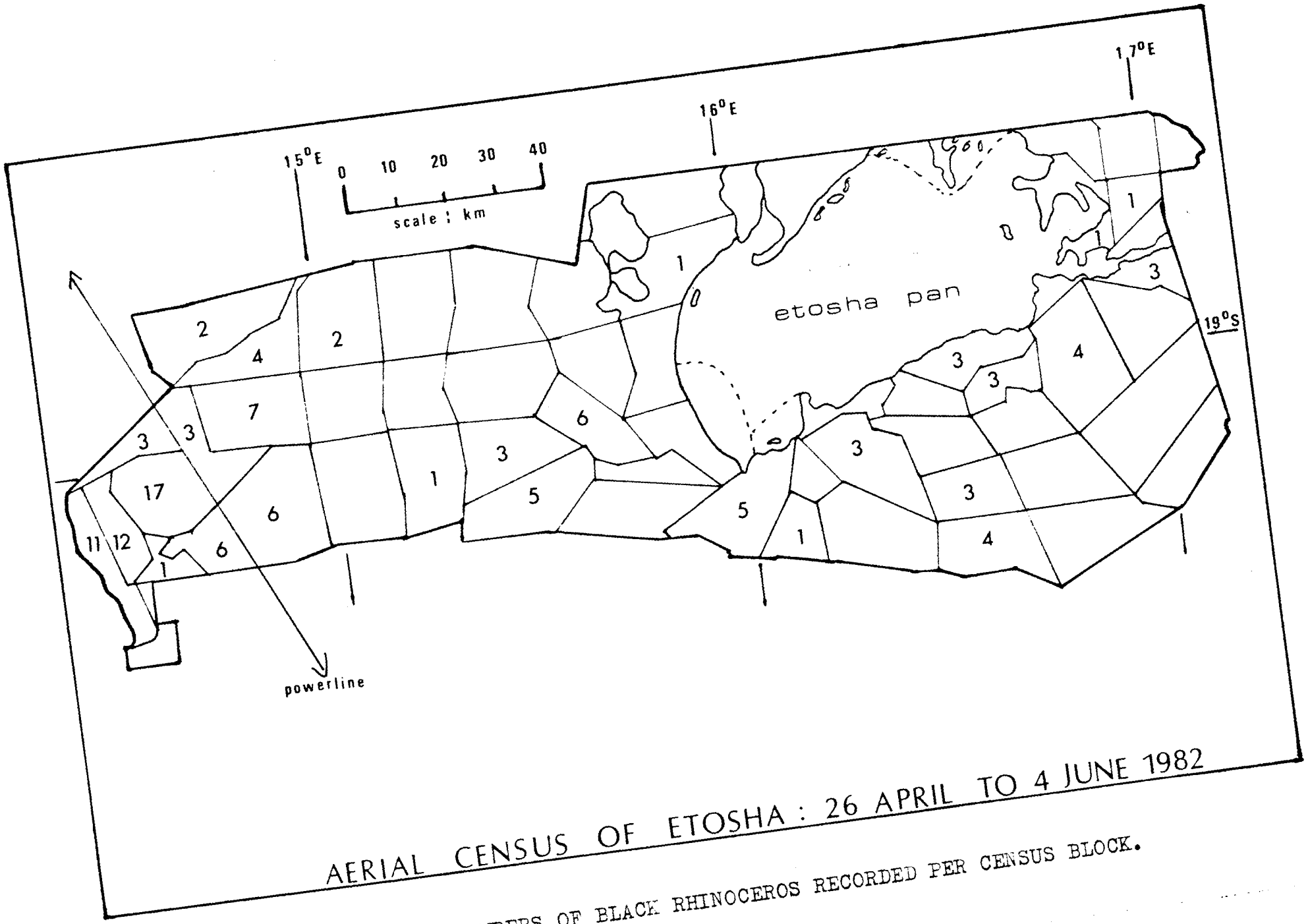

FIG. 13 : DISTRIBUTION AND NUMBERS OF BLACK RHINOCEROS RECORDED PER CENSUS BLOCK.

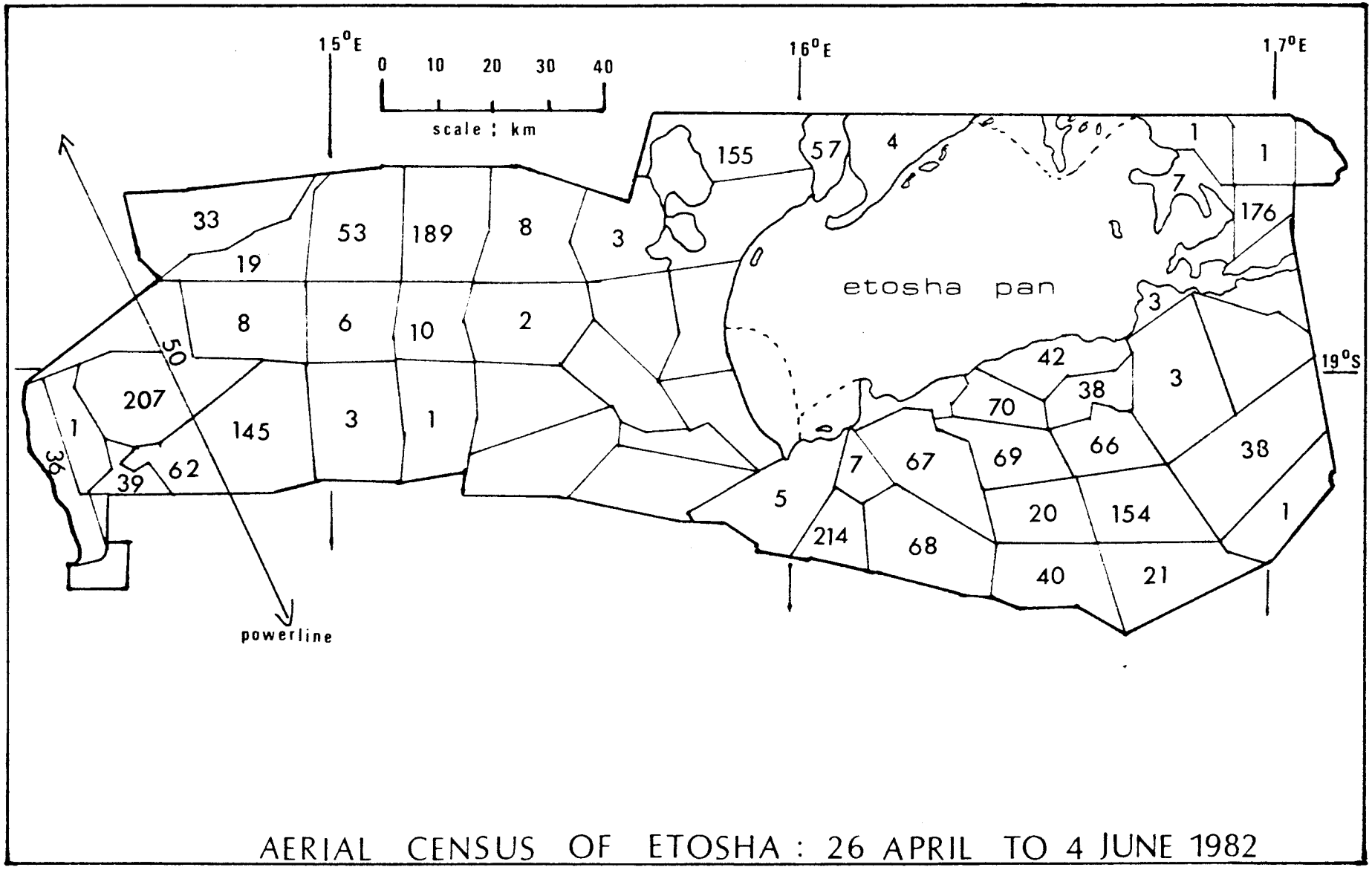

FIG. 14 : DISTRIBUTION AND NUMBERS OF ELEPHANT RECORDED PER CENSUS BLOCK.

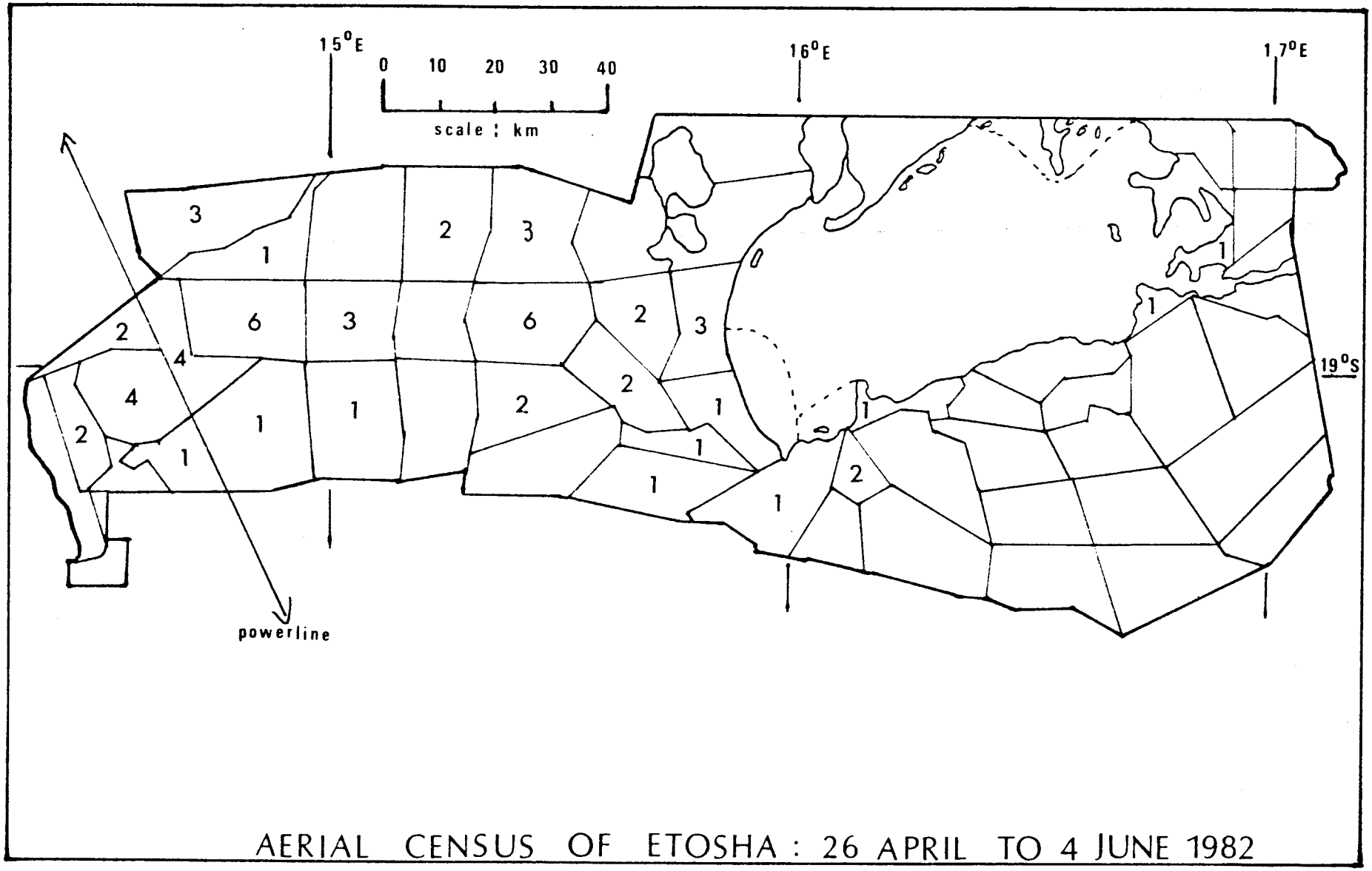

FIG. 15 : DISTRIBUTION AND NUMBERS OF ELEPHANT CARCASES RECORDED PER CENSUS BLOCK.

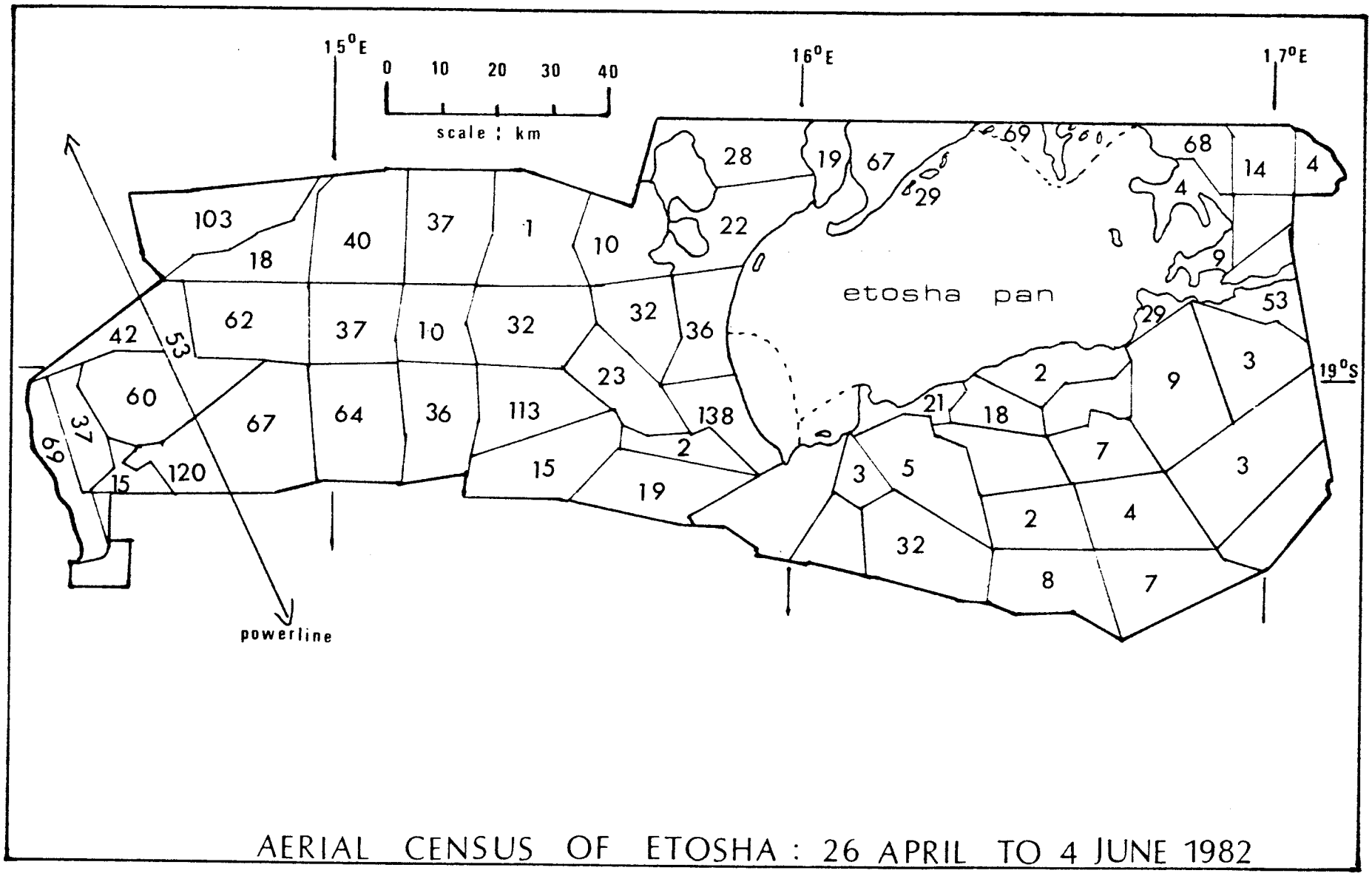

FIG. 16 : DISTRIBUTION AND NUMBERS OF OSTRICH RECORDED PER CENSUS BLOCK.

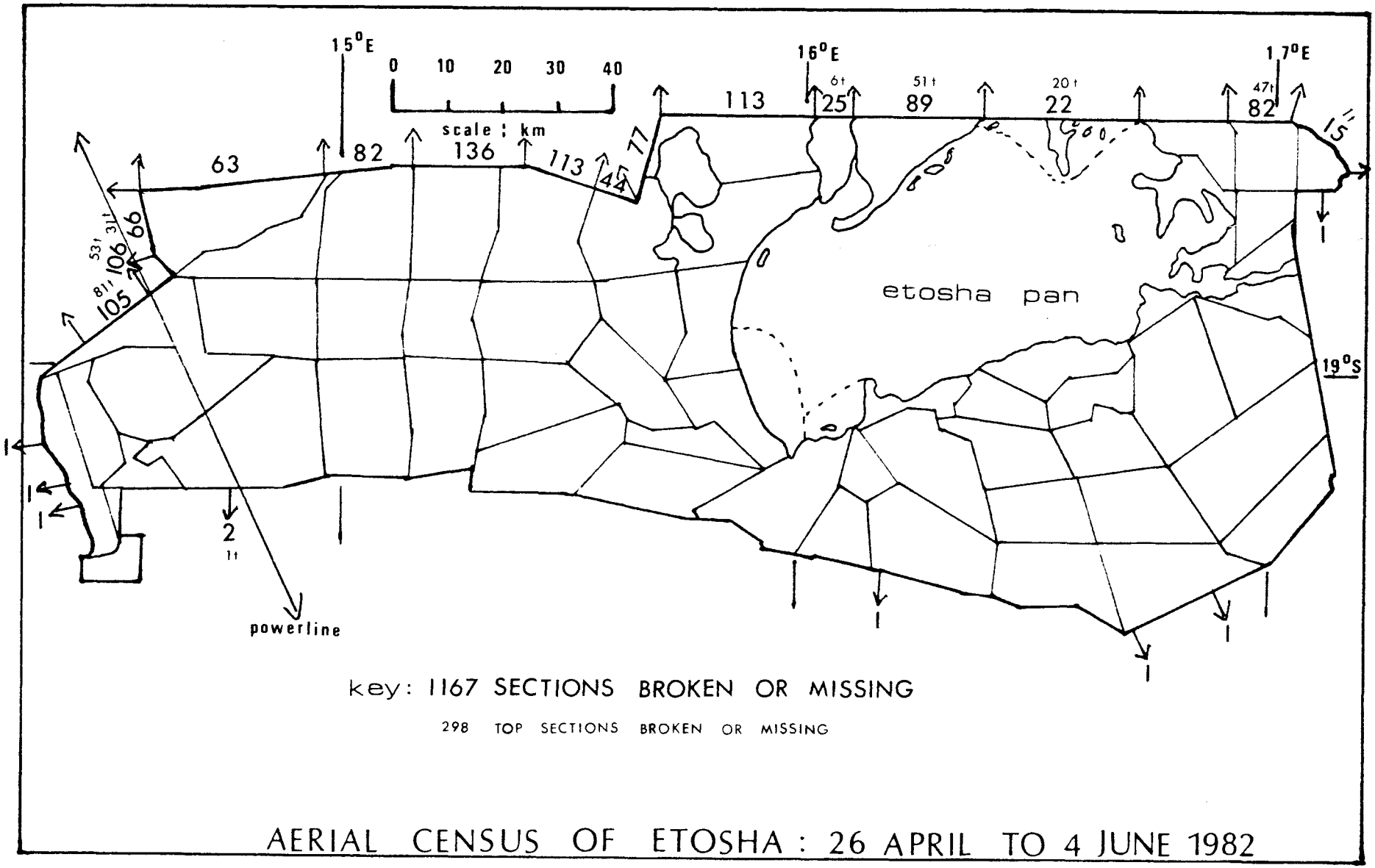

FIG. 17 : NUMBER OF COMPLETE AND PARTIAL FENCE BREAKS EXISTING ON THE BOUNDARY OF ETOSHA (15-16 MAY).

4 DISCUSSION

4.1 Flying times

The helicopter's total flying time was 107h 48min, with a daily range of 1h 31min (Block 25) to 5h 46min (Block 8)(mean daily time flown: 3h 36min). Actual census time totalled 90h 16min (daily range: 1h07 (Block 30) to 5h 17min (Block 8); mean 3h 01min). Ferry time comprised 17h 22min or 16% of the time flown.

The fixed-wing's total flying time was 89h 57min, with a daily range of 56min (Block 28) to 5h 03min (Block 4) (mean daily time flown: 3h 06min). Actual census time totalled 60h 03min (daily range: 52min (Block 28) to 3h 50min (Block 25); mean 2h 4min). Ferry time comprised 29h 54min or 33% of the time flown.

4.2 Number of transects flown.

The helicopter flew a total of 837 transects with a minimum daily amount of 12 (Block 30) and a maximum of 74 (Block 8). The daily average was 26 transects.

The fixed-wing flew a total of 776 transects with a minimum daily amount of 13 (Block 30) and a maximum of 44 (Block 3). The daily average was 26 transects.

4.3 Environmental conditions

Ambient temperature varied from 10 - 28°C during the counts, whilst wind speed was mostly light to gentle (<20km/h) and only fresh on one day (<40km/h). Cloud cover was zero for 25 of the 30 census days and on the remaning 5 days it varied between 2 and 4 octas high cloud. Consequently visibility was good, with only a few days where it could be regarded as average and one day when haze made visibility poor.

4.4 Species totals

Since this is the first time that Etosha has been totally censussed, comparisons with previous, incomplete censusses must obviously be treated cautiously. However, certain trends in a few species become apparent. For example: elephant appear to have continued their increase in numbers (de Villiers, 1980) and now stand at the highest population yet recorded (2202). Likewise, Hartmann's zebra have increased dramatically from 516 in 1980 to 2665 (an increase supplememted by emigration from Damaraland and Kaokoland). Although not accurate, the rhino count (121) reflects an increased population.

In contrast, two species which have been fairly accurately monitored in the past, namely Burchell's zebra and wildebeest, show a continued decline in numbers: zebra by 55% since 1974 and wildebeest by 33%. This decrease follows the predictions of Berry (1980). Springbok too may have declined since 1978 (18 980 to 16 011), although they are notoriously difficult to count from the air and the difference may be largely due to observer error.

In the case of the remaining species such as gemsbok, giraffe, kudu, eland and hartebeest, we have for the first time an indication of their numbers, albeit a gross underestimation in the case of kudu. Giraffe are also well underestimated, but gemsbok, eland and hartebeest were probably accurately counted. Consequently, it can be said that gemsbok (5081) are a strong population, eland (692) are far fewer than earlier, ground counts show, and hartebeest have become less numerous than expected (549 in 1973, 396 in 1982).

Obviously, no conclusious can be made about the populations of steenbok, duiker, warthog and the carnivores.

Only 19 roan were recorded, compared to a total of 140 released since 1974 (van Wyk, 1981). Considering that 65 roan were released in a wet cycle (1974 - 79) and 75 were released in a dry cycle (1980 onwards) it appears that this species has not adapted well to Etosha's present environmental pressures.

In the case of impala, the figure of 93 counted is a good example of by how much a medium size antelope which typically occurs in herds, can be undercounted. Ground counts of impala in Etosha indicate that there may be up to 1000 present.

Lastly, Ostrich are well-represented, with a population of at least 1 835 present, but Kori Bustard were noticeably few in number (45 recorded), this probably being due to the effects of the severe drought.

To summarise: the majority of Etosha's large mammal populations do not seen to have been strongly affected by the drought, but certain species, notably Burchell's zebra and wildebeest have decreased further while roan which were introduced over an 8- year period have been decimated. The drought has, predictably, favoured the browsers and exerted further pressure on the grazers (le Roux, 1980).

4.5 Comparison between the fixed-wing and helicopter

In Table 3 it can clearly be seen that in open areas, where most animals congregate, the fixed-wing greatly undercounted all species (34% of the helicopters count), but in more dense vegetation, where fewer animals occur, the fixed-wing's count was almost the same as that of the helicopter (92% and 93% respectively). In some cases, the fixed-wing's count was higher than the helicopter's.

Factors which are responsible for the increased accuracy of the helicopter count of the concentrations of animals on the plains are better visibility, slower speed and greater manoeuvreability than the fixed-wing.

4.6 Availability of drinking water

From Fig. 3 it is clear that the census must be regarded as a wet season count. A total of 1 010 temporary pans, pools and gravel-pits containing rain water were recorded. The western area of Etosha was especially well supplied with drinking water, this being due to the census taking place shortly after the rains, which typically occur late in the wet, hot season (January to April) in the west. Consequently, animals occupied the "wet season dispersal areas" (Bigalke, 1961) which are inhabitable for about four months of the year.

Furthemore, it became evident that large portions of the southern edge of the Pan seep water at the point where the porous calcrete beds meet the impervious clay. These "contact fountains" (Winter et al., 1979) give the impression of a giant sponge seeping onto the Pans edge, when viewed from an aircraft, and it must be borne in mind that they are perennial, flowing during even the most severe droughts. Consequently, there are hundreds of places where animals can obtain water throughout the year and this will have a considerable influence on full-moon counts at waterholes. In the past, only some of these fountains have been monitored for ground counts and the results are therefore of limited value.

4.7 Distribution of 12 major species

4.7.1 Burchell's zebra (Fig. 4)

16% of the population occurred west of the powerline, while 24% occurred west of the tourist area (M'bari). Thus 76% of Etosha's zebra are distributed in the eastern half of the Park, especially along the edge of the Pan.

4.7.2 Hartmann's zebra (Fig. 5)

99% of the population occurred west of the powerline, with a few vagrants which had moved eastwards during the drought, still scattered amongst Burchell's zebra herds. This unnaturally heavy concentration of zebra in the Otjovasandu area accounts for the overutilised, trampled and denuded state of the pasture there.

4.7.3 Springbok (Fig. 6)

Well-distributed throughout the Park, except the south-eastern sector, where they were not recorded. 74% of the springbok population occurred on the plains adjoining the Pan.

4.7.4 Gemsbok (Fig. 7)

Gemsbok are ubiquitous in Etosha and were recorded in 58 of the 60 census blocks as well as on the Pan itself. 72% of the population occurred in the western half of the Park (west of M'bari), with 29% occurring west of the powerline. This compounds the present overutilisation problem at Otjovasandu, when account is taken of the zebra numbers recorded there.

4.7.5 Wildebeest (Fig. 8)

Only 1% of Etosha's wildebeest occurred west of M'bari and the herd seen regularly near Onangombati in the past was not sighted. 53% of the population occurred on the Pan, where the nutritious, halophytic grass Sporobolus salsus (= tenellus) occurred in pure stands. The importance of the saline Pan as a dry season grazing area for wildebeest (Berry, 1980) was again evident.

4.7.6 Giraffe (Fig. 9)

29% of the population occurred west of the powerline, whilst 43% occurred west of M'bari. Giraffe were recorded in most vegetation types with the exception of the pure grasslands and the Onaiso-Paradys veld (Fig.2).

4.7.7 Kudu (Fig. 10)

35% of the population occurred in the Namutoni area, whilst 48% occurred south of the Pan. Otjovasandu accounted for 19% of the kudu population.

4.7.8 Eland (Fig. 11)

91% of the population occurred west of M'bari, whilst 31% occurred west of the powerline. Only 17 of the 60 census blocks were recorded as harbouring eland.

4.7.9 Hartebeest (Fig. 12)

Hartebeest are well-distributed with 56% of the population occurring west of M'bari.

4.7.10 Rhino (Fig. 13)

41% of the numbers recorded were west of the powerline, with 83% west of M'bari. This distribution is predictable and in accordance with Joubert (1971), indicating marked habitat preference.

4.7.11 Elephant (Fig. 14)

The area to the south of the Pan accounted for a large portion (42%) of the elephant population. Distribution is as described by de Villiers (1981a), with elephant occupying 46 of the 60 census blocks.

Elephant carcases (Fig. 16)

It is evident that the die-off of elephant towards the end of 1981 commenced in the anthrax-endemic areas around Okaukuejo, spreading westwards to Otjovasandu. Although anthrax was probably the ultimate cause of death in most of the elephants which were affected, the proximate cause may have been nutritive stress. This mortality may therefore be seen as a natural control mechanism in an overabundant population. Approximately 130 elephant carcases were located and burnt at the end of 1981 and a further 54 carcases were found during the census. Thus it is possible that up to 200 elephant (10% of the population) died in a period of a few months.

4.7.12 Ostrich (Fig. 15)

56% of the population occurred west of M'bari and ostrich, along with gemsbok and springbok, are the most ubiquitous of the large species at Etosha. They were found in 56 of the 60 census blocks.

4.8 Fence breakages (Fig. 17)

An aerial check of the boundary fence on 15 and 16 May, using the fixed-wing aircraft, showed that a total of 1 465 sections were partially or completely broken.

Of these only 7 occurred in the areas adjoining the traditional white farms, whilst the rest adjoined the traditional black states

of Kaokoland and Owambo. Not all the fence breakages were caused by elephant, since long sections of wire have also been reported stolen.

The areas of most severe fence breakages were predictably at Onaiso and Otjivalundu where the fence crosses major elephant trails. It is by now abundantly clear that the present northern and western boundaries of Etosha are ecological non-entities which will continue to cost Nature Conservation enormous sums of money and hours of manpower.

4.9 Primary production versus herbivore demand in the Otjovasandu area

In the absence of more detailed data on plant production we have referred to de Villiers (1981b) findings on grass availability in the western sector of Etosha, since this area has become the most critical in regard to overutilisation. Grass samples were clipped at a radius of 5 km and further from permanent drinking places (i.e. Okawao) since within a 5 km radius there was virtually no grass cover remaining. We calculated grass production in kg. ha^{-1} and then balanced this against the permissable forage removal (66% : le Roux, 1980) based on a 240-days grazing period. The results are given in Table 4, from which it appears that the dry season carrying capacity is in the region of 1 850 LSU as apposed to the 4 300 LSU still present after the removal of 1 080 zebra (= 767 LSU) by the Capture Unit in June/July (an overstocking factor of 2,3).

We want to emphasize that our calculations of permissable large stock units are based on a simple correction factor which converts the wild species' body mass to the internationally accepted standard of one large stock unit of 454 kg. However, because energy requirements are not linear to body mass (Bartholomew, 1972), the actual energy demand by the wild species at Etosha will be considerably more than the arithemetically expressed "large stock unit". Consequently, the permissable LSU given in Table 4 are an absolute maximum and the equivalent in actual energy demand will be much higher.

TABLE 4: Mean dry season grass availability in the Otjovasandu area and its permissable removal, expressed as estimated carrying capacity or permissable large stock units (data from de Villiers 1981b).

Area	Size (hectare)	Grass available (kg. ha^{-1})	Permissable grass removal (ton) *	Estimated carrying capacity ($ha.LSU^{-1}$) **	Permissable LSU (1 LSU=454kg) ***
Wet season dispersal	188 200	88,18	10 953	51,5	3 651
Dry season concentration	95 500	88,18	5 558	51,5	1 853

* Permissable grass removal $= \frac{\text{grass available (kg, ha}^{-1})}{1000\text{kg}} \times \text{area} \times \frac{66}{100}$

** Estimated carrying capacity $= \frac{\text{surface area}}{\text{permissable LSU}}$

*** Permissable LSU $= \frac{\text{permissable grass removal (kg)}}{12,5\text{kg. day}^{-1} \times 240 \text{ grazing days.}}$

5 COST

An operation as extensive as a total census of Etosha includes direct expenses, such as fuel and hire of aircraft, plus indirect expenses, such as transport of personnel by road to reach points where aircraft are based. Inevitably, last-minute changes in the program led to replacement of personnel and this incurred additional expenses. Furthermore, the aircraft accident which occurred during the census involved unforeseen expenses and these have been omitted from the cost analysis.

ITEM		RAND
Aviation fuel	(100 drums at R157-20 each)	15 720
Helicopter hire	(on site: 109,5 hrs at R200/hr)	21 900
	(ferry Windhoek-Cape Town return)	2 880
	(pilot and engineer expenses)	1 994
Fixed-wing hire	(105 hours at inclusive rate of R125/hr)	13 125
Fuel and personnel transport	(10 732 km at 33c/km)	3 542
S and T claims	(40 days x 6 persons at R14-75)	3 540
	(40 days x 2 persons at R11-75)	940
	TOTAL:	63 641

6 CONCLUSIONS AND RECOMMENDATIONS

Now that baseline data on the numbers of the herbivore species in Etosha have been established, future censusses should be able to detect significant changes or trends. The question arises as to how often a total census is required to detect possible significant change in numbers so that management procedures can be implemented. In similar situations, such as Kruger Park, a total census is conducted annually (S. Joubert, 1982) and both a fixed-wing and a helicopter are used. However, it must be remembered that a pivotal reason for this census is to determine the numbers of elephant and buffalo so as to establish a sound basis for culling overpopulous areas (Hall-Martin, pers comm; 1982). At Etosha, the infrastructure and logistical support for a commercially orientated culling program does not exist and so annual censusses may be superflous.
However, it is advisable that we should monitor Etosha's animal populations on a regular basis. The 1982 total census, using aircraft, was successful and our method appears acceptable.

We recommend, without hesitation, that Etosha should be censussed using a helicopter in the areas of high densities of animals, while a fixed-wing aircraft can be employed in areas where animal densities are relatively low. We feel that, due to the cost factor and our present management capabilities, a total census needs to be carried out at intervals of 3 to 5 years. Based on present experience at Etosha, a total census appears to be preferable to sample counts.

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