I U C N / W W F / N Y Z S

October 1979

LUANGWA VALLEY

ELEPHANT, RHINO, AND WILDLIFE SURVEY

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ACKNOWLEDGEMENTS

As in every detailed aerial survey, the Luangwa Elephant, Rhino and Wildlife Count of October 1979 became possible through the efforts of many parties, and we are grateful to all who helped.

We acknowledge our debt first to the Government of Zambia for honouring us with an invitation to make this survey as part of the IUCN Elephant and Rhino Programmes.

The Survey was planned for many years before it took place, and although it suffered several postponements, due to circumstances beyond the control of any of the participants, we are grateful to the Department of Wildlife and to the Zambian Wildlife Society for their consistent determination to see it through.

The Zambian Wildlife Society not only organized the logistics, but also paid for the cost of fuel and transported it to base camp, near the Lukuzye River airstrip. We are particularly grateful to Ian Tanner and Chris Legge in this respect. Norman Carr and his family gave us food, and lodging in his beautiful camp at Chibembe on the edge of the Luangwa River, where we could relax and contemplate our data after a day's flying.

Attig Olivier welcomed us to Kasama when we first arrived in Zambia, and malfunctioning communications stranded us at our port of entry. We are very grateful for his help, in particular lending us the wherewithal to buy petrol for the onward journey to the valley.

We are also indebted to our sponsors. The costs of flying expenses, data analysis and the preparation of the report were paid for by the World Wildlife Fund and came to $5,000. Dr. Hillman's salary was paid by the New York Zoological Society. We are grateful also to the African Wildlife Leadership Foundation for office facilities provided.

INTRODUCTION

The purpose of the IUCN Elephant Rhino and Wildlife Survey was primarily to detect changes in the elephant and rhino populations since the systematic counts made by FAO in 1973, which have been published by Caughley and Goddard (1975) for the elephant, and whose results also appear in the FAO document (Naylor, Caughley, Abel, and Liberg, 1973).

The Luangwa Valley, with its winding river that passes through no less than four National Parks, is among the last true strongholds of the elephant and rhino. It was also important to the IUCN Elephant & Rhino Programmes to obtain comparative data in order to complete an overview of the continental status of the two species.

We were invited by the Zambian Government to conduct an aerial survey, using the techniques developed in recent years in East Africa. It was planned that the survey should be financed by the sponsors of the IUCN Elephant Programme, namely the World Wildlife Fund and the New York Zoological Society and that the Zambian Wildlife Society would arrange for petrol, food and lodging for the crew.

Although we understand that other surveys have been made since 1973 FAO count, we have not had access to the raw data and are unable to make comparisons. (Barlass,1979).

METHODS

The Census Zone chosen measured exactly 20,000 square kilometres, as indicated on the Base Map on page 2. It covered Luangwa North and South National Parks, the Munyamadzi Corridor, and the Luambe and Nsefu National Parks. It was sampled by flying east-west parallel transects, ten kilometres apart, which collected data on numbers, distribution and habitat conditions simultaneously. The methods used were virtually identical to other counts of the IUCN Elephant Survey and Conservation Programme, and followed those developed at the Serengeti Research Institute (Norton-Griffiths, 1975).

Transects were flown at 300 feet above ground level and two rear seat observers scanned a strip of ground demarcated by rigid markers attached to the wing struts on either side of the aircraft. The two strips amounted to 289 metres giving a sampling intensity of slightly less than 3%.

Height was regulated by the pilot using a radar altimeter which was independently monitored by the front seat observer, Hillman.

All animals seen within the strips were counted and the results were dictated into tape-recorders so that the observers did not have to take their eyes off the ground. The narrowness of the strips was chosen to make it easier to see animals in thick vegetation and to compensate for the observers' initial inexperience.

(A high intensity sample count was made of the Nsefu National Park) (Page 42).

Elephant carcasses and skeletons were recorded as an indication of recent mortality.

Large groups, which could not easily be counted by eye were photographed. This was necessary for buffalo, but not for elephant, which in Luangwa have small group sizes.

Ecological data on habitats were also recorded by the front-seat observer, who took photographs periodically so that a complete photographic library was built up of every major habitat type. All data were recorded so that observations could be related to the grid squares in which they occurred.

Actual strip widths were calibrated by flying about thirty times over markers laid out on the runway at Lukuzye and taking the average strip width actually seen by the observers during flight.

The aerial observations were transcribed, in the field, from the tape recorders on to data sheets, and from these were summarized, by grid squares to give distributions on the Base Map, and by transects to give sample units for estimations of species populations.

Preliminary analysis was completed, before ending the exercise, for elephants and rhinos, so that the Department and the Wildlife Society should know the estimates without delay. The analysis was made with the aid of a portable, battery operated, programmable Hewlitt Packard 97 calculator.

Estimates of large herds were corrected at a later stage, against photographs, and final adjustments were made to the total numbers.

BIAS

Observer bias is generally recognized as the largest source of error in aerial censuses, usually leading to an underestimate. Observer experience is widely held to be an important factor.

We attempted to minimize observer bias by selecting a narrow strip width of about 150 metres per observer, which did not impose much difficulty in terms of area to be scanned. One observer, Holt, had considerable previous experience with the Serengeti Monitoring Flights, and the other, Ansell, is employed in a capacity in which he is expected to spot animals as a guide to tourists and has a great deal of practice in doing so. Ansell was calibrated against Holt and we found no significant difference.

Holt himself was calibrated against a number of experienced East African observers at the Second International Workshop on Aerial Survey Methods held in Nairobi shortly after the Luangwa count. His performance was measured on a controlled transect where observers were asked to count a number of objects placed on the ground of known quantity. The most cryptic of the models were black polythene sheets, far harder to see than elephants. Holt counted 85% of these difficult black objects, but

LUANGWA VALLEY CENSUS ZONE (20,000 km2)

DRY SEASON OCTOBER 1979

	Population estimate	Density Nos/Km ^{2}	Standard error	Confidence limits 95%
Baboon	2,640	0.132	1200	2470
Buffalo	26,900	1.350	7760	16000
Bushbuck	69	0.003	47	50
Bushpig	104	0.005	75	154
Crocodile	832	0.042	386	794
Eland	2,220	0.111	1410	2910
Elephant	35,300	1.770	4260	8770
Elephant skeleton	5,720	0.286	662	1360
Giraffe	35	0.002	35	72
Greater Kudu	486	0.024	237	489
Hartebeeste	1,140	0.057	395	814
Hippo	13,300	0.666	2120	4370
Hyaena	139	0.007	95	101
Impala	29,500	1.470	5020	1030
Lion	69	0.003	69	73
Puku	8,640	0.432	1830	3780
Rhino	867	0.043	250	515
Roan	312	0.016	270	557
Small ungulate	173	0.008	70	144
Warthog	4,510	0.225	727	1500
Waterbuck	9,600	0.484	2140	4410
Wildebeeste	11,100	0.557	3490	7190
Zebra	15,300	0.763	2850	5870

Table 1 : Uncorrected Population Estimates

on two sets of white objects combined he scored 99%. Overall he scored 1-3% above the average observer in these trials, and rated almost exactly comparable to one of the most experienced East African observers, C. Hillman, who normally uses a similar method of strip sample counting. The results of these trials will be published in the proceedings of the Workshop.

From these empirical tests of observer performance we assume that any differences between our results and those of previous counts in Luangwa do not result from deficiencies, or lack of experience on the part of our observers.

In presenting results we have not corrected for bias, since the main purpose of our survey is to elicit the trend in elephant numbers since Caughley and Goddard's count, who themselves presented uncorrected results.

The count was made in good visibility conditions at the end of the dry season from 2nd - 5th October, before most of the trees had come into leaf.

RESULTS

Estimates for whole Census Zone (20,000 km^2)

Population estimates for all large mammal species are summarized in Table 1. Elephants were estimated at 35,300 at a density of 1.7/km^2. The standard error was 4260, which gave 95% confidence limits of 8770. In other words there was a 95% chance that the true numbers of elephants within the Census Zone lay between 26,530 and 44,070. It is plain that the elephant dominates the large mammal biomass.

Rhino at 867 are certainly underestimated, as will be discussed.

Impala and buffalo are the second most numerous species, at densities of 1.47 and 1.35/km^2 respectively.

Hippopotamus at 13,300 animals, encountered only in rivers or on their banks, were very abundant. The count was not designed for hippo and the estimate must be far too low. Olivier and Laurie (1974) in their Mara hippo study, estimated that aerial counts should be increased by a factor of 2.65 which suggests the order of correction factor necessary for these Luangwa results. The hippo population of Luangwa is therefore a major one in Africa and must be a dominant factor in the ecology of the Park, especially in its impart on plant communities near the rivers.

The smaller and more cryptic animals are subject to a greater underestimate. However, the data has been collected in a standardized manner and can be manipulated by any researcher according to their own preferred correction factors.

The estimates for highly cryptic species, like bushbuck, bushpig, hyaena and lion, or rare species like giraffe, are not intended to be taken seriously.

*Table 2 - LUANGWA VALLEY Elephant Estimates for three sub-samples - comparison of 1979 results with 1973 Census (Caughley & Goddard, 1975)

Area Name	Area Km²	1973 Ele. Total	1973 Ele. Density	1973 St. Error	1979 Ele. Total	1979 Ele. Density	1979 St. Error
North Luangwa NP	4,460	17,700	3.97	2,790	7,360	1.65	1,520
Corridor	2,400	6,700	2.79	1,430	3,350	1,39	455
South Luangwa NP	9,420	31,600	3,35	2,650	22,800	2.42	3,500
TOTAL	16,280	56,000	3.44		33,510	2.06	

	NLNP	Corridor	SLNP	Total
Percent decline 1973-1979	58%	50%	28%	40%
Decline in Nos. 1973-1979	10,340	3,350	8,800	22,400

*Table 3 - LUANGWA VALLEY Live and Dead Elephants seen within transects in three sub-samples

Area Name	LIVE	Recent Dead		"Old" Dead	
		1	2	3	4
North Luangwa NP	206 88%	0	2 1%	22 10%	2 1%
Corridor	111 74%	1 1%	3 2%	33 22%	2 1%
South Luangwa NP	546 87%	3 0.5%	4 0.5%	68 11%	7 1%
TOTAL	863 85%	4 0.5%	9 1%	123 12.5%	11 1%

Carcass Categories:

1. FRESH - Skin and flesh present, body rounded and may have vulture droppings.
2. ROT PATCH - Decomposition fluids stain soil and skin may be present or absent.
3. NO ROT PATCH - Vegetation growth around skeleton skin may still be present.
4. OLD BONES - Bones grey in colour with cracks and chips.

* See also map diagram of carcass ratios on Page 27

Elephant Trends

For the purpose of revealing trends in the elephant population we recalculated elephant population estimates for those portions of our transects which fell within exactly the same boundaries used by Caughley & Goddard (1975), that is for the North and South Luangwa National Parks and the Munyamadzi Corridor. Our results are presented in comparison with theirs in Table 2.

It would appear that in all three areas there has been a substantial decline in elephant numbers. With a combined population estimate today of 33,510, it would appear that there are 22,400 elephants fewer than were estimated in 1973.

We have discussed under Methods why we do not believe that this drop can be attributed to any deficiency in our observers.

The hypothesis that the drop might be caused by sampling error is also untenable, in view of the massive difference in numbers and the consistency with which the decline is replicated in the three sub-samples.

We conclude that the calculated overall decline of 40% between 1973 and 1979 is close to reality. The frequency of elephant carcasses and skeletons also has bearing on this apparent trend.

Elephant Carcasses and Skeletons

We have suggested elsewhere the value of recording dead elephants on aerial censuses, as an indicator of mortality (Douglas-Hamilton and Hillman, 1979). Factors affecting rate of breakdown of elephant carcasses are discussed in this paper.

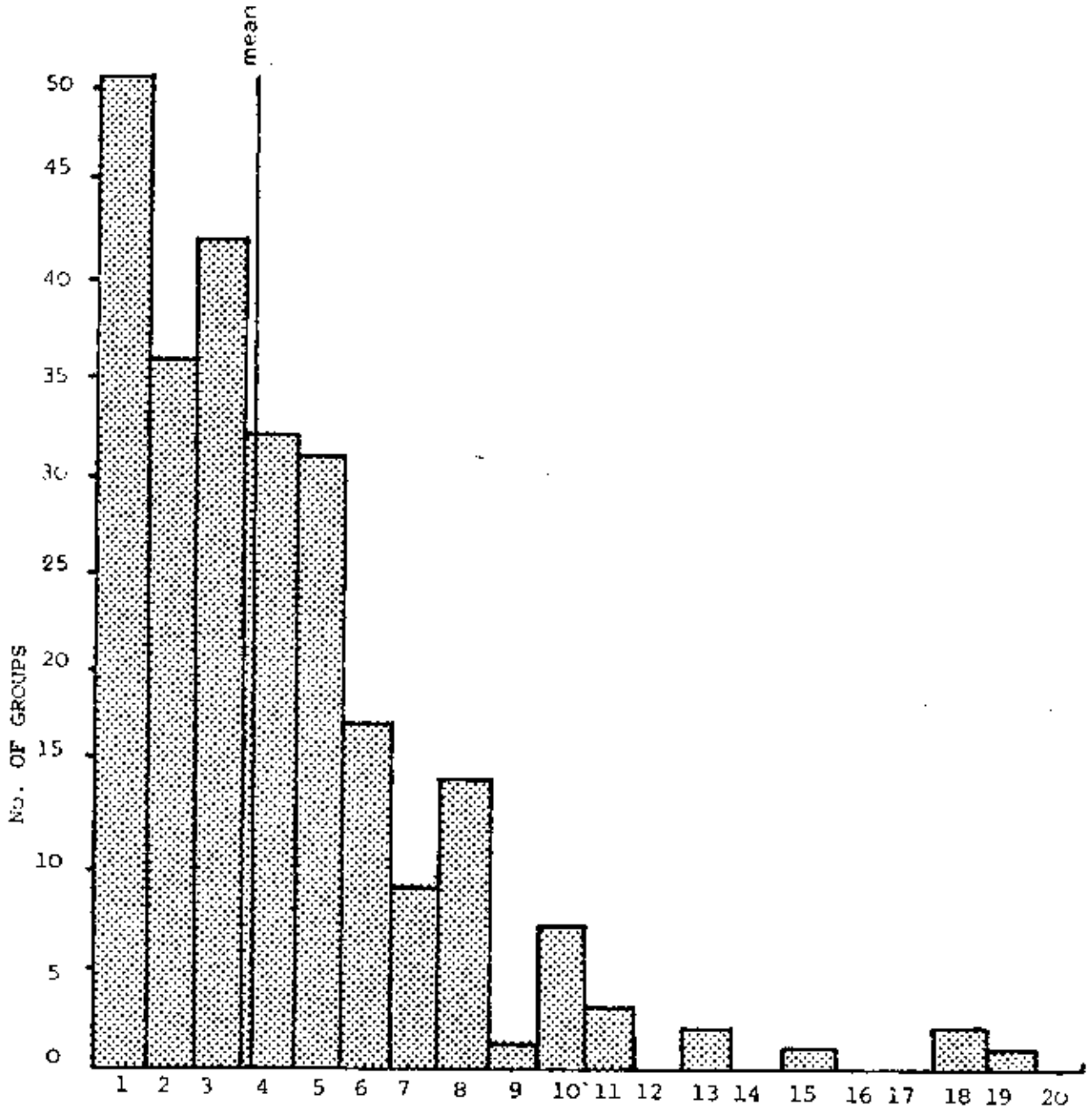
The total estimate of 5,720 dead elephants for the 20,000 km^2 Luangwa Census Zone gives a ratio of 14% dead to 86% live. The ratios have also been calculated seperately for the Luangwa National Parks North and South, and the Munyamadzi Corridor, according to the Caughley and Goddard (1975) boundaries, and the results are presented in Table 3. The ratios for these three sub-divisions are plotted diagrammatically on page 27. It appears that there has been a heavier mortality in the Munyamadzi Corridor than in either of the two Parks.

Without ground controls, it is impossible to assign accurate ages-since-death to carcasses, and hence to estimate annual mortality. However, each dead elephant has been recorded according to our standardized categories (op.cit.) and these records may be used as a base line for future aerial surveys made in the Luangwa Valley.

The proportion of dead to live in Luangwa is, nevertheless, high relative to IUCN/WWF/NYZS counts made under similar habitat and visibility conditions in the Ruaha, Rungwa, Kizigo Census Zone in 1977, and in the Selous Census Zone in 1976, both in Tanzania (Douglas-Hamilton 1976 a & b, 1977, 1978; Douglas-Hamilton & Hillman 1979). It is not as high, however, as the massive carcass ratios observed in Tsavo National Park, Kenya, and Kabalega National Park, Uganda, following uncontrolled outbreaks of

FIG 1 ELEPHANT GROUP SIZE FREQUENCIES

Luangwa Valley Oct. 1979.



N = 251

poaching in the mid 1970's. Nor does the proportion of"recent"carcasses in Luangwa suggest a massive recent mortality (i.e. those which are"fresh" or which still had a visible"rot patch"left by the decomposing fluids on the ground around the carcass, which we would usually consider to be less than a year old). Rather it would seem that the decline of Luangwa's elephants has been caused by an excessive,but not catastrophically high, mortality sustained over a number of years.

Elephant Group Size

Two hundred and fifty elephant groups were recorded along the transect. In each case,where a group lay across a transect boundary,it was counted in its entirety and the number within the transect was recorded. This method of recording allowed us to calculate group size frequencies and the mean group size, which are summarized in Fig. 1.

The mean group size was between three and four. This is the same as in the Selous Game Reserve, but very much lower than Tsavo National Park, Kenya, at 20, or the Kabalega National Park, Uganda, at 30.7. It has been suggested that group size may be related to the degree of harassment to which an elephant population has been subjected and that large herds of several hundred elephant are caused by excessive mortality among the matriarchs and a resulting tendency for the survivors to pack closely together.

While this explanation may be at least partly true for the large herds in Tsavo and Kabalega, it also appears that large herds are only found in relatively open habitat . Conversely, elephants living in thick habitat tend to be found in smaller groups even if they are harassed. The habitats of both Selous and Luangwa are both thick. The behavioural factors determining group size defy any simple explanation.

Habitat Parameters

The grid maps for Human Settlement and Poaching, Baobab Presence and Relative Damage; Grass, Shrub, and Tree, Greenness and Cover; Recumbent and Coppiced Trees; Bare Ground; Burn and Water Availability; and finally Habitat Type, are presented between pages 5 and 18. We are aware that far better maps may exist and that the ten by ten kilometre grid squares are,at best, a crude first-approximation of these parameters. Nevertheless, the quantities averaged for each sub-unit are assessed on the same pattern as the species distributions and are available for any desired correlation analysis.

It is interesting to note that evidence of poachers, such as huts or meat racks, marked by a P, and the incidence of burning, appear to increase towards the escarpment.

Baobabs only occurred rarely, but with increasing frequency towards the South. The level of damage to their bark by elephants was clearly more severe within the Park boundaries than to the East of the river or to the south.

The proportions of recumbent trees appeared to be most heavy in the North-East of Luangwa South National Park, whereas coppicing appeared throughout most of the mopani, and especially in the Luangwa North National Park.

Many of the clearly demarcated areas of dead trees appear to be associated with lower-lying basins and could have been due to hydrological or edaphic factors, rather than elephants.

Water was easily available throughout the Census Zone.

Species Distribution (for the month of October)

The sightings of each species have been summed for each grid square and converted to a density. This is intended to give the pattern of density distribution, but grid squares should not be considered individually. Species maps are arranged alphabetically between pages 19 and 41.

Elephants (page 25) show a definite concentration towards the river and away from the escarpment, whereas elephant skeletons appear to have a distribution approaching a random pattern.

Rhino (page 35) were found mainly in the Luangwa South National Park, towards the river. The highest density was found in the Nsefu block which was the subject of an additional high intensity count (page 42).

Giraffe (page 28) are strangely rare. Although to our East African eyes much of the Census Zone looked favourable giraffe habitat, they were virtually absent except in the South and only one was seen within our transects.

Hartebeeste (page 29) tend to be found at the foot of the escarpment unlike most other species.

Hippopotamus (page 30) not surprisingly have the most sharply defined distribution which matches almost exactly the major water courses.

Wildebeeste seemed curiously restricted to the North-Eastern portion of the Census Zone. Zebra, however, were distributed widely in both Parks.

DISCUSSION

Elephant Management

Although the elephant destruction of woodlands has obviously been widespread and severe, as detailed in the FAO studies and reflected in our distribution maps of recumbent and coppiced trees (pages 13 & 14) it would appear that there has been a fundamental change in elephant population density since 1973. Our estimate of 1.7 elephants per square kilometre for the whole Luangwa Census Zone is still relatively high, falling between the Selous Game Reserve at 1.48/km^2 and the Ruaha National Park and environs at 2.41/km^2 (Douglas-Hamilton 1976,1977).

It is also perhaps worth making a rough estimate of the numbers of elephants in the whole Luangwa Valley which covers 145,000 km^2. Caughley and Goddard, extrapolating their results, suggested that there were unlikely to be less than 100,000 elephants in the whole valley. The areas we have compared show a 40% decrease. It is likely that the decline in elephants will be greater in the less well policed ranges outside of the National Parks. Extrapolating the 58% decline registered for the Luangwa North National Park, and applying it to the remaining populations outside the National Parks and Corridor areas, we have calculated that the whole Luangwa Valley elephant population may now be of the order of 50,000 animals.

The combined density within the Luangwa National Parks North and South and the Corridor has however, decreased from 3.44/km^2 to 2.06/km^2. The effect of elephants on the trees within these areas may be presumed to have decreased proportionately, that is by approximately 40%. Whether or not this is enough to permit tree regeneration to match tree destruction cannot be answered without a long-term ground monitoring of the woody vegetation.

There are several possible options when elephants begin to destroy trees faster than they can regenerate:-

1. "Neglective laisser faire" - Leave everything alone. Let the elephants destroy the trees and starve if they will, or let the poachers slaughter them.

2. "Positive Laisser faire" - Carry out a policy of minimum interference, use management sparingly. Allow habitat changes induced by elephants and allow them to starve if necessary. Tolerate any habitat changes short of those which are irreversible, but prevent poaching.

3. "Harassment" - Shoot at the elephants sporadically, frighten them with sirens and thunderflashes, chase them with helicopters, force them to move outwards, to decompress, and lower their density.

4. "Cropping" - Limit the elephant numbers scientifically, so that a sustained yield is exacted, and numbers are stabilized at a level, set by management, at which they do not much affect the habitat. Use their products to the maximum economic advantage.

5. "Culling" - Simulate a natural disaster for the elephant. Shoot their numbers down, well below the level at which the habitat can sustain them, and then let them recover.

In the Luangwa Valley there was a time when several of these solutions would have been sound, although some have obvious disadvantages. Now the situation is less clear-cut. The reason is that poaching seems to have taken a firm hold and caused the decline in elephants (Kaweche 1978). The increase in poaching is a continent-wide phenomenum associated with the rise in the price of ivory, and has caused elephant decline in many countries. (Douglas-Hamilton, 1979).

It could be argued that one acceptable policy would be to turn a blind eye to poaching and allow it to reduce the elephants until their density has reached a desired level. There are three obvious disadvantages to this policy:-

1. There is no easy way of stopping the poachers once the desired elephant density is reached. Poachers usually continue until elephants are so scarce that they no longer reward the effort of hunting them.

2. Rhinos tend to be taken by ivory poachers as the opportunity arises and would most likely become extinct well before the poachers found elephants uneconomical to hunt.

3. Lawlessness, if condoned in one sphere, is likely to be translated into a general contempt of the law. Indeed it is in countries which have experienced corruption, or where the law is held in generally low regard, that the declines of elephants and other wildlife have been the most spectacular.

Likewise, "culling", "cropping", or "harassment", under the present circumstances, need to be approached with great caution as management options, at any rate until the poaching is under control. For the future, a carefully controlled elephant cropping, which brought returns to local people, would be a beneficial policy for the elephants and the National Parks, but today, without poaching control, could lead to an uncontrolled acceleration of the elephant decline.

Licensed hunting within the valley, on the other hand, seems to have a highly positive effect in deterring poaching gangs, according to Mr. Phil Berry and numerous other informants we met. The system of honorary wardens seems, at present, the only form of effective control of poaching.

In summary, for elephants, the control of poaching appears to be the outstanding priority, and until this is accomplished cropping or culling projects should be shelved. On the other hand, licensed hunting, even of elephants, should continue.

Rhinoceros Trends

It is well known that population estimates of rhinos based on aerial counts are usually underestimates, but by how much is a matter for conjecture. Goddard (1969) increased his rhino estimates from two to seven times in analysing aerial count data collected in Tsavo National Park. However, his correction factors may have been too large, being derived from a calculation based on individuals in Olduvai Gorge, and the questionable premise that all his known animals were present in the same area at the time when he made his aerial censuses. Western estimated a correction factor of 1.6 based on six years of regular aerial monitoring compared to known individuals in Amboseli National Park, Kenya. He used the same technique of aerial strip sampling which we employed in Luangwa. The Kenya Rangeland Ecological Monitoring Unit (KREMU) have adopted a correction factor of 2, but on what reasoning we do not know. However, their population estimate agrees well with the independent estimate of the Kenya Rhino Action Group.

Since Luangwa has a denser vegetation cover than Amboseli and hence poorer visibility, we have adopted a correction factor of 2, which we believe is conservative. When applied to the Luangwa data it gives a rhino population of 1,734 and a density of .09/km^2 for the Luangwa Census Zone of 20,000 km^2. The true figure could be higher.

Rhinos also occur outside the Parks, and until November 1979 were being shot on licence, but reports by knowledgeable people in the area and geologists working outside the Park, indicate that the density of rhinos and other wildlife is far less outside the Parks. Rhinos are probably completely absent from many areas. An overall mean density for the whole of the rest of the valley of 0.01 rhinos/km^2, we consider a reasonable figure. This gives a rough estimate of 1,250 rhinos for the rest of the valley's 145,000 km^2.

The whole valley could thus contain between 2,500 and 3,500 rhinos, possibly considerably more. This, nevertheless, is substantially less than Naylor et al's 1973 estimate of 4,000 to 12,000. The increased poaching of rhinos (Berry P pers. comm.) and a drop in the mean weight of trophy horns for 2.43 kg to 1.54 kg between 1973 and 1977 (Kaweche & Mwenye 1978) all indicate a considerable reduction in the rhino population of Luangwa Valley.

In conclusion, anti-poaching measures are needed even more urgently to conserve the rhino than the elephant. Further information on rhinos was obtained in a high intensity count of the Nsefu National Park (page 42).

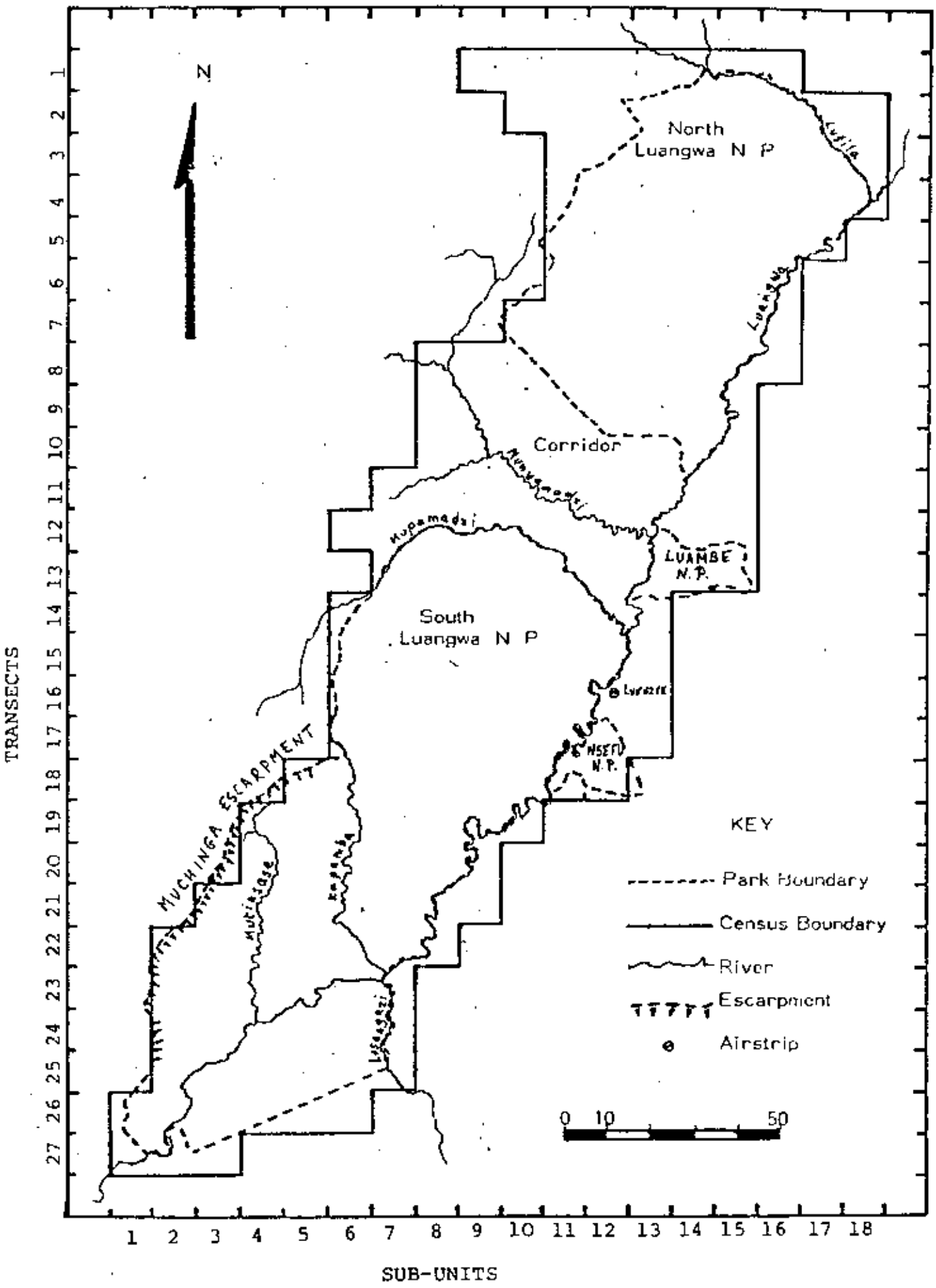
LUANGWA VALLEY CENSUS ZONE

Dry Season Oct. 1979

Dates:	2-5 October 1979
Aircraft:	5Y BAD Cessna 185
Pilot:	Iain Douglas Hamilton
Front seat observer:	Kes Hillman
Back seat observers:	Patrick Ansell and Patrick Holt
Mean flying height:	298.97 ft.
Total area:	20,000 Km.^{2}
Mean combined strip width:	288.35 m

LUANGWA VALLEY CENSUS ZONE

Dry Season October 1979



LUANGWA VALLEY CENSUS ZONE

Dry Season Oct. 1979

Transect No.	Length Km.	Transect Area Km^2
1	80	23.07
2	90	25.95
3	80	23.07
4	80	23.07
5	70	20.18
6	60	17.30
7	70	20.18
8	90	25.95
9	80	23.07
10	80	23.07
11	90	25.95
12	100	28.84
13	90	25.95
14	80	23.07
15	80	23.07
16	80	23.07
17	80	23.07
18	80	23.07
19	70	20.18
20	60	17.30
21	70	20.18
22	70	20.18
23	60	17.30
24	60	17.30
25	60	17.30
26	60	17.30
27	30	8.65
Total	2000	577.00

Mean strip width = 288.35

Table 3: Transect Data

LUANGWA VALLEY CENSUS ZONE

DRY SEASON OCTOBER 1979

Transect No.	Baboon	Buffalo	Bushbuck	Bushpig	Crocodile	Eland	Elephant	Elephant skeleton	Giraffe	Greater Kudu	Hartebeeste	Hippo
1	15	0	0	0	0	0	0	1	0	0	0	2
2	0	101	0	0	0	0	0	8	0	0	0	0
3	0	11	0	0	0	1	8	1	0	0	0	0
4	1	3	0	2	0	0	31	7	0	0	3	4
5	0	30	0	0	0	0	33	6	0	3	5	29
6	0	12	0	0	0	0	47	3	0	2	0	17
7	0	73	0	0	0	0	55	6	0	0	1	29
8	0	5	0	0	0	0	21	2	0	6	0	29
9	0	0	0	0	0	5	26	4	0	0	8	39
10	8	98	0	0	0	0	38	8	0	0	0	1
11	0	0	0	0	1	0	33	19	0	0	0	1
12	1	1	0	0	4	0	38	10	0	0	5	26
13	5	75	1	0	0	1	65	9	0	0	0	13
14	6	138	0	0	0	0	43	4	0	0	0	20
15	0	0	0	0	10	0	90	3	0	0	0	26
16	0	0	0	0	0	0	44	10	0	0	0	16
17	0	5	0	1	3	0	76	7	0	0	6	11
18	0	5	0	0	0	37	50	7	0	0	0	31
19	0	0	1	0	0	0	77	11	0	2	0	3
20	0	0	0	0	0	0	19	2	0	0	0	11
21	0	90	0	0	0	0	33	3	0	0	2	6
22	0	119	0	0	0	0	28	5	0	0	0	0
23	0	0	0	0	4	0	17	9	0	1	3	23
24	0	0	0	0	0	0	71	8	0	0	0	5
25	0	8	0	0	2	0	39	8	0	0	0	22
26	30	2	0	0	0	20	37	3	0	0	0	6
27	10	0	0	0	0	0	0	1	1	0	0	14

Table 4 : Animals per Transect

LUANGWA VALLEY CENSUS ZONE

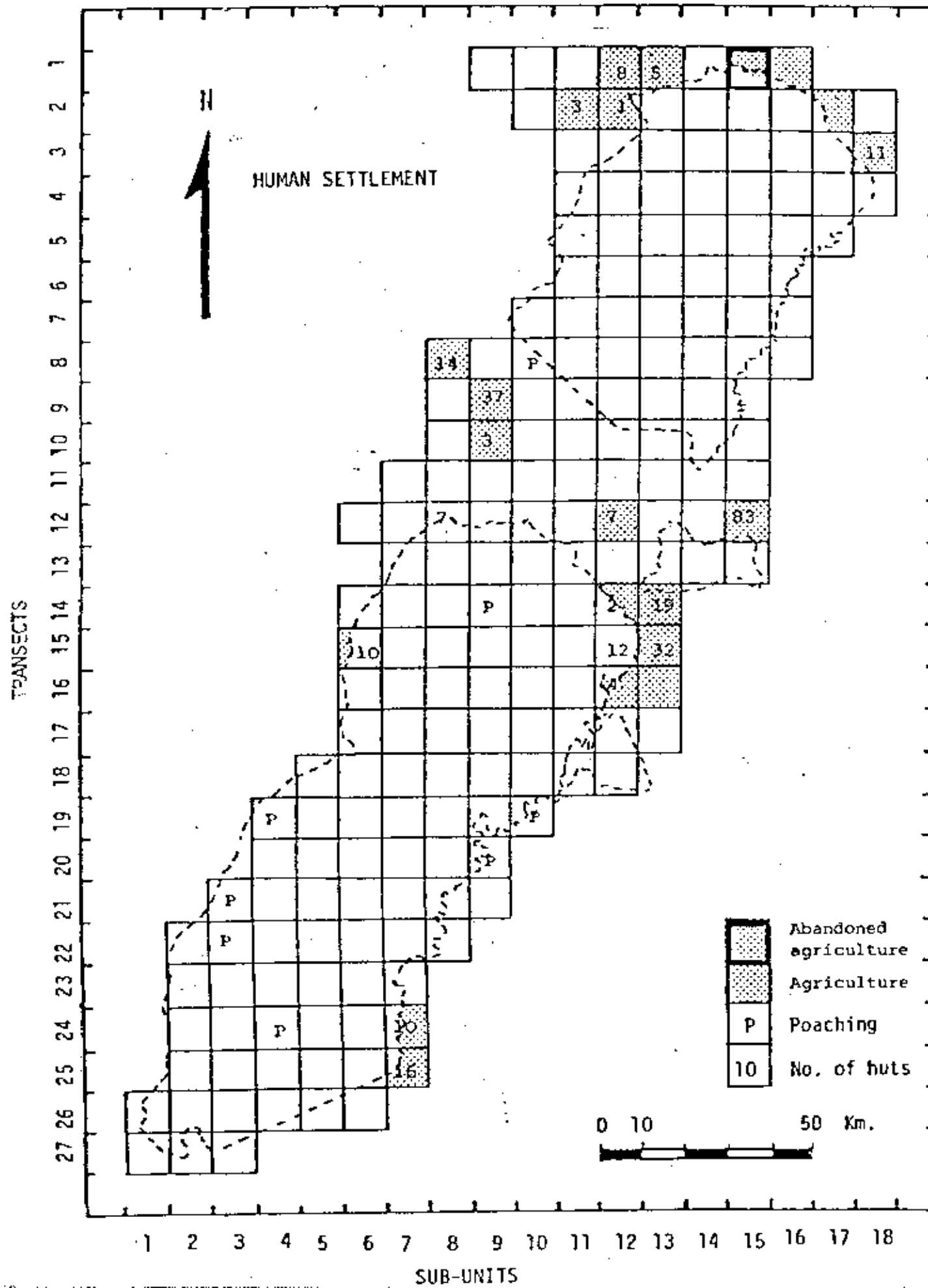
DRY SEASON OCTOBER 1979

Table 4 cntd.

Transect No.	Hyaena	Impala	Lion	Puku	Rhino	Roan	Small Ungulate	Warthog	Waterbuck	Wildebeeste	Zebra
1	0	0	0	0	0	0	1	2	7	0	8
2	0	0	0	0	0	0	1	4	0	64	20
3	0	15	0	0	1	0	1	0	0	0	4
4	0	15	0	0	1	0	0	16	22	29	27
5	0	28	0	8	0	0	0	1	13	0	42
6	0	11	2	2	0	0	0	0	15	32	16
7	0	13	0	30	0	0	1	0	0	0	7
8	0	86	0	2	0	0	0	6	0	3	1
9	0	48	0	15	0	0	0	7	25	3	13
10	0	0	0	0	0	0	0	9	0	3	4
11	0	18	0	12	0	0	0	9	44	55	6
12	0	57	0	25	2	8	0	13	19	35	13
13	0	50	0	20	0	0	0	8	50	64	41
14	2	86	0	11	0	0	0	11	13	7	61
15	0	33	0	27	2	0	0	3	5	0	51
16	0	41	0	0	2	0	0	1	12	1	30
17	0	24	0	8	1	0	0	0	7	1	0
18	0	30	0	0	3	0	0	5	12	24	27
19	0	83	0	19	2	0	1	6	3	0	23
20	0	30	0	5	0	0	0	3	7	0	0
21	0	0	0	0	0	0	0	1	0	0	10
22	0	11	0	15	2	0	0	3	7	0	17
23	0	85	0	32	1	0	0	2	7	0	14
24	0	24	0	2	2	0	0	4	3	0	5
25	0	61	0	11	6	1	0	8	8	0	0
26	2	1	0	0	0	0	0	1	0	0	0
27	0	0	0	5	0	0	0	7	0	0	0

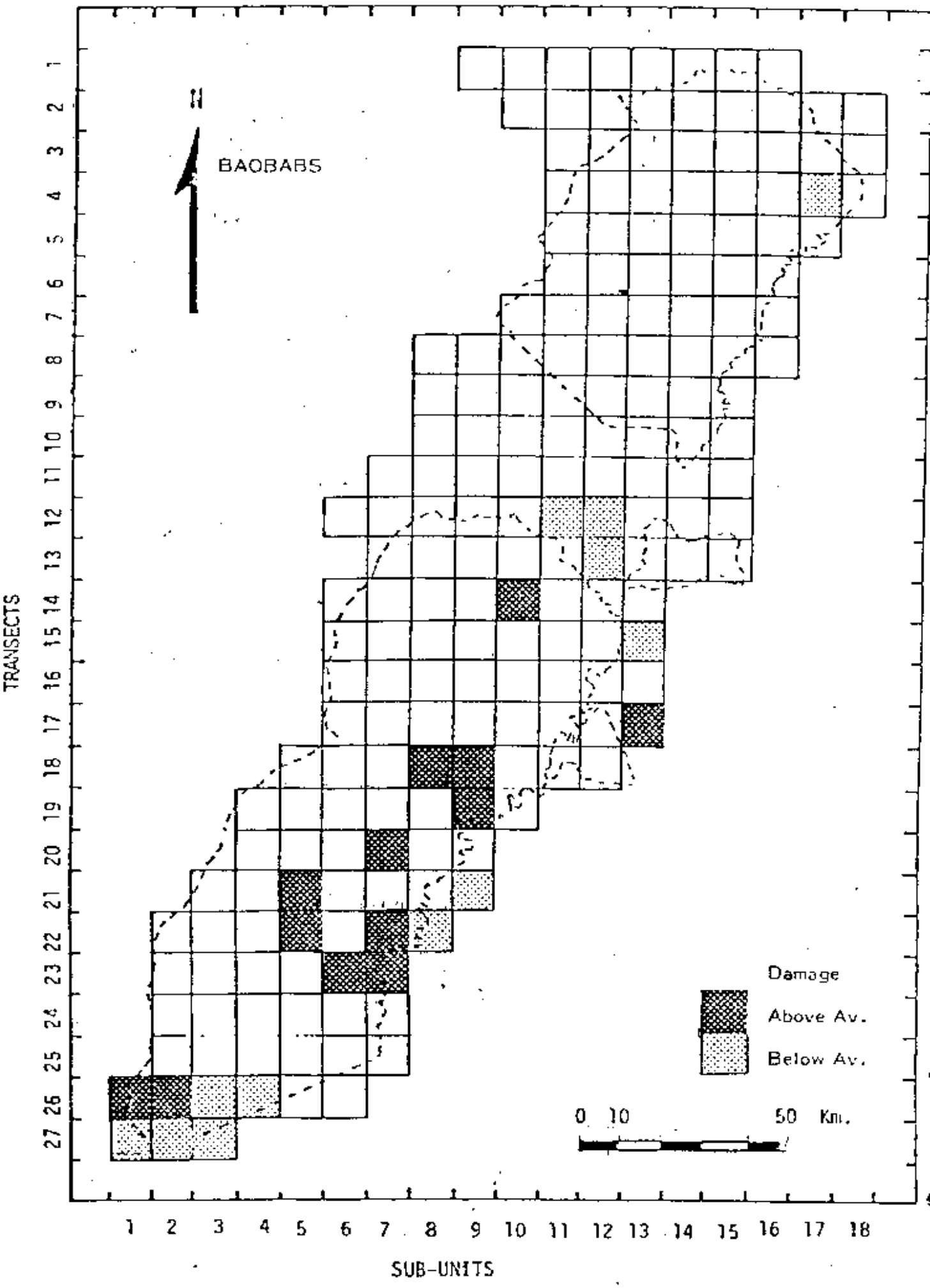
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979

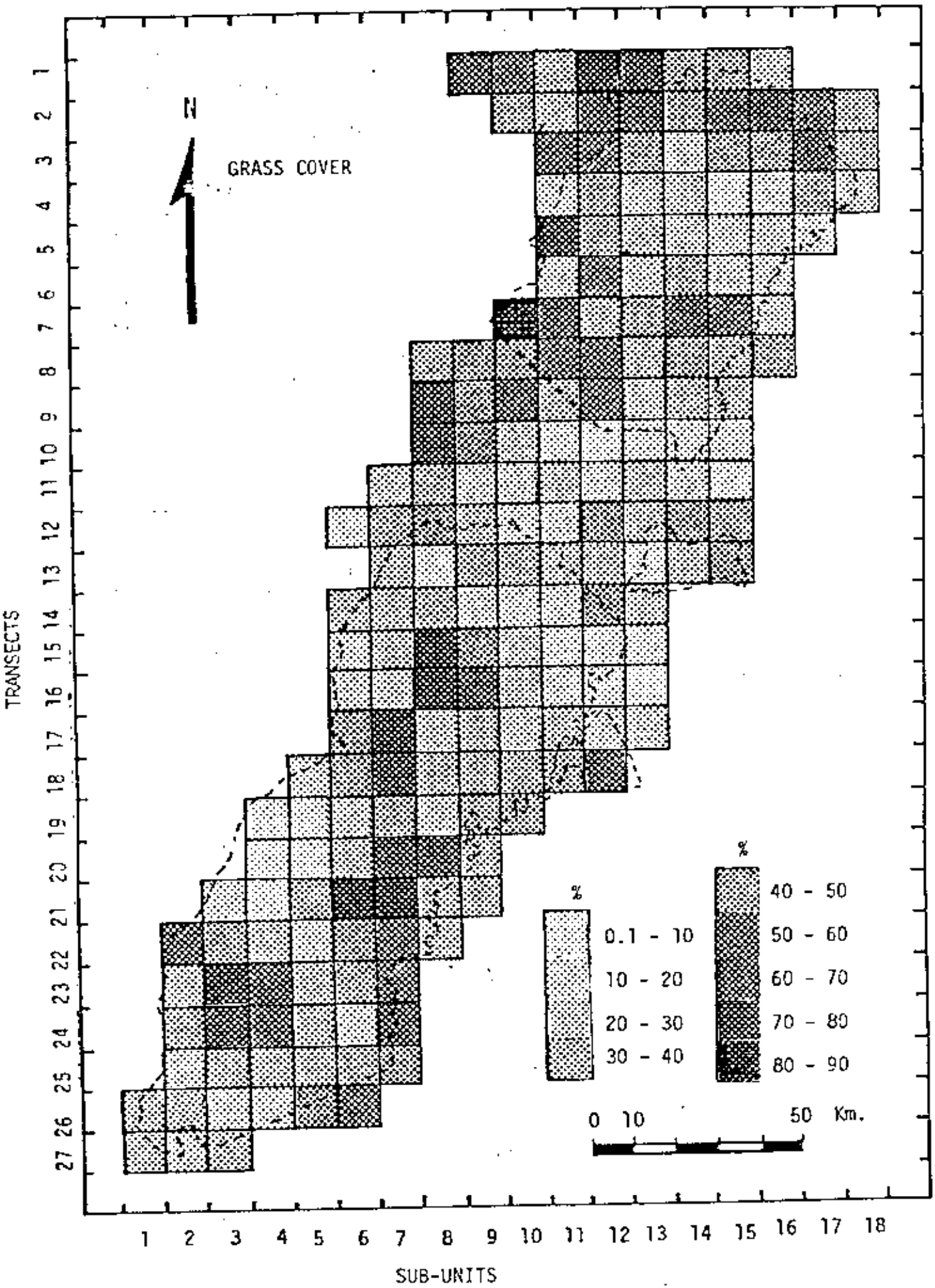


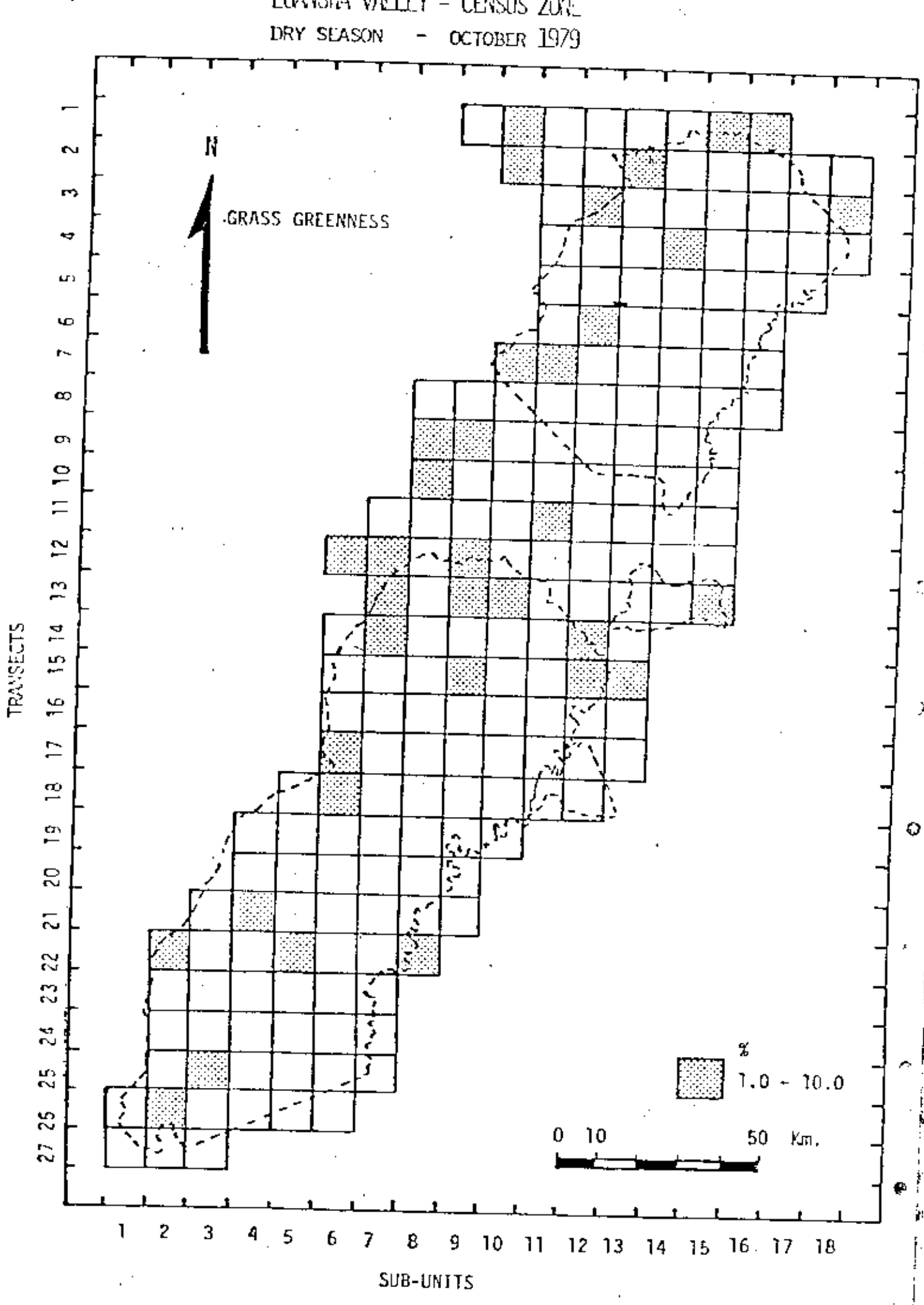
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



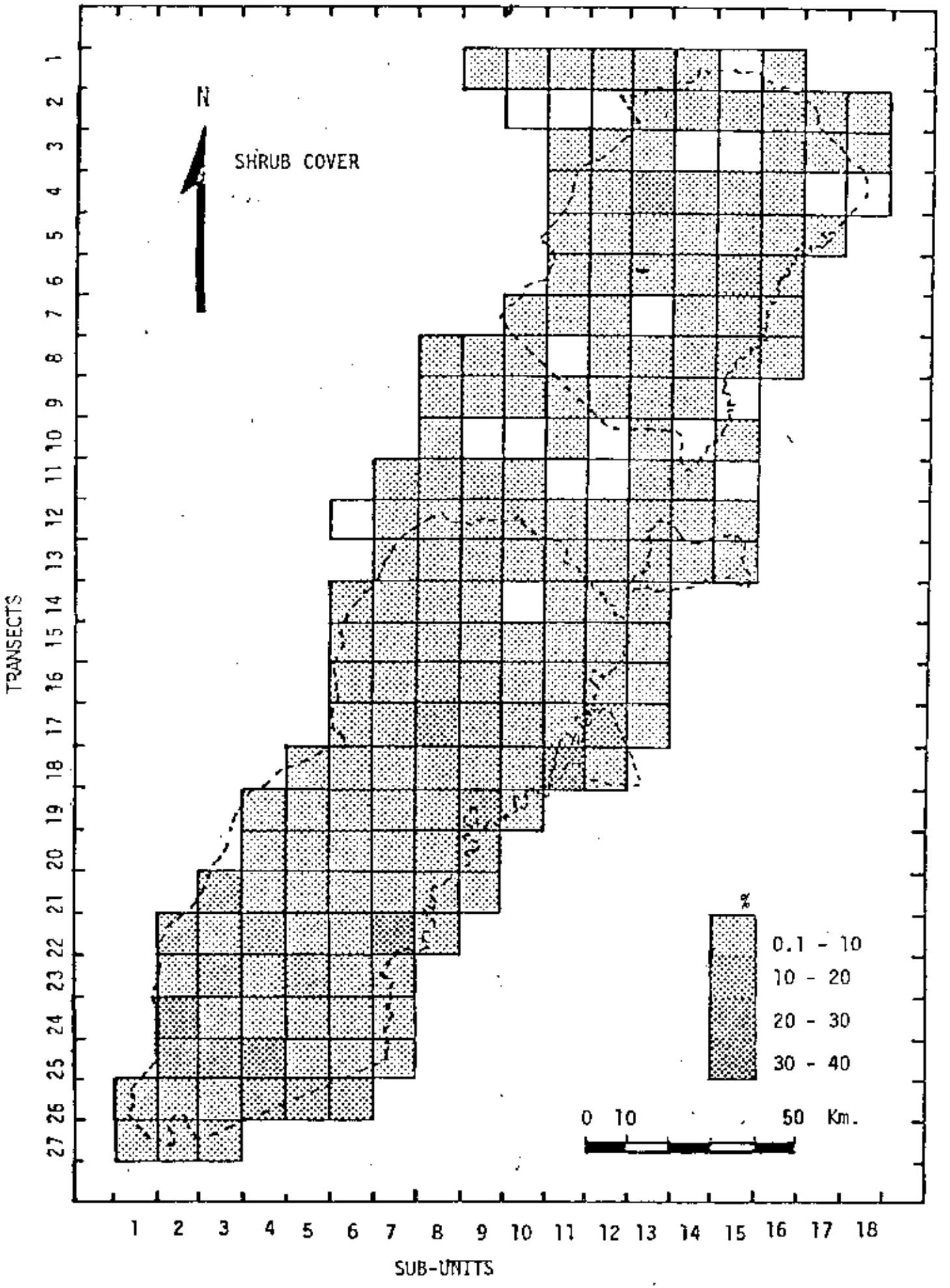
LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979




LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979
N
GRASS GREENNESS
TRANSECTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 27
SUB-UNITS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
%
1.0 - 10.0
0 10 50 Km.

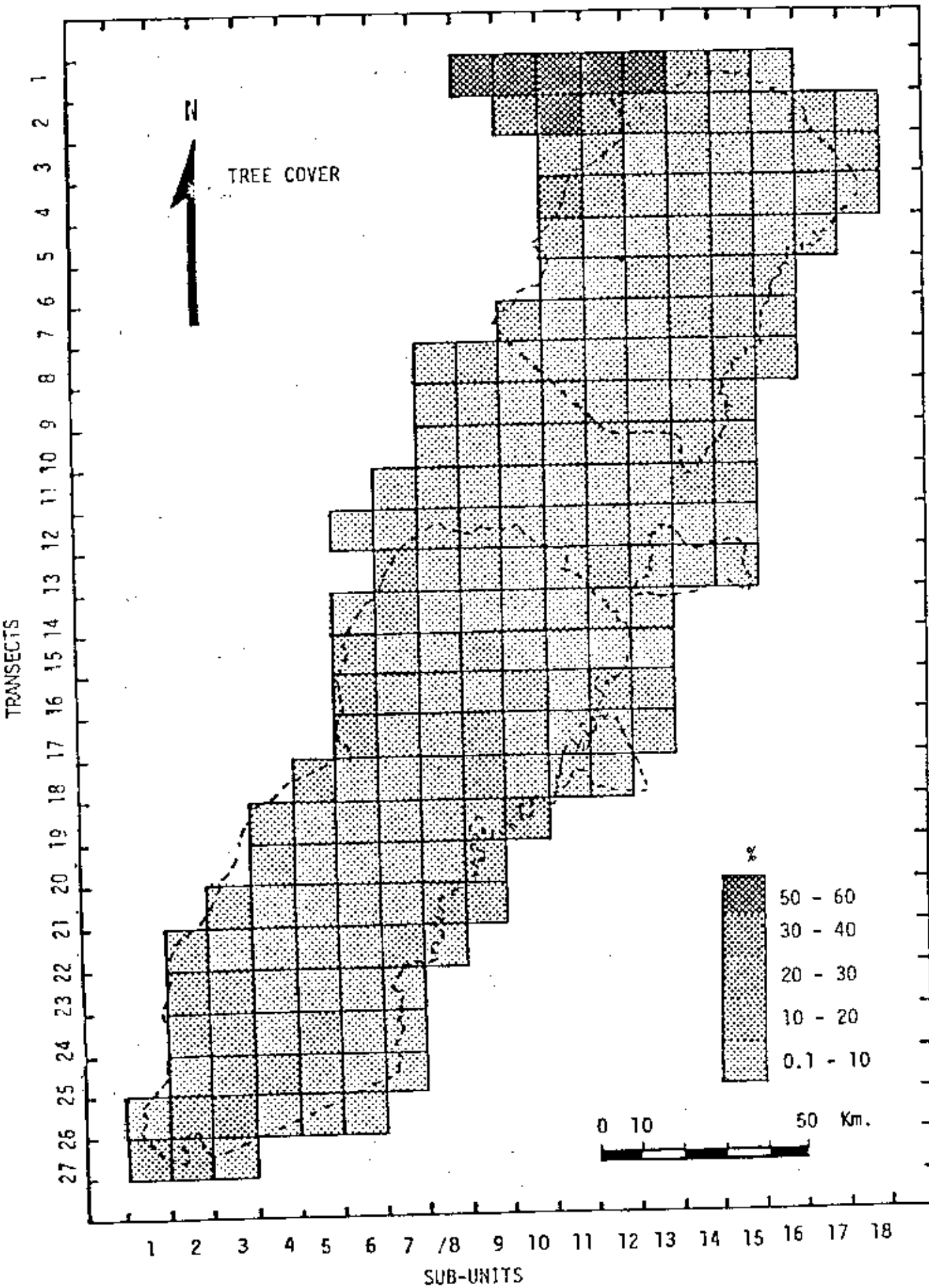
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



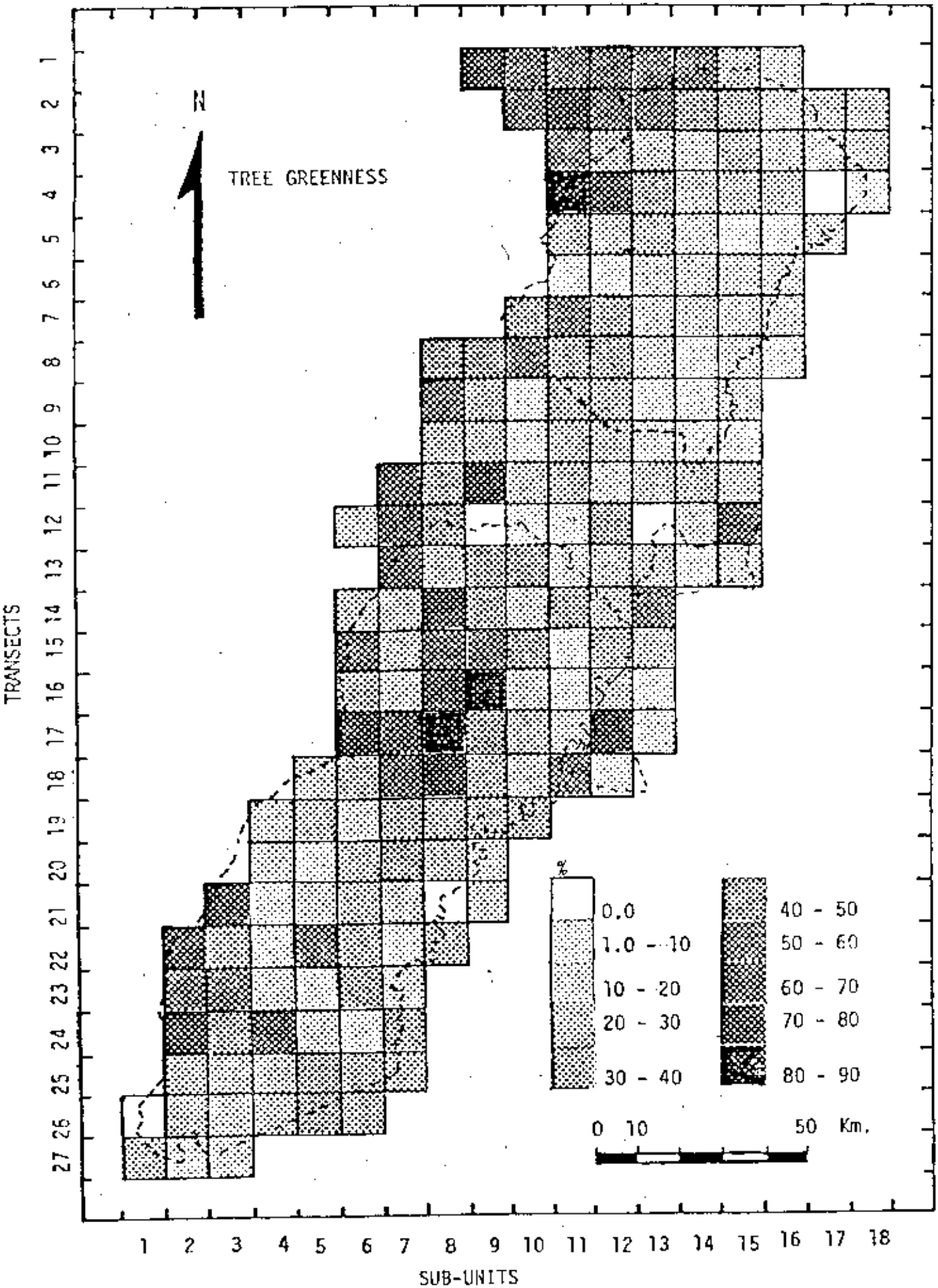
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



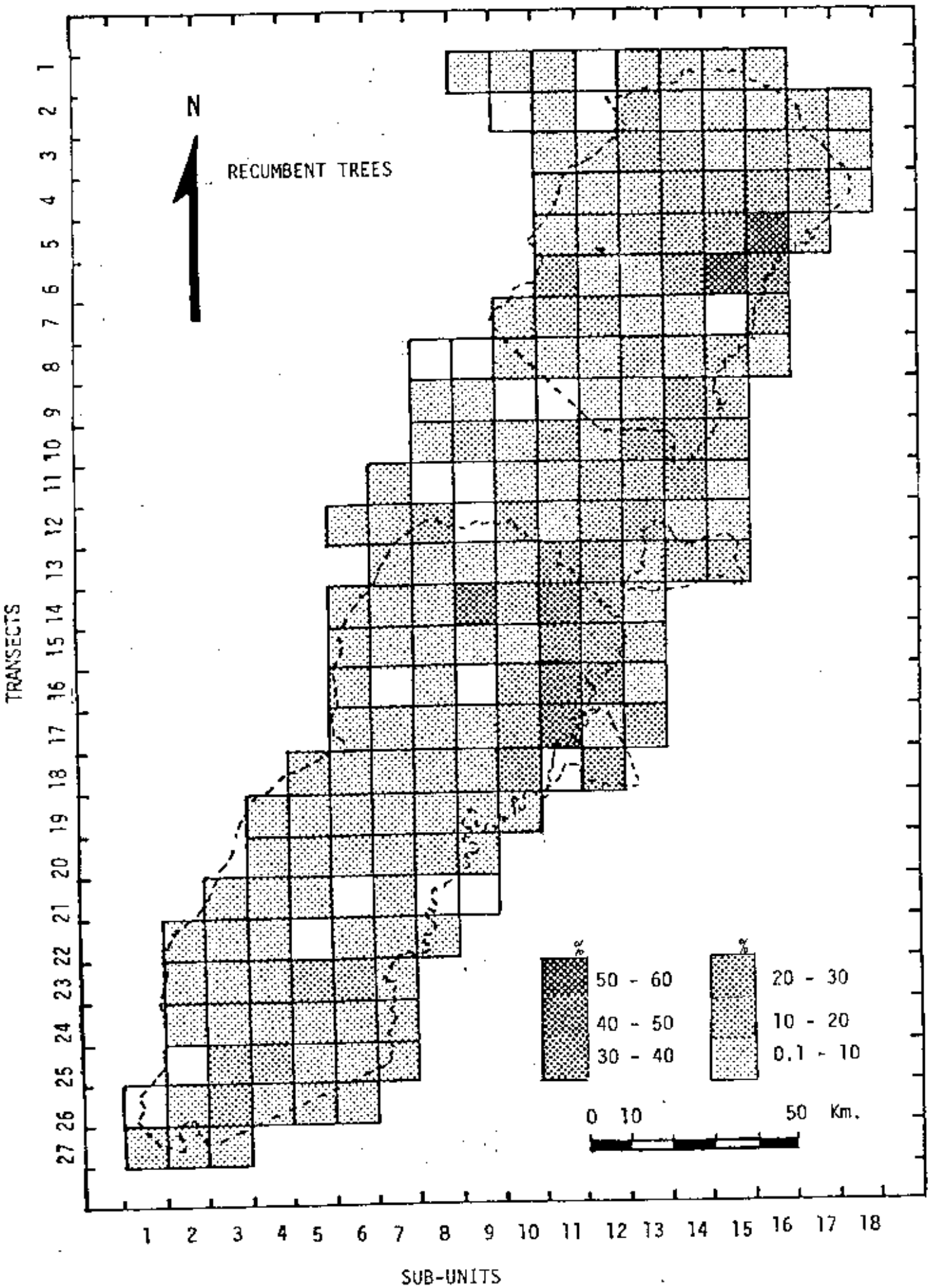
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



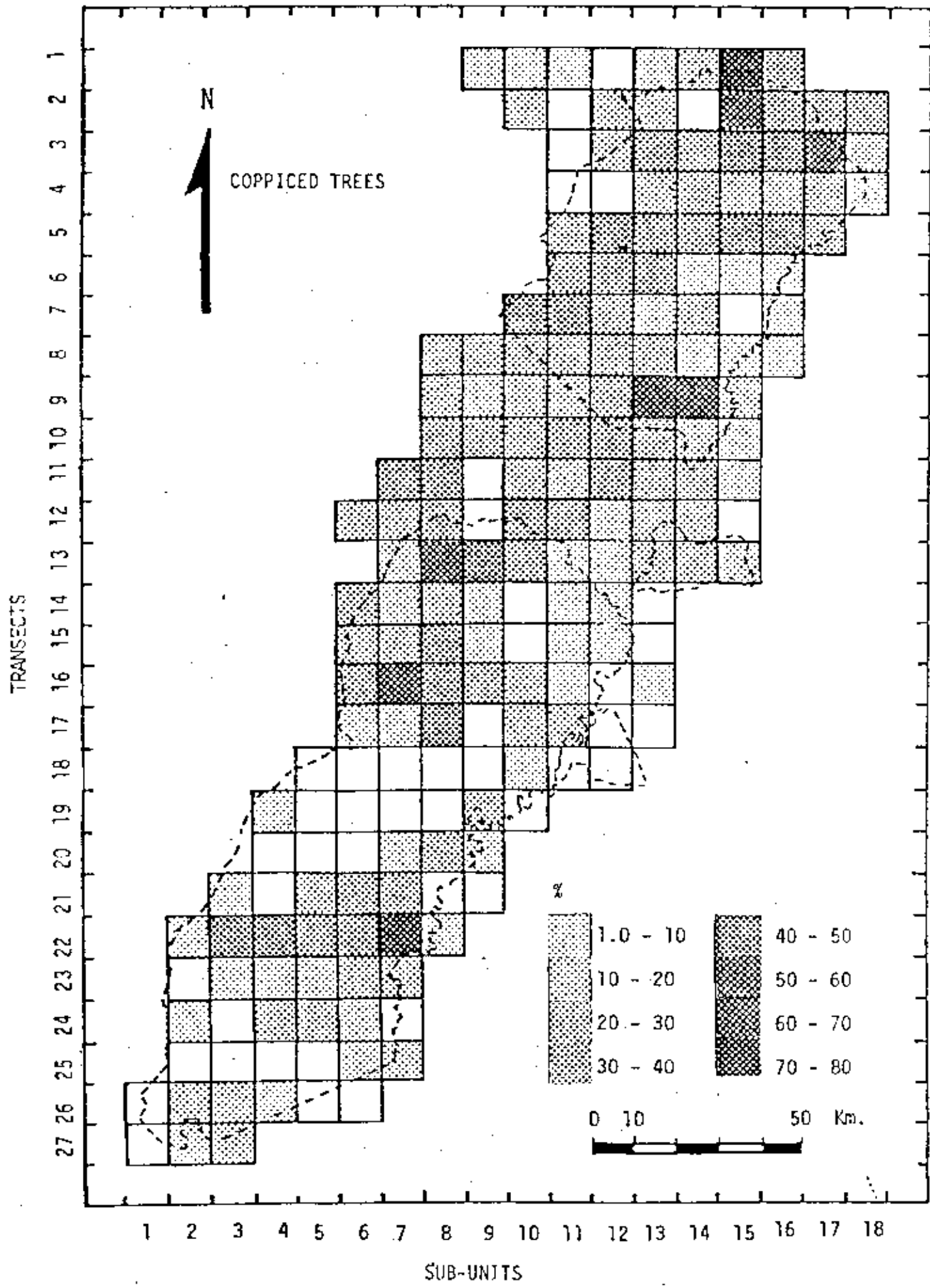
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979

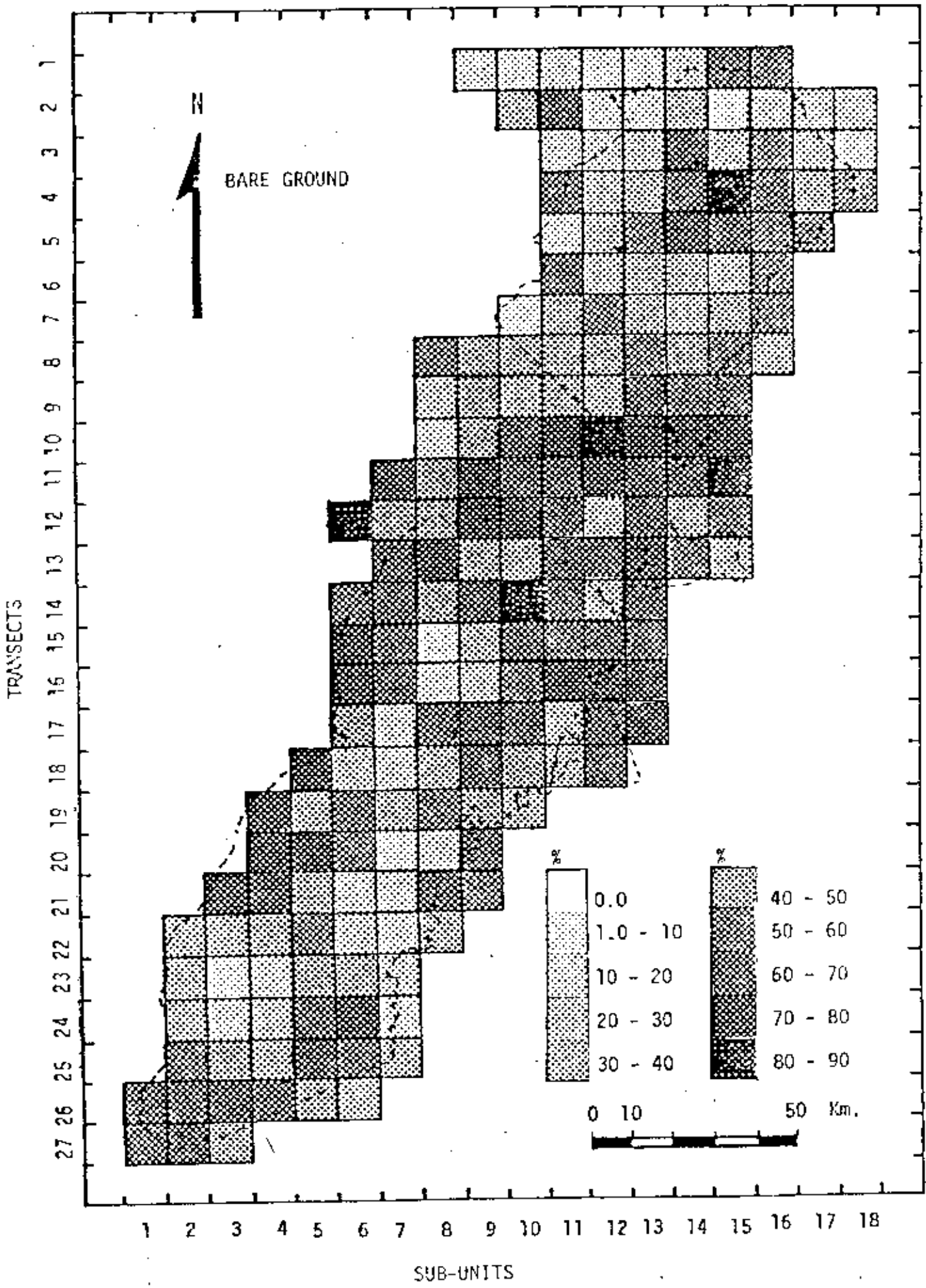


LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979

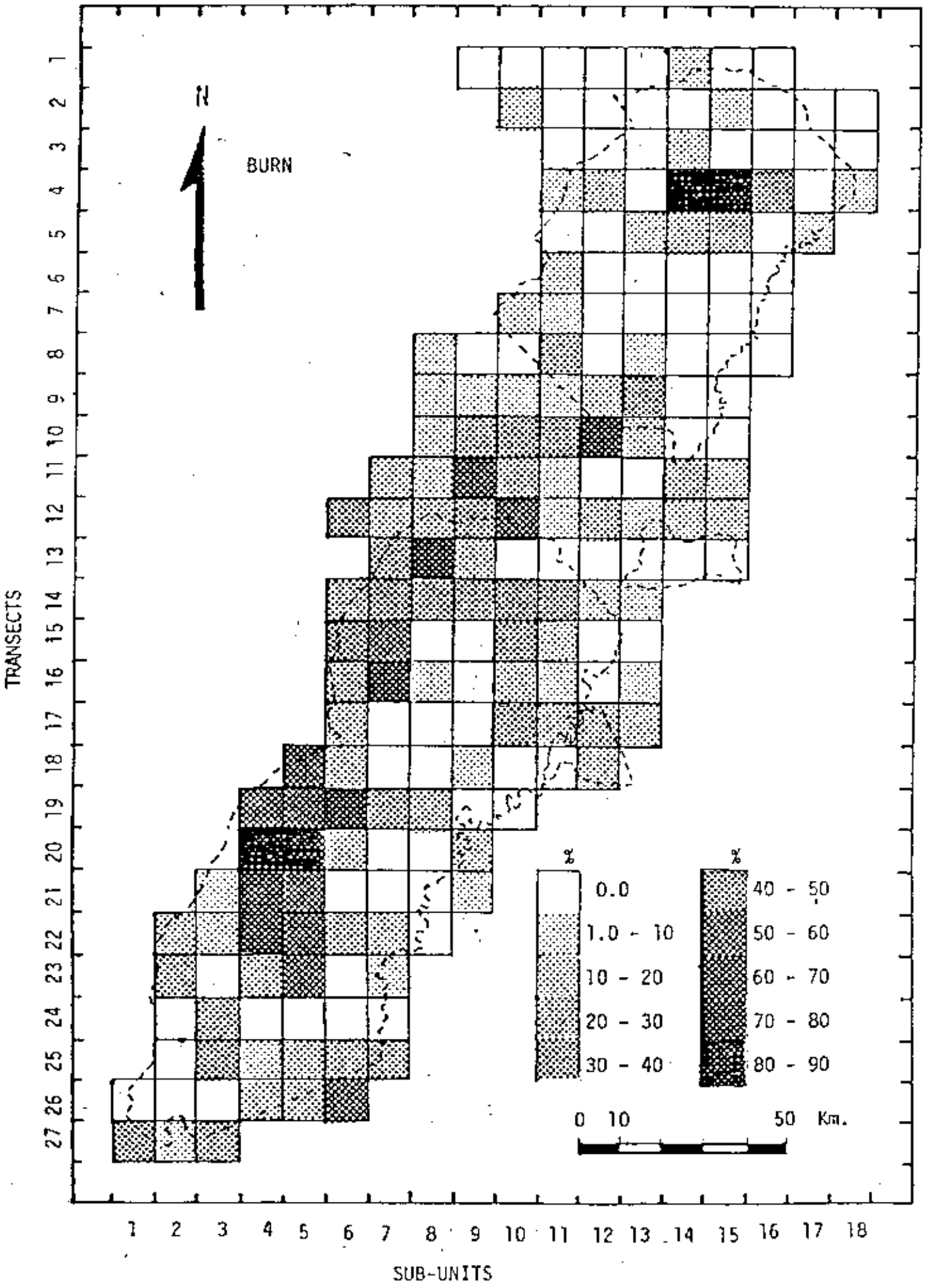


LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979



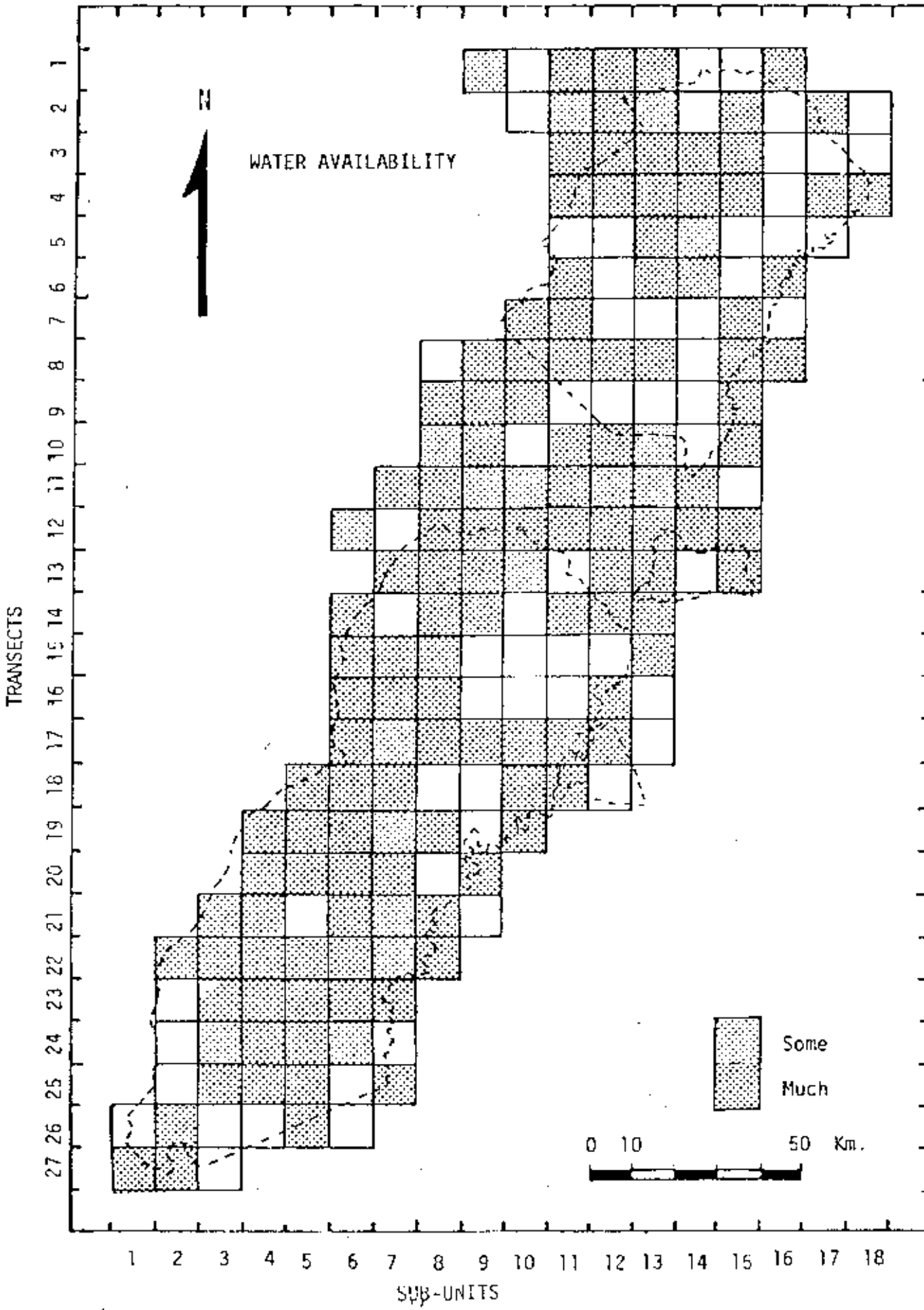
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



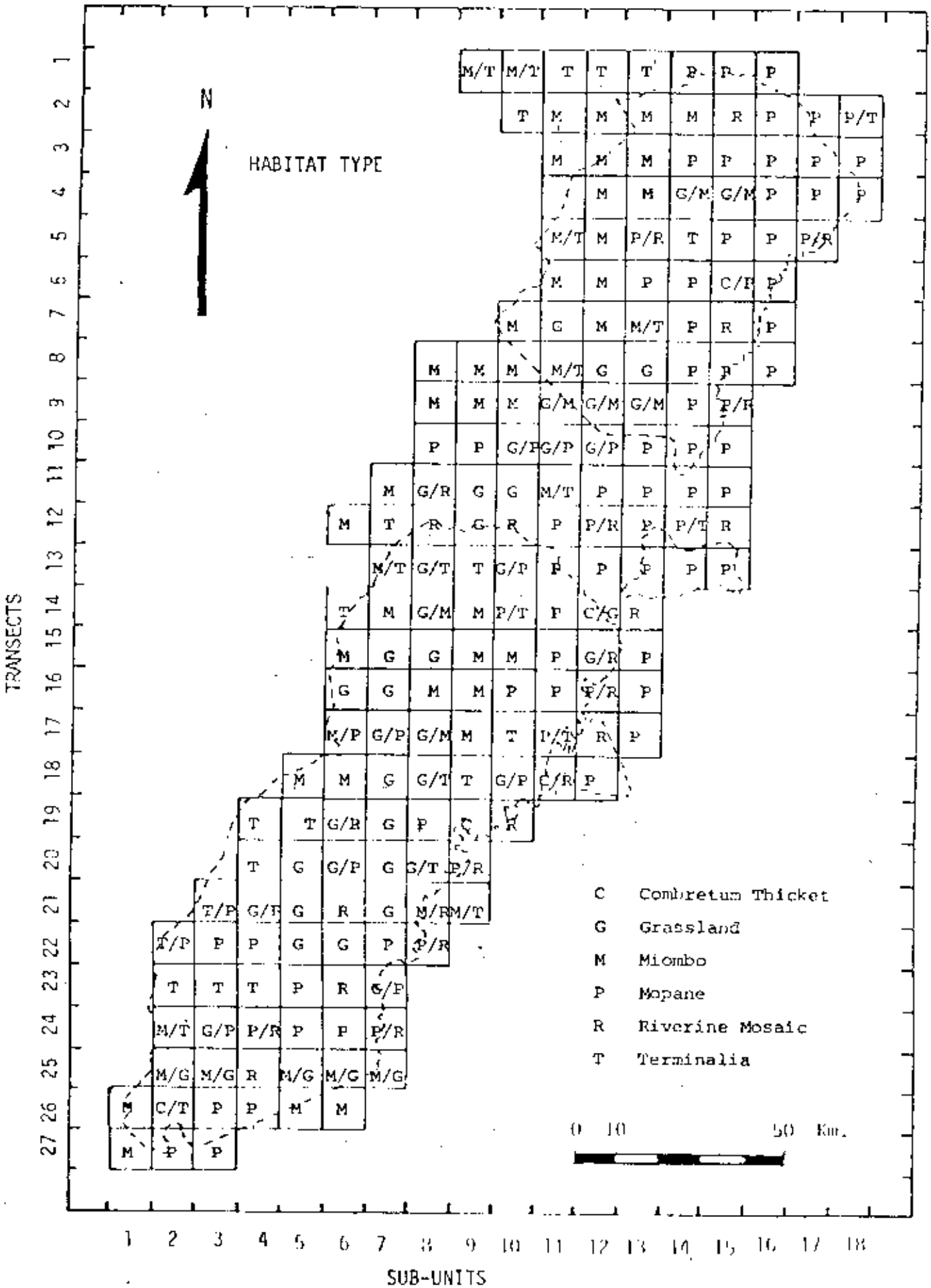
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



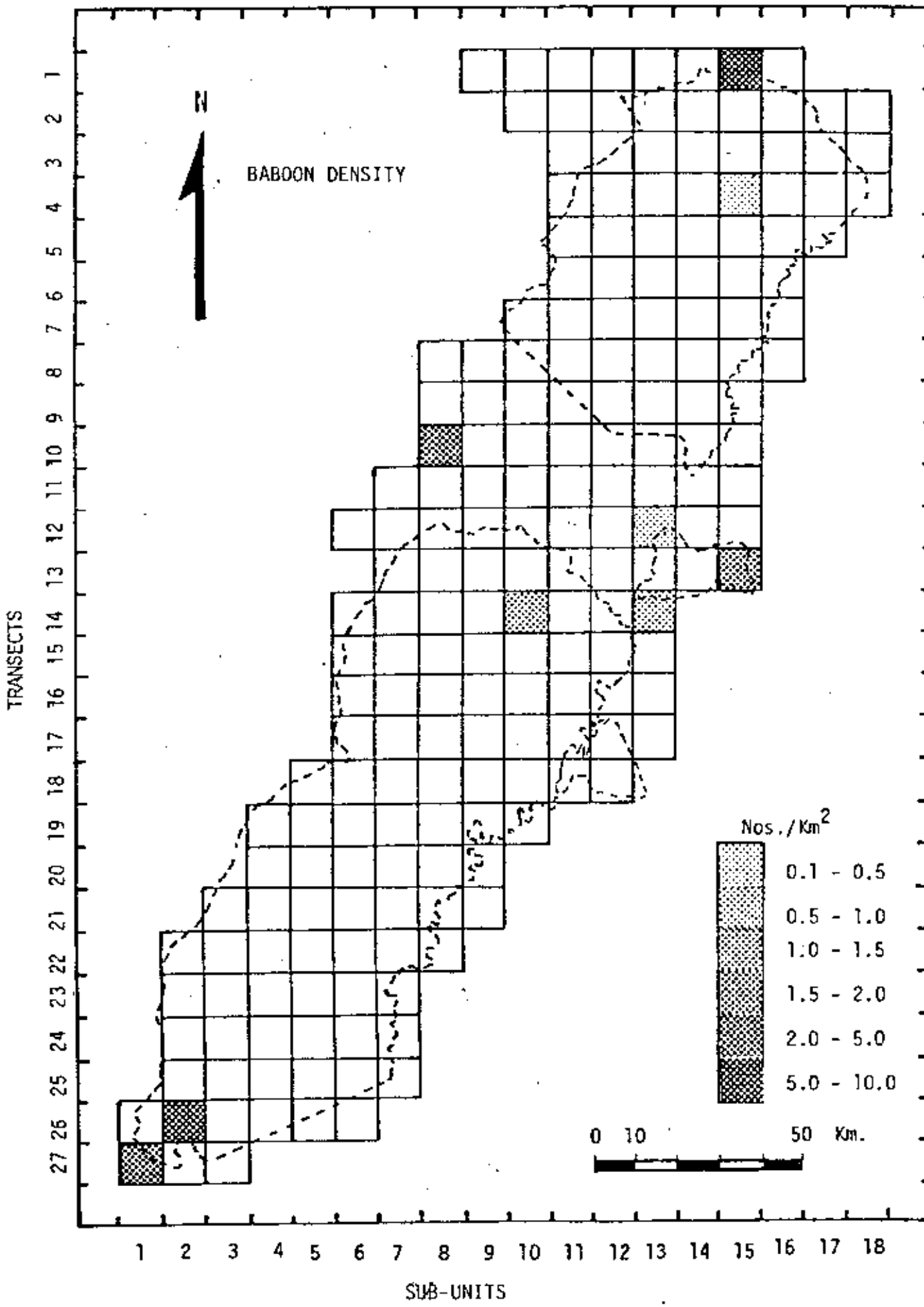
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



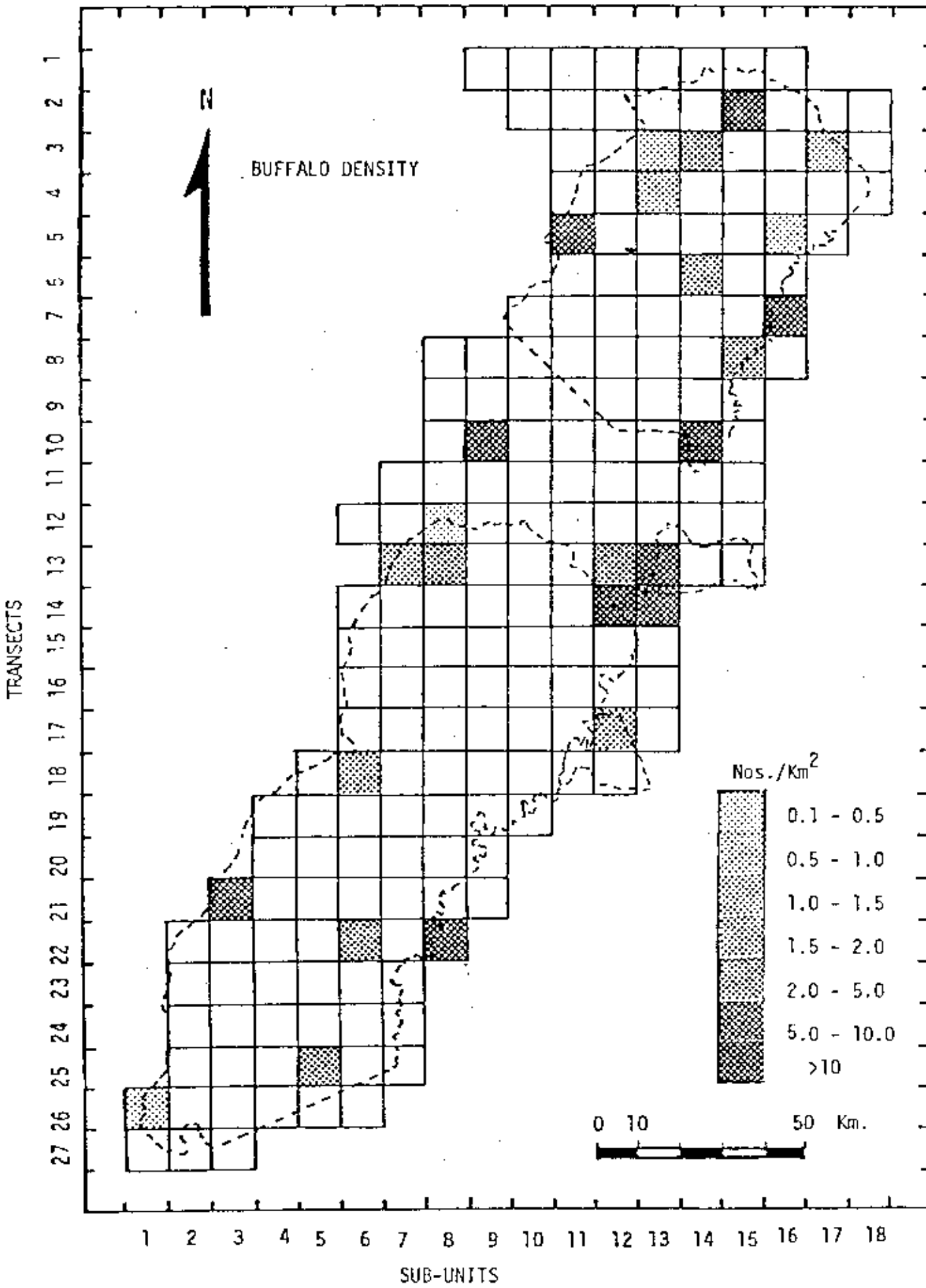
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



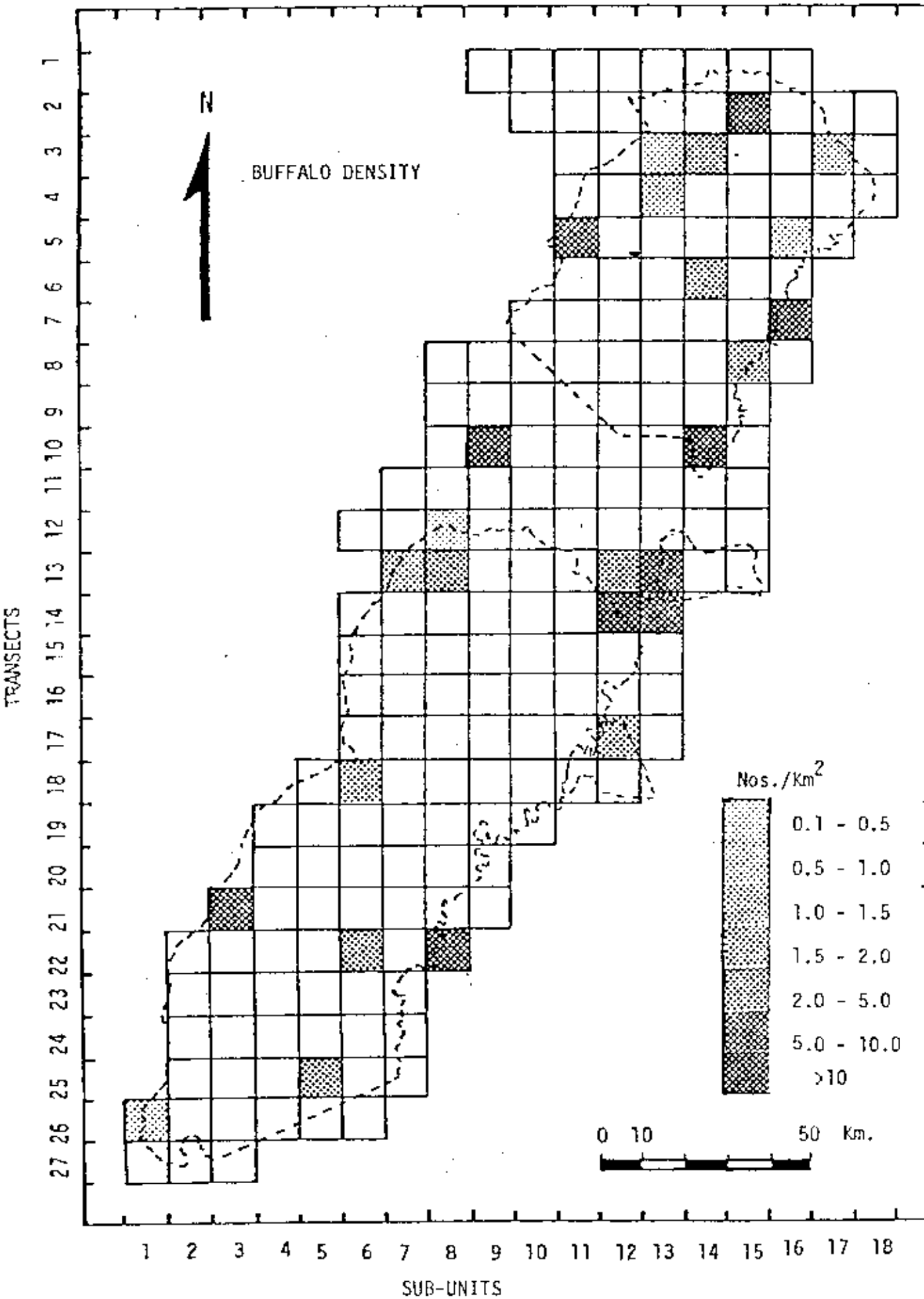
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



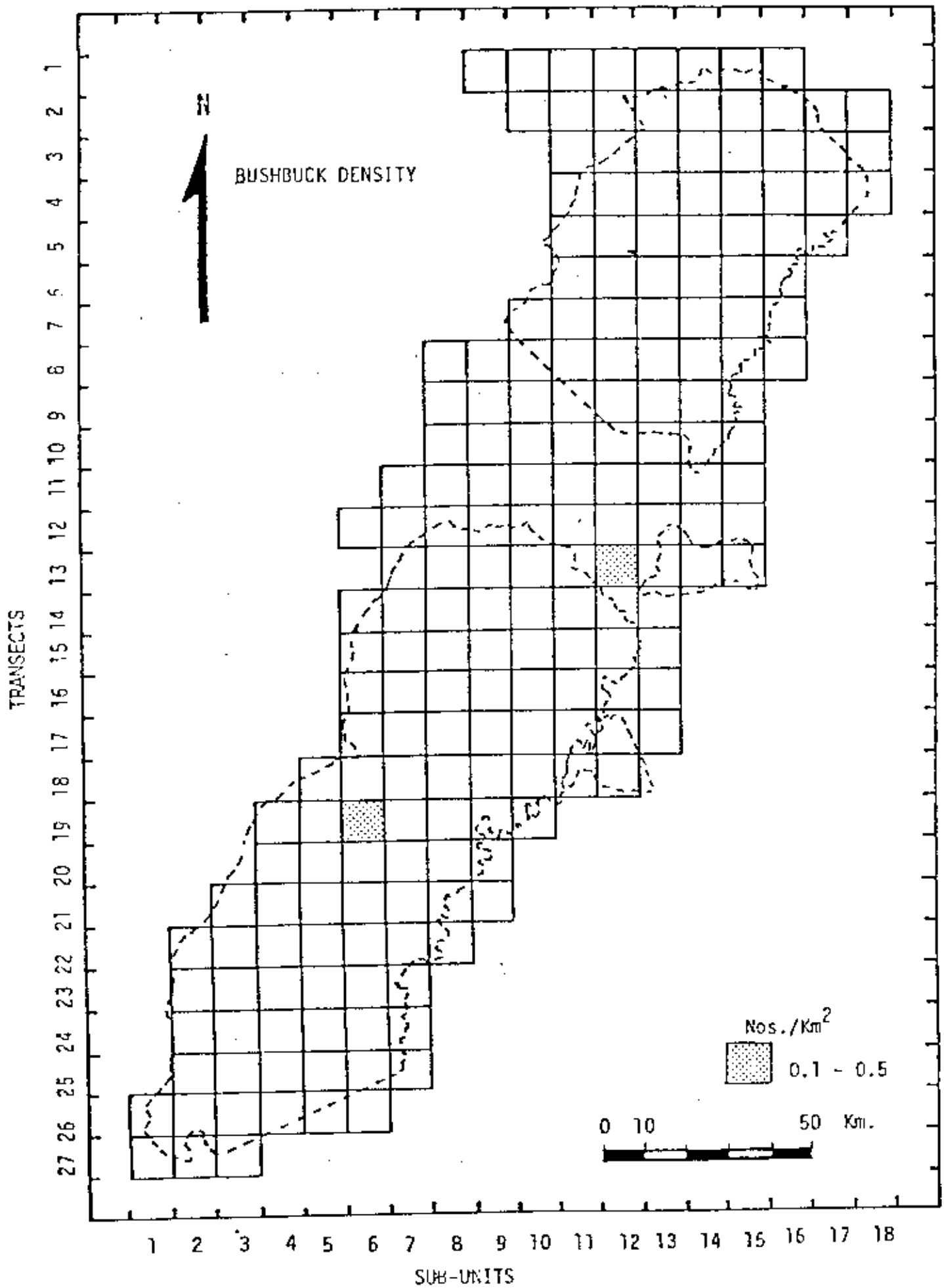
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



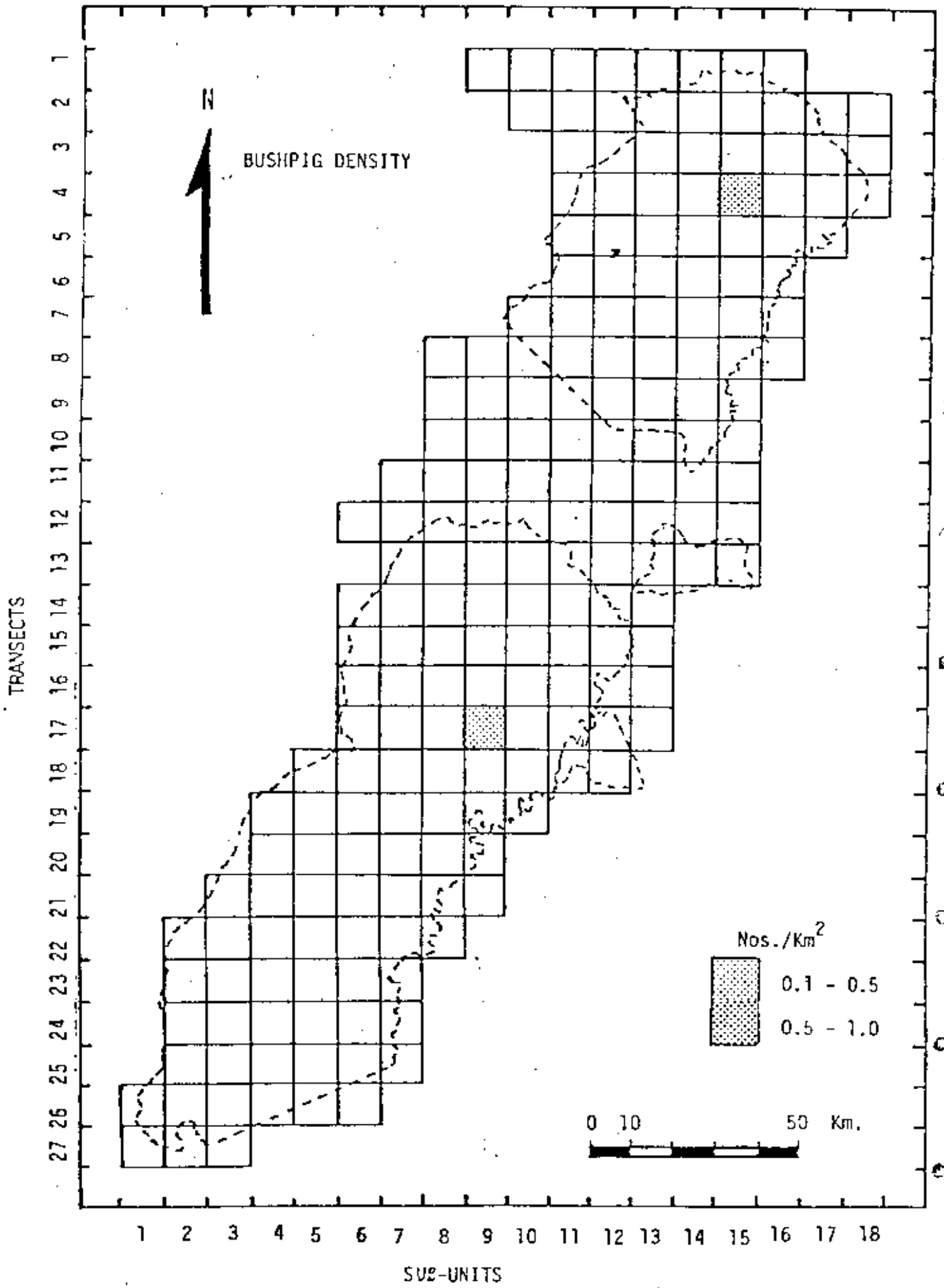
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



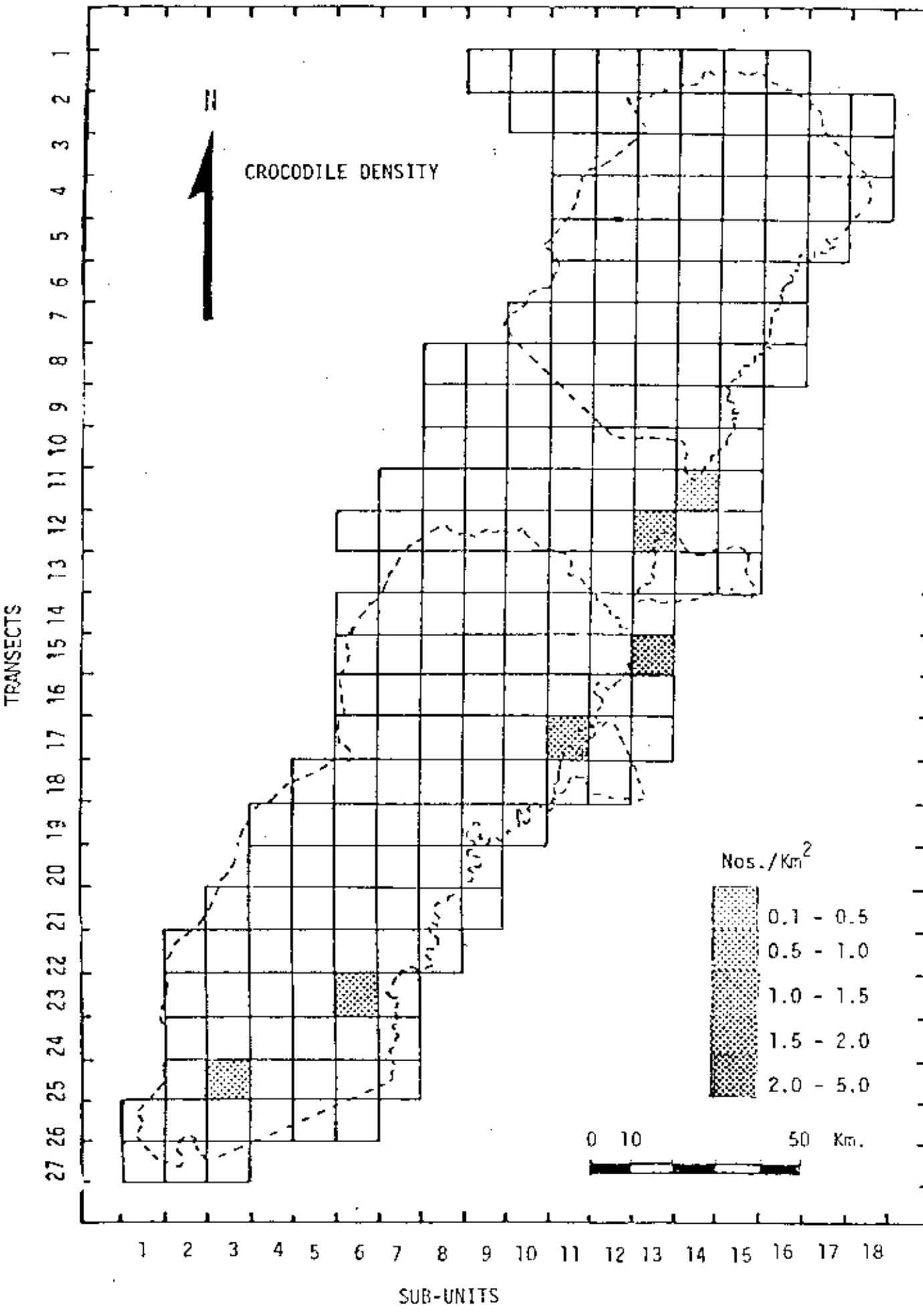
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



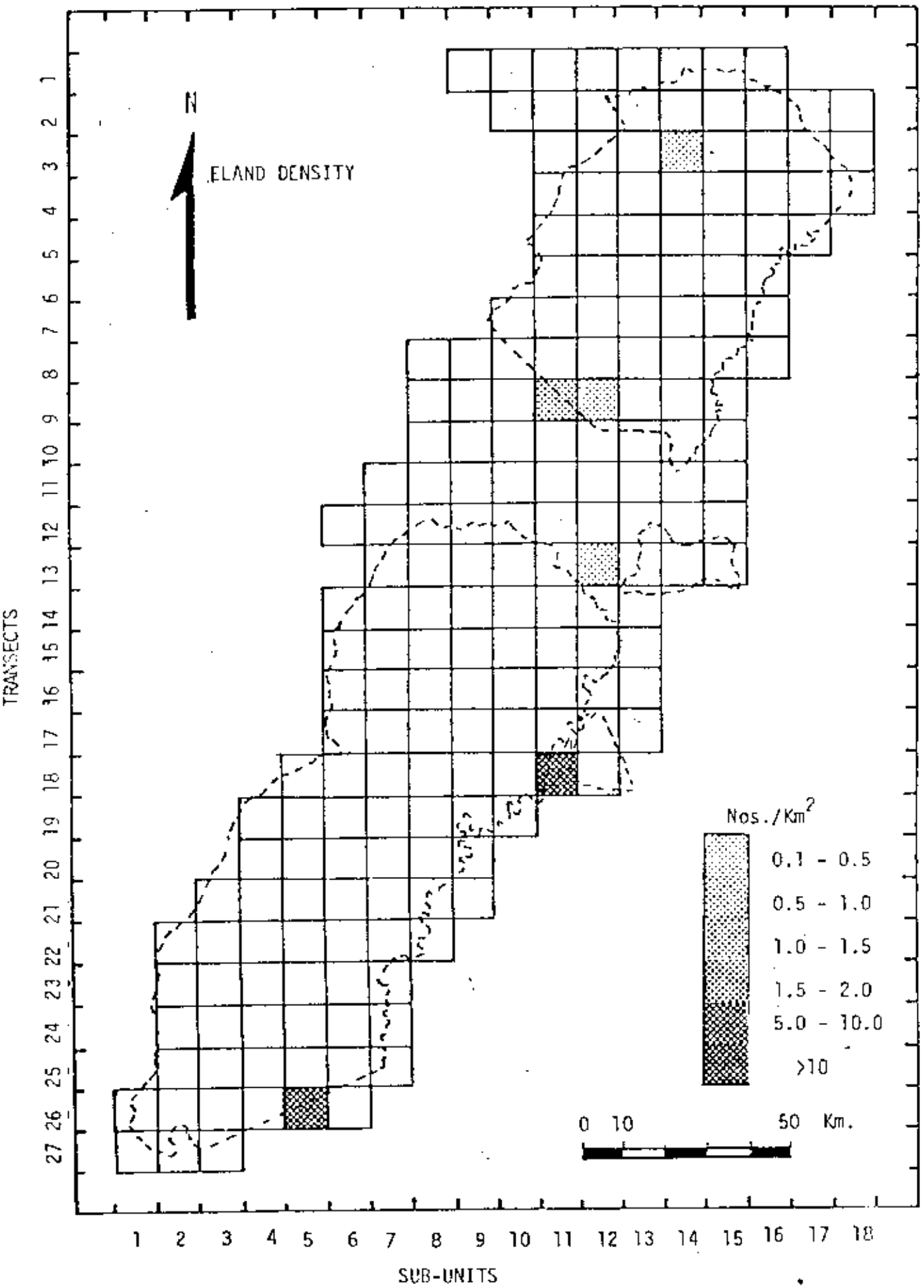
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



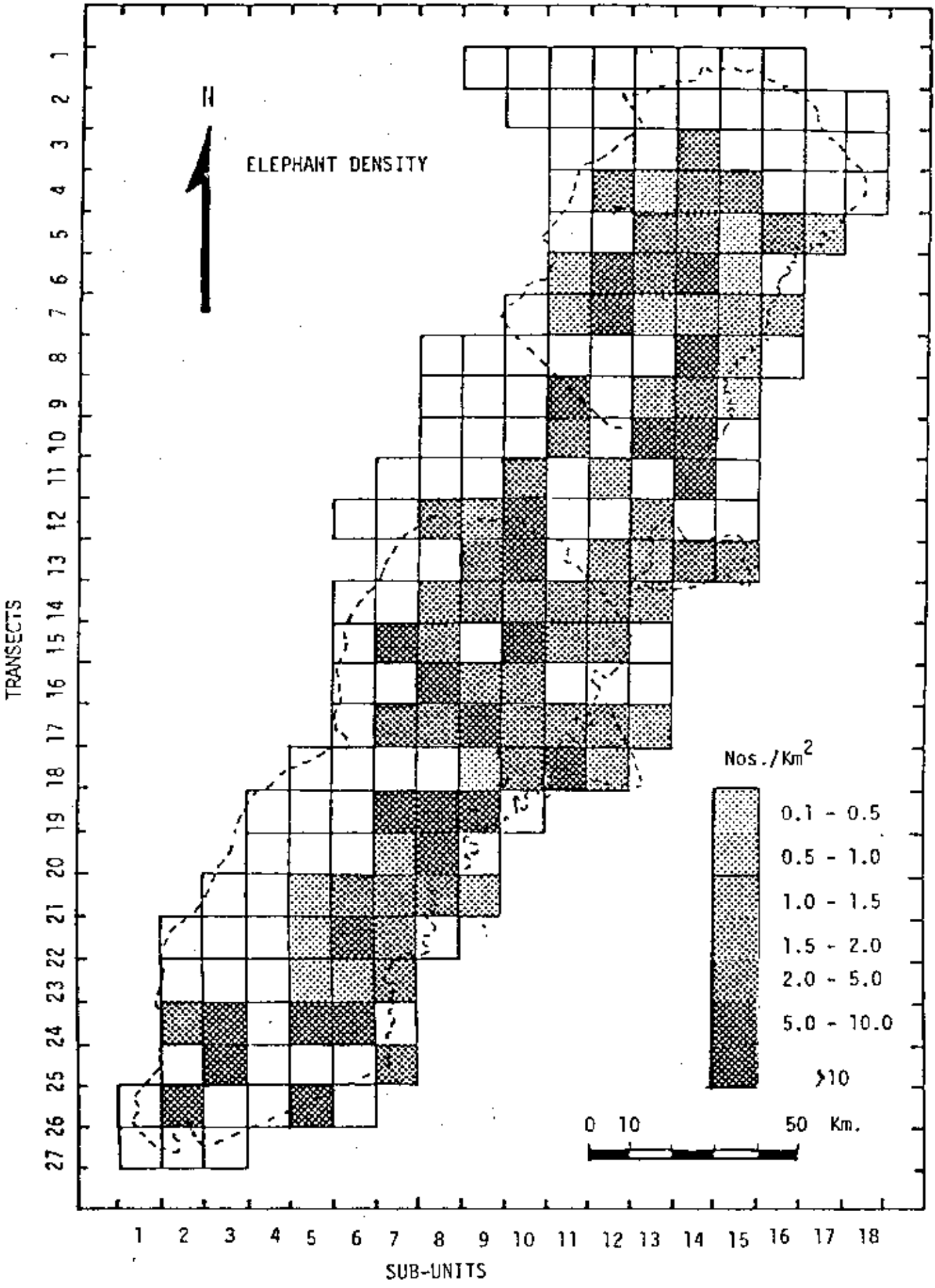
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



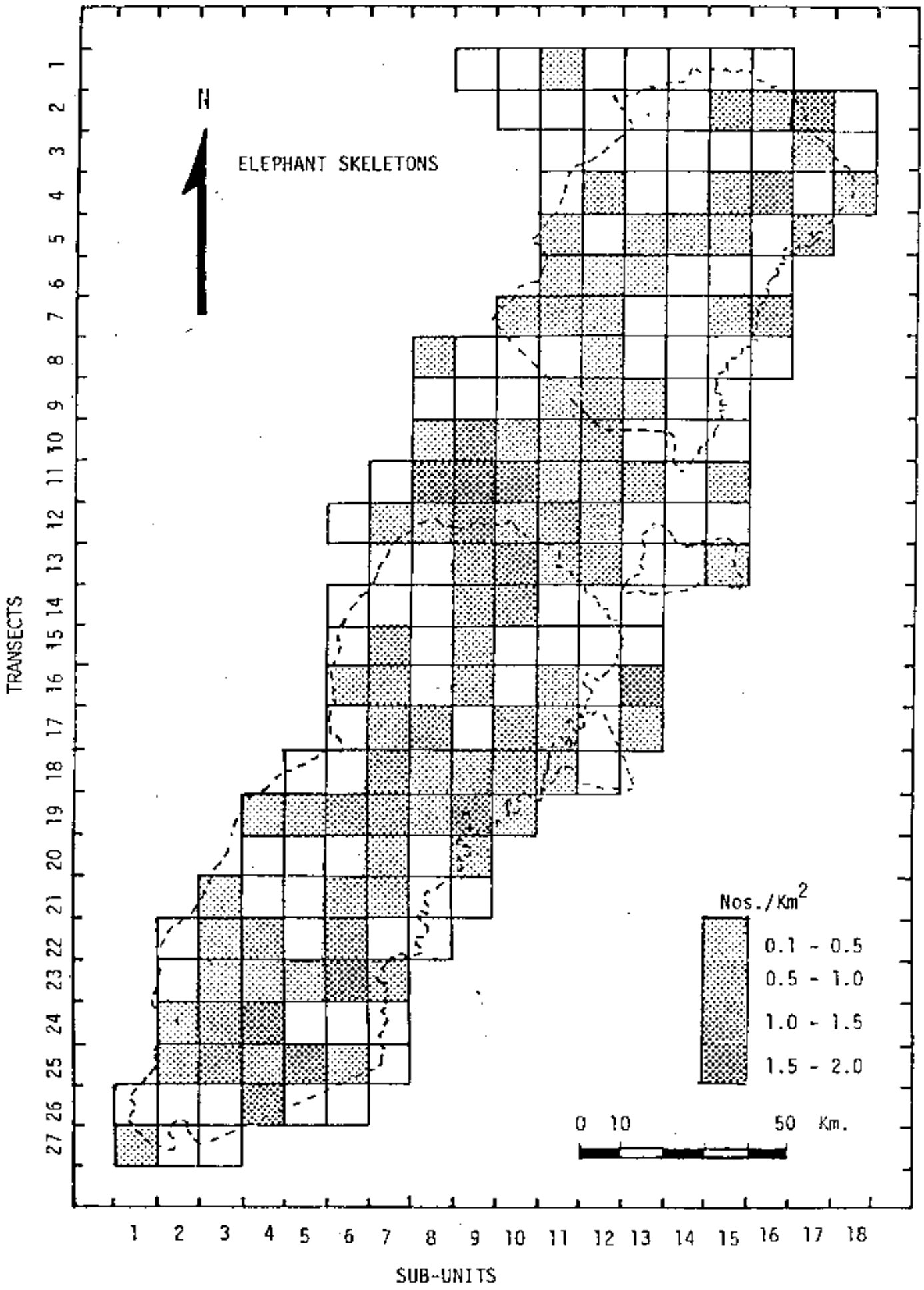
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



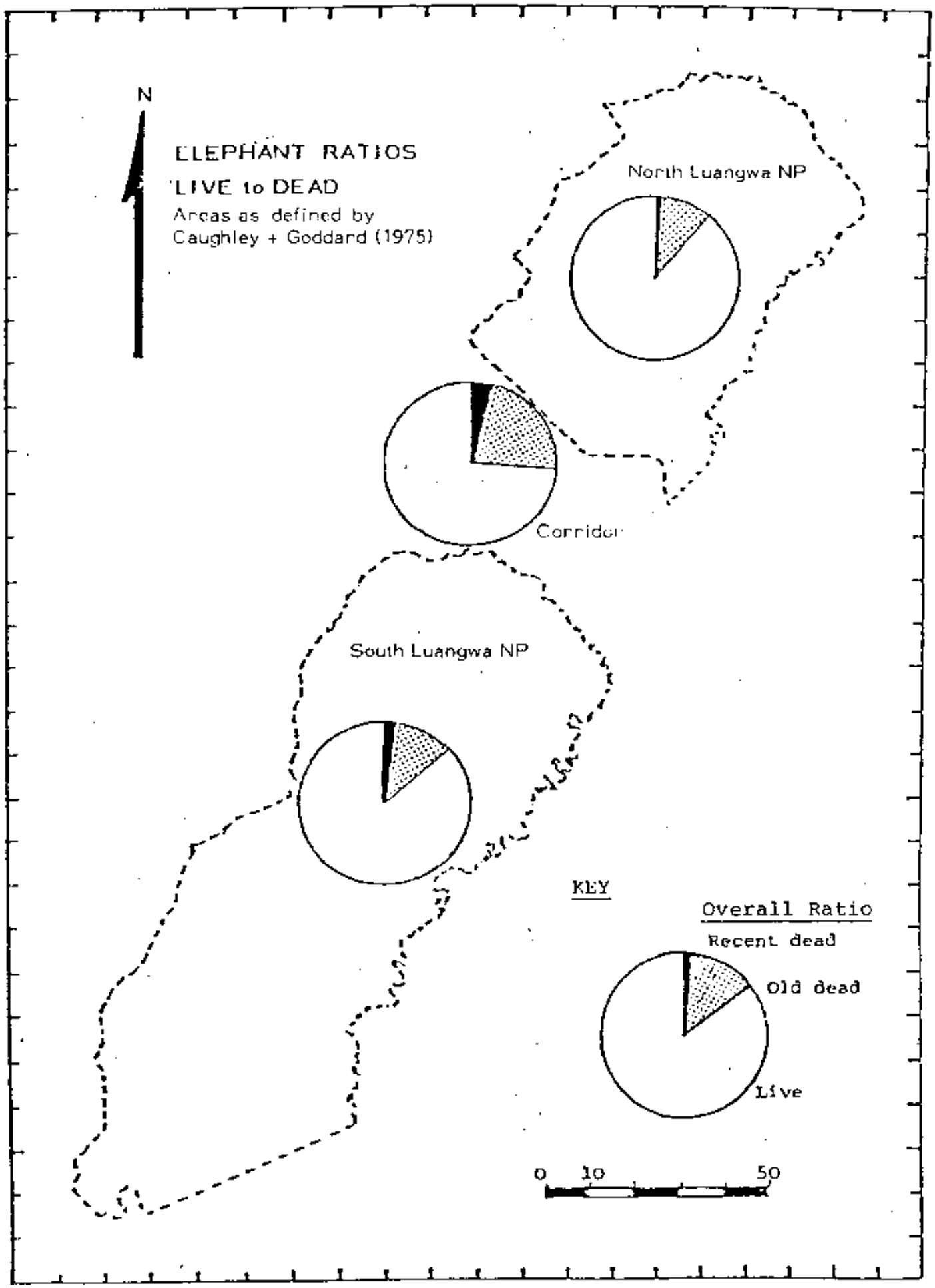
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



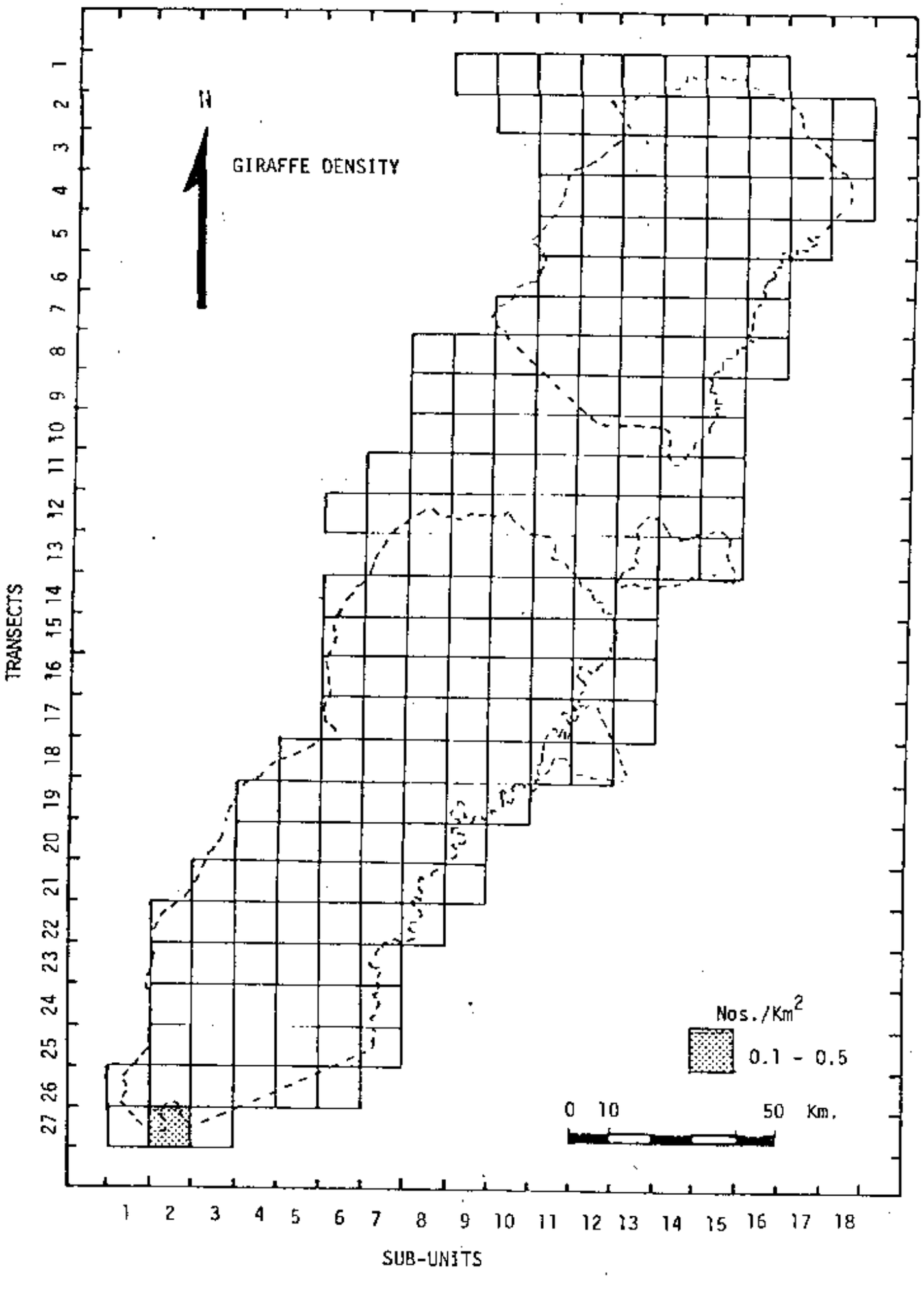
LUANGWA VALLEY CENSUS ZONE

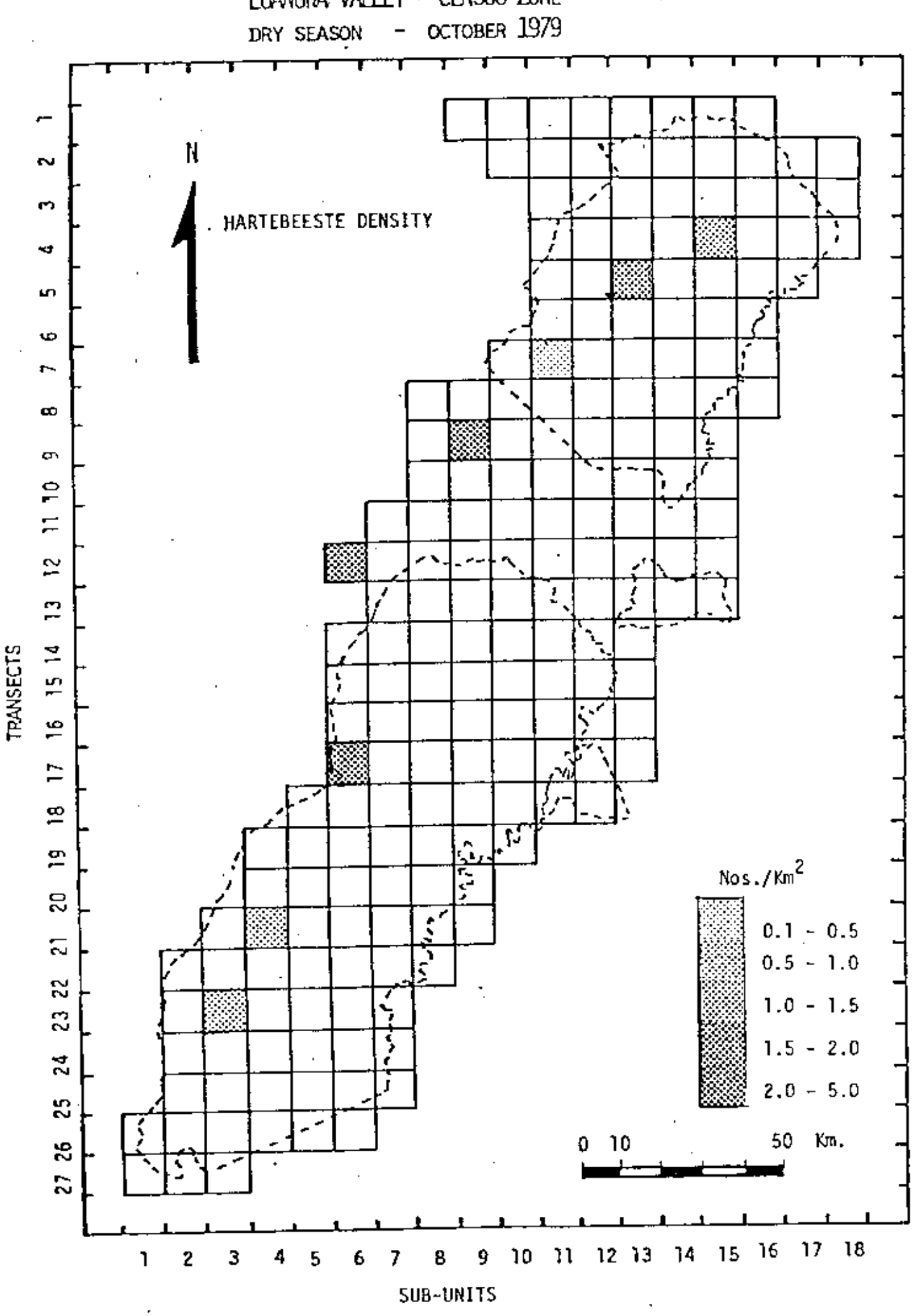
Dry Season Oct. 1979



LUANGWA VALLEY - CENSUS ZONE

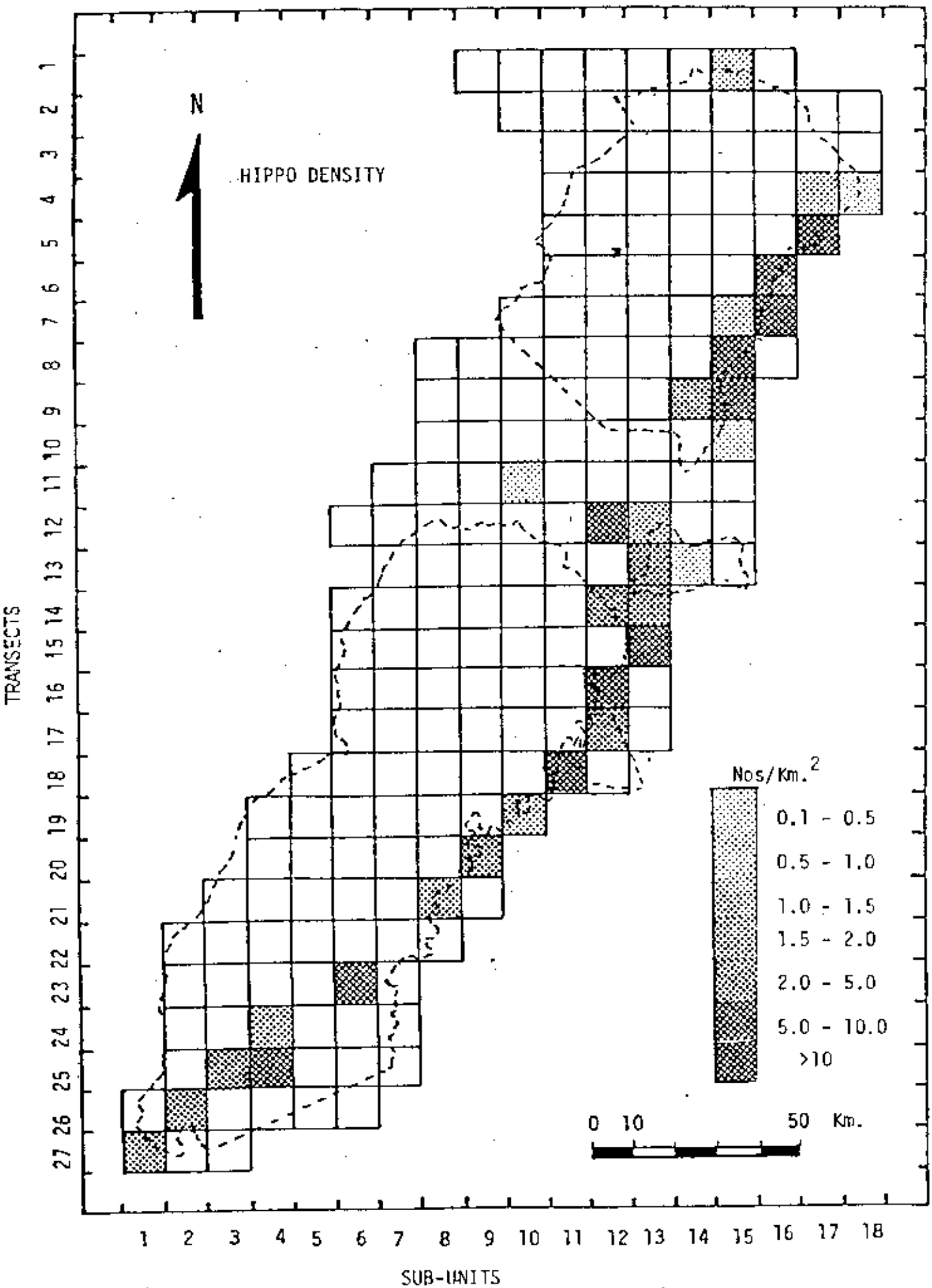
DRY SEASON - OCTOBER 1979




LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979
N
HARTEBEESTE DENSITY
TRANSECTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
SUB-UNITS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Nos./Km²
0.1 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 5.0
0 10 50 Km.

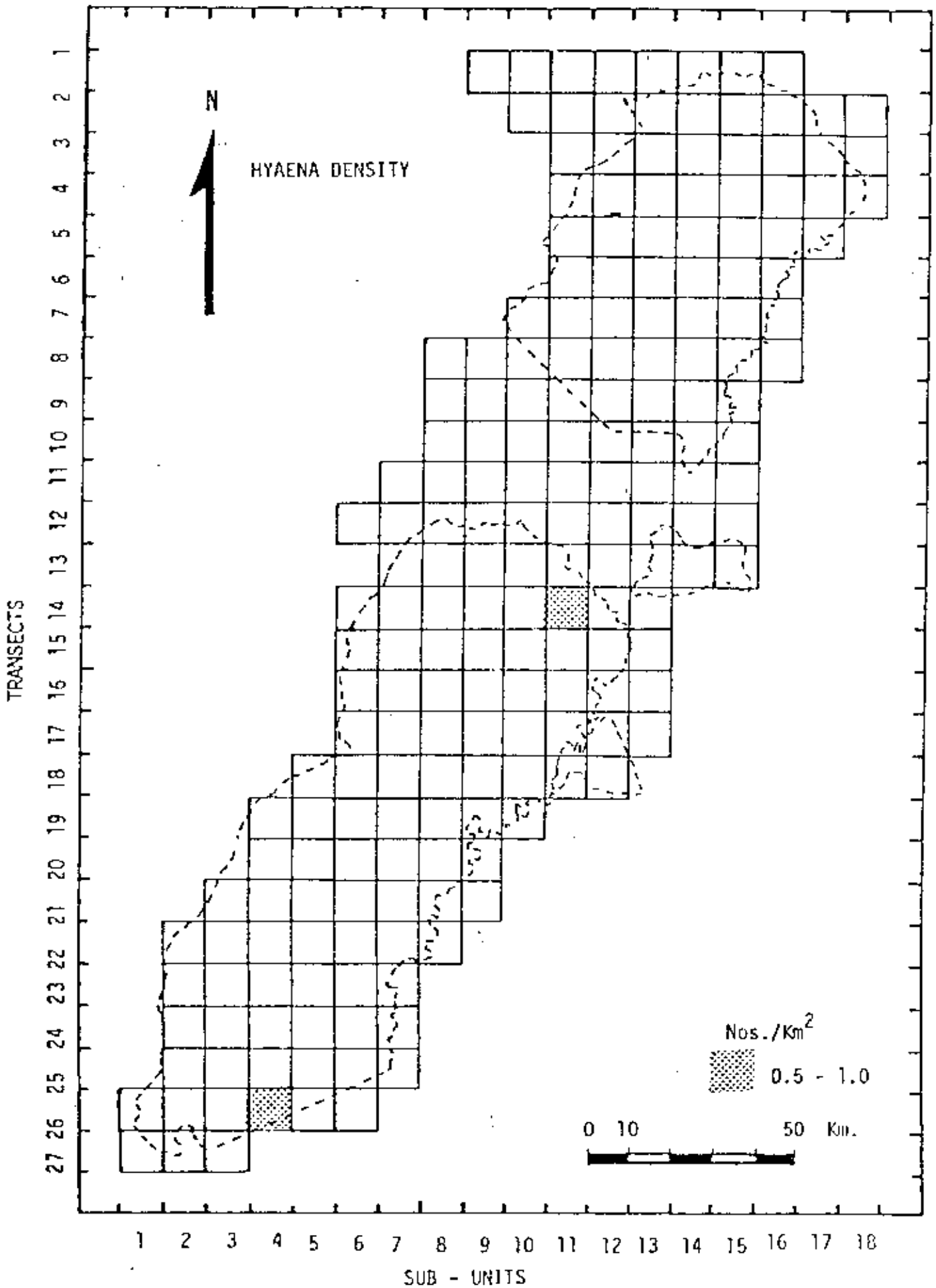
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



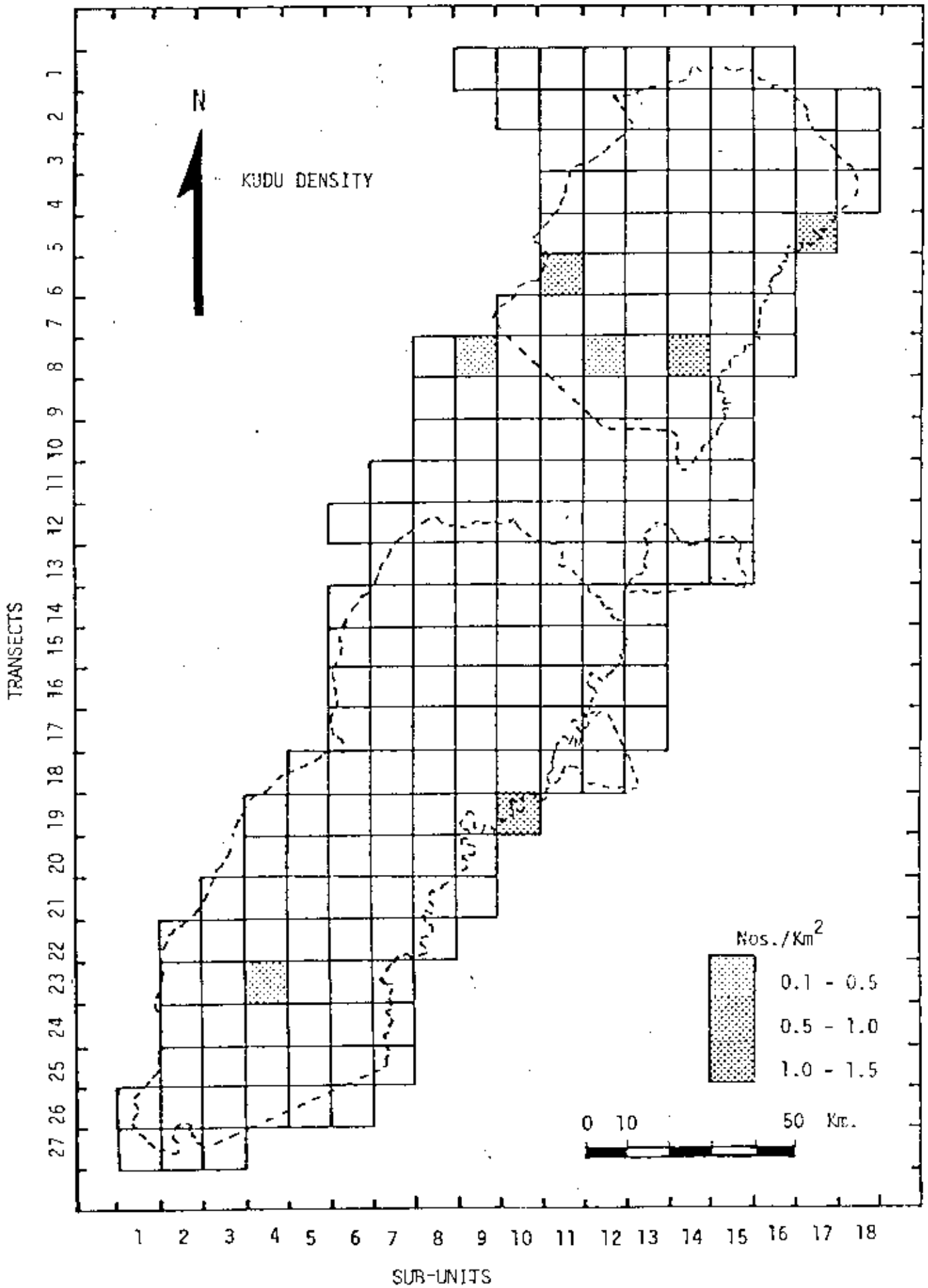
LUANGWA VALLEY - CENSUS ZONE

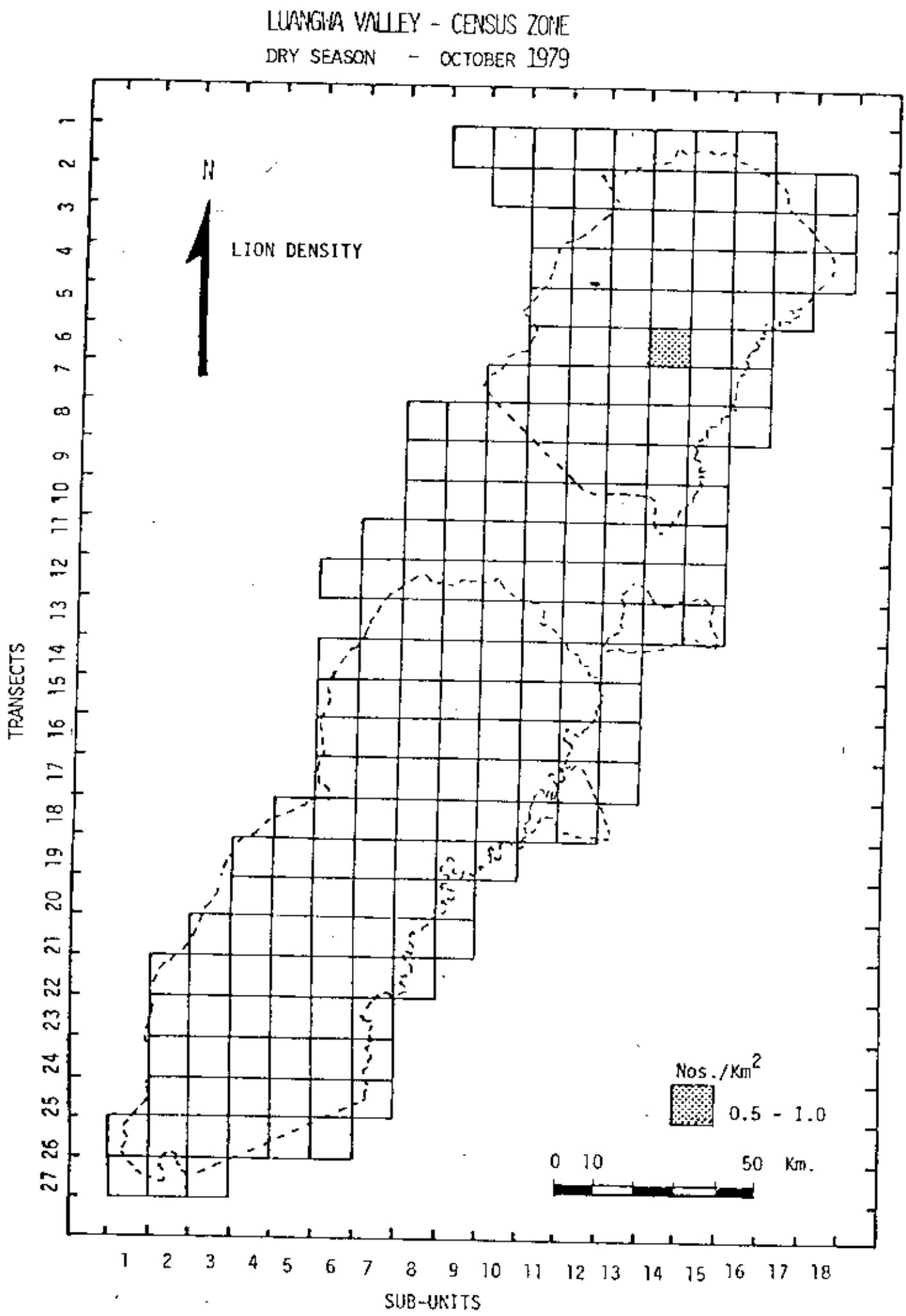
DRY SEASON - OCTOBER 1979



LUANGWA VALLEY - CENSUS ZONE

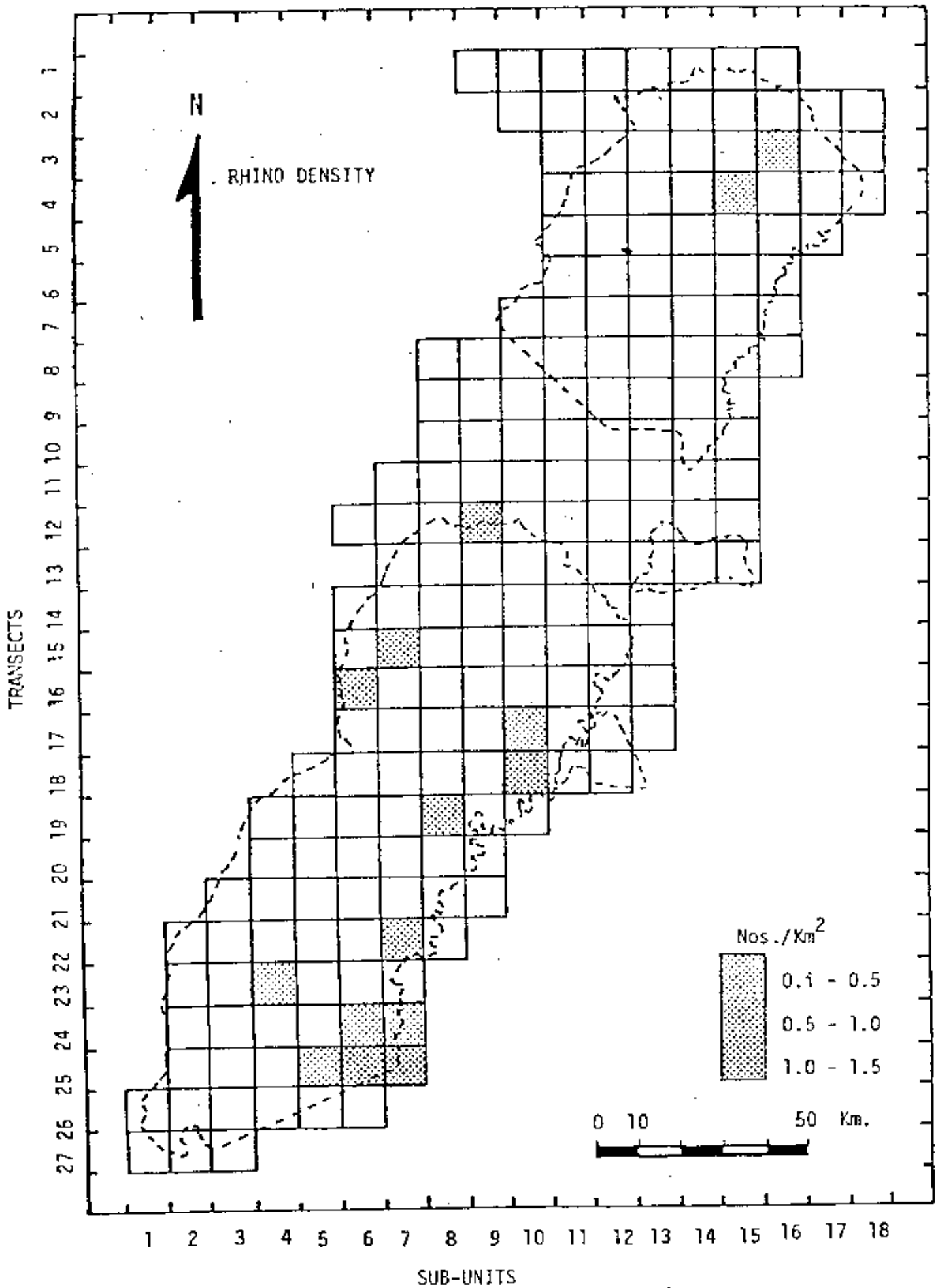
DRY SEASON - OCTOBER 1979




LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979
N
LION DENSITY
TRANSECTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
SUB-UNITS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Nos./Km²
0.5 - 1.0
0 10 50 Km.

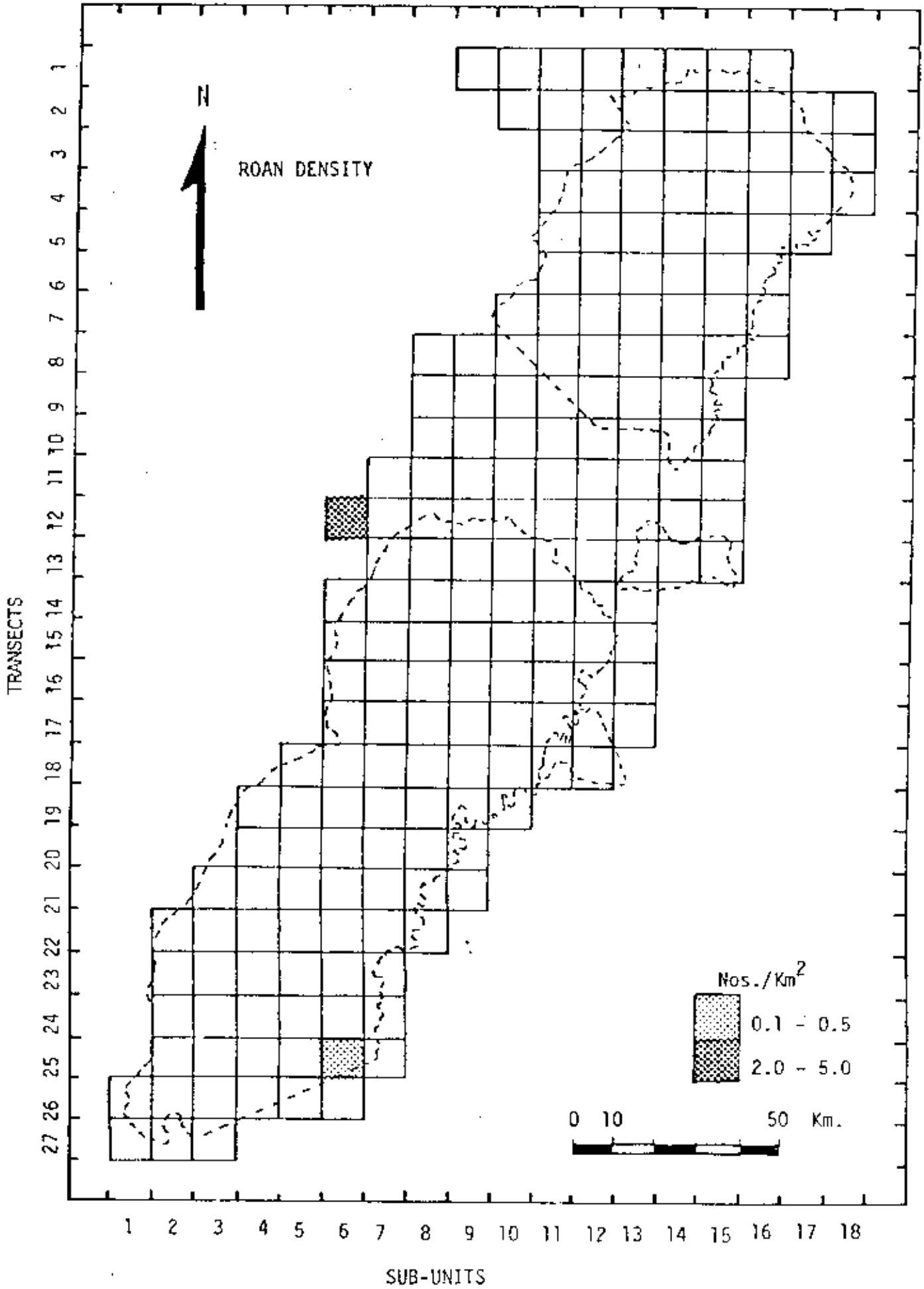
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979

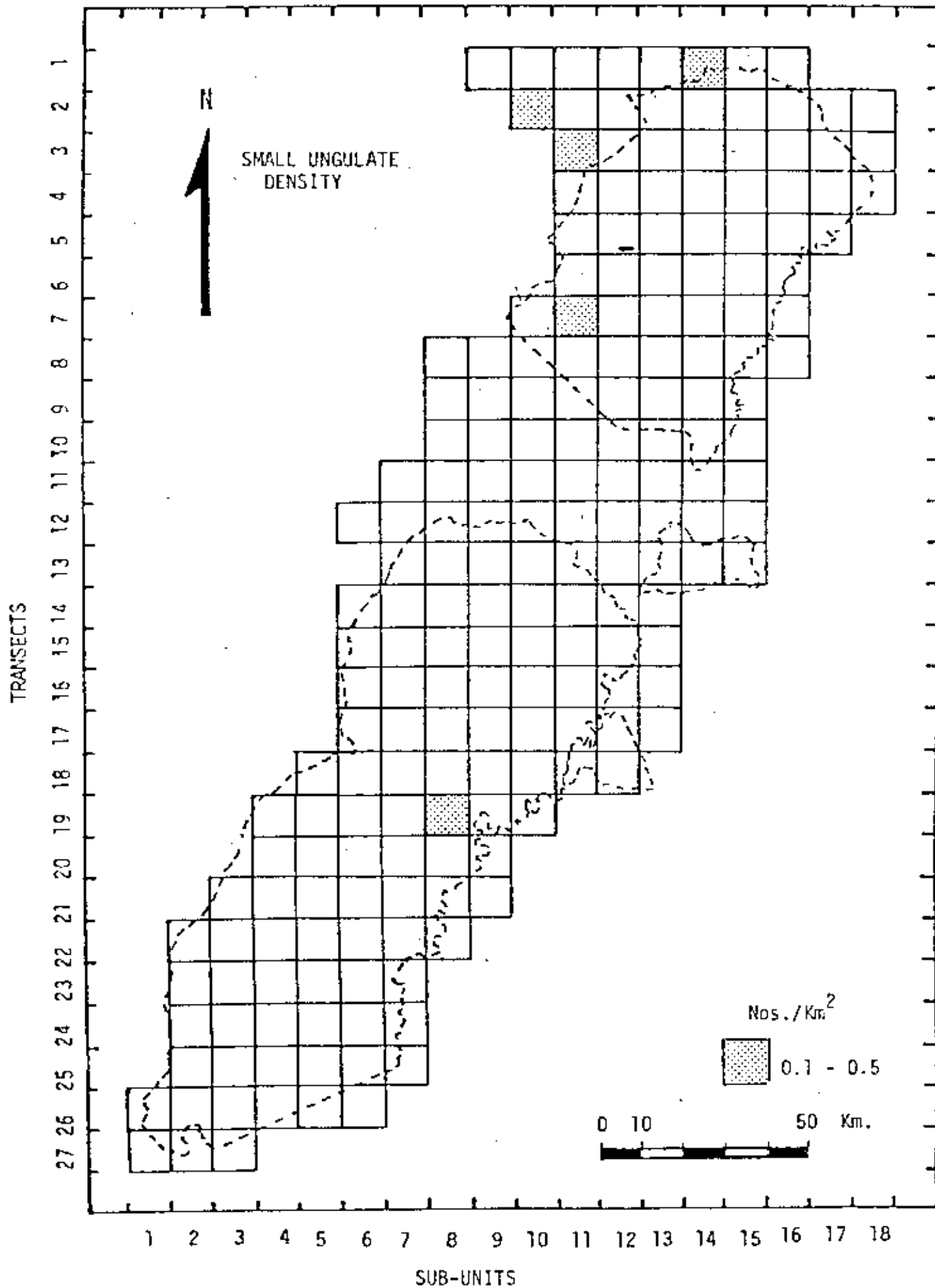


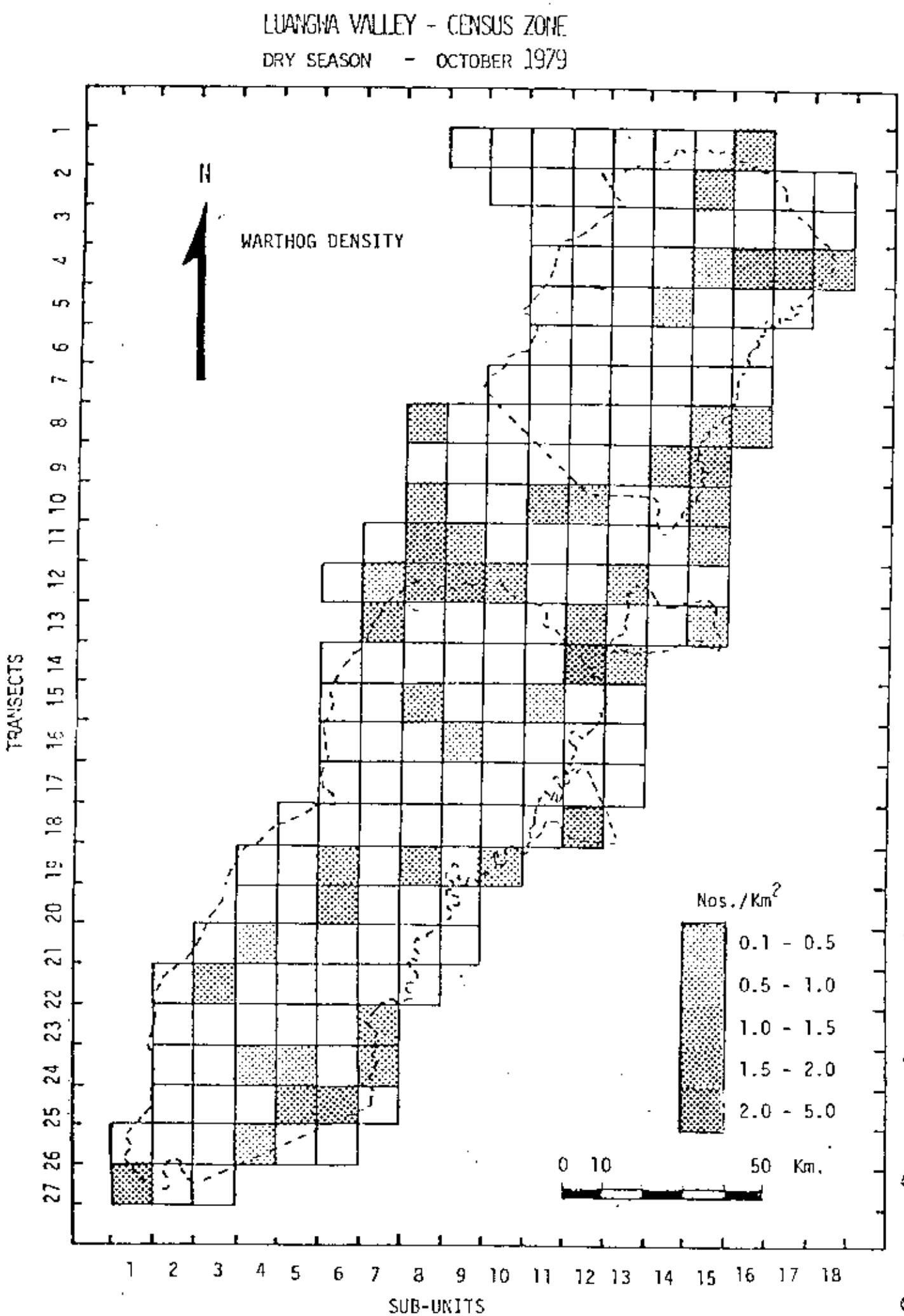
LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



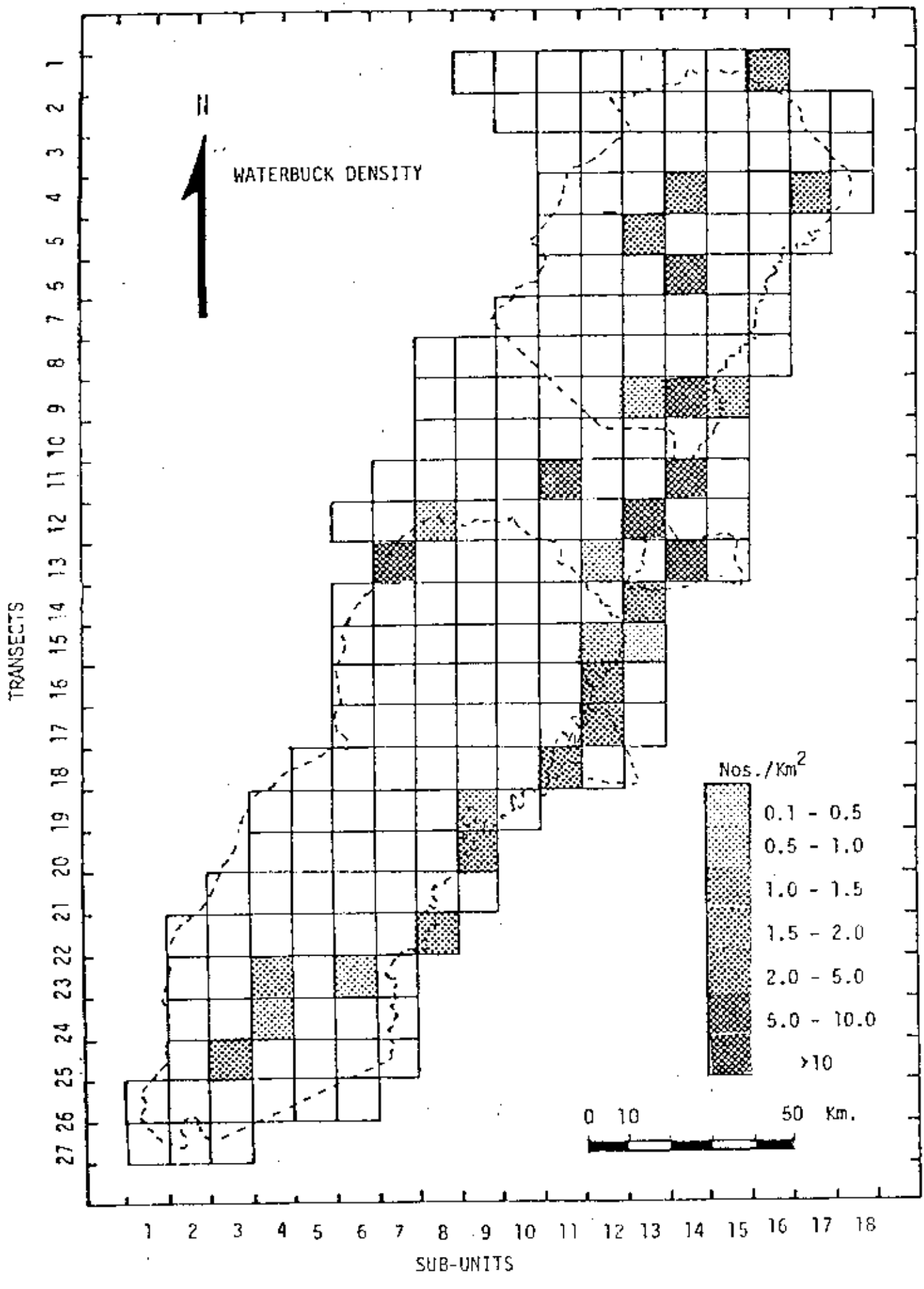
LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979

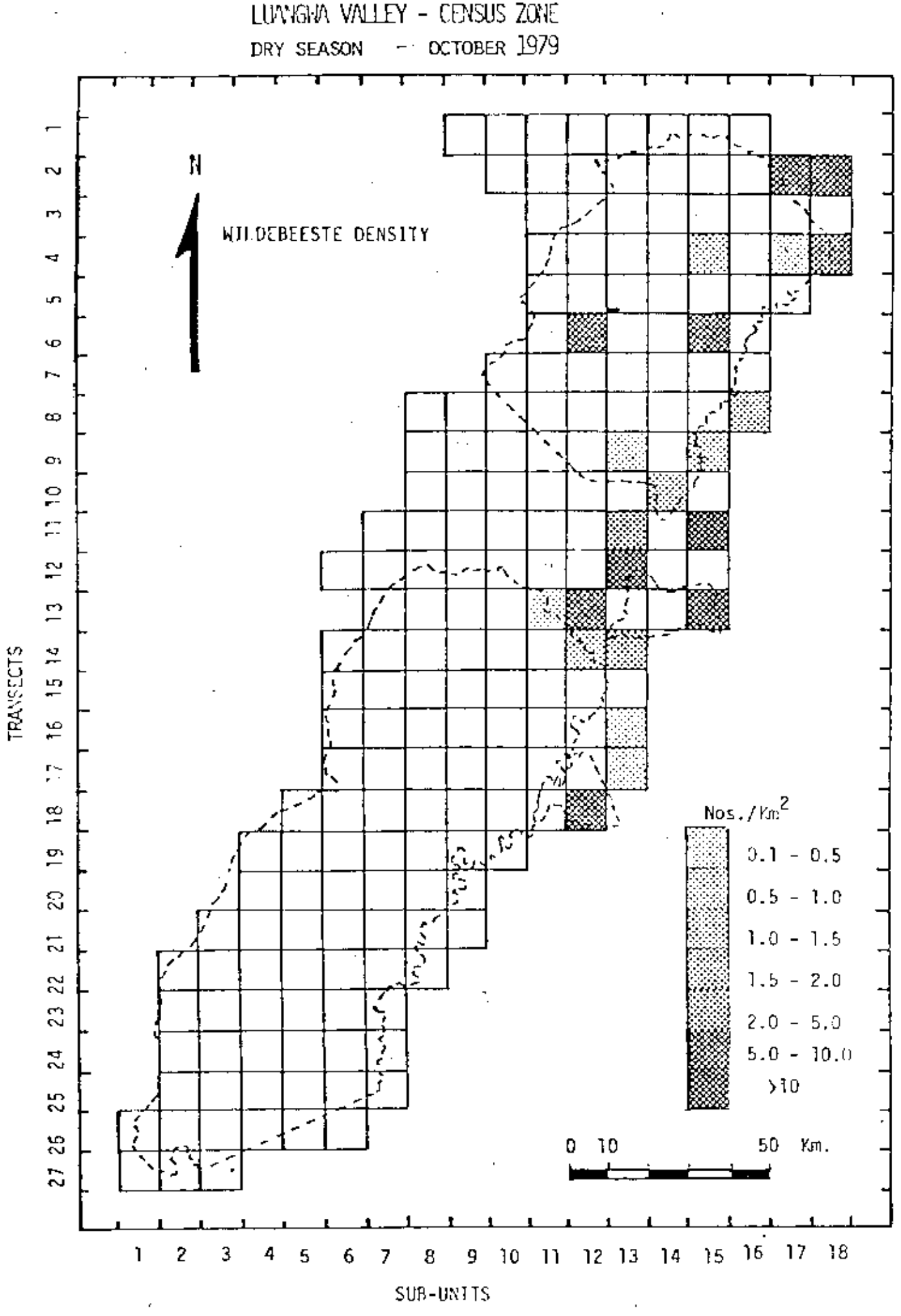



LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979
N
WARTHOG DENSITY
TRANSECTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
SUB-UNITS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Nos./Km²
0.1 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 5.0
0 10 50 Km.

LUANGWA VALLEY - CENSUS ZONE

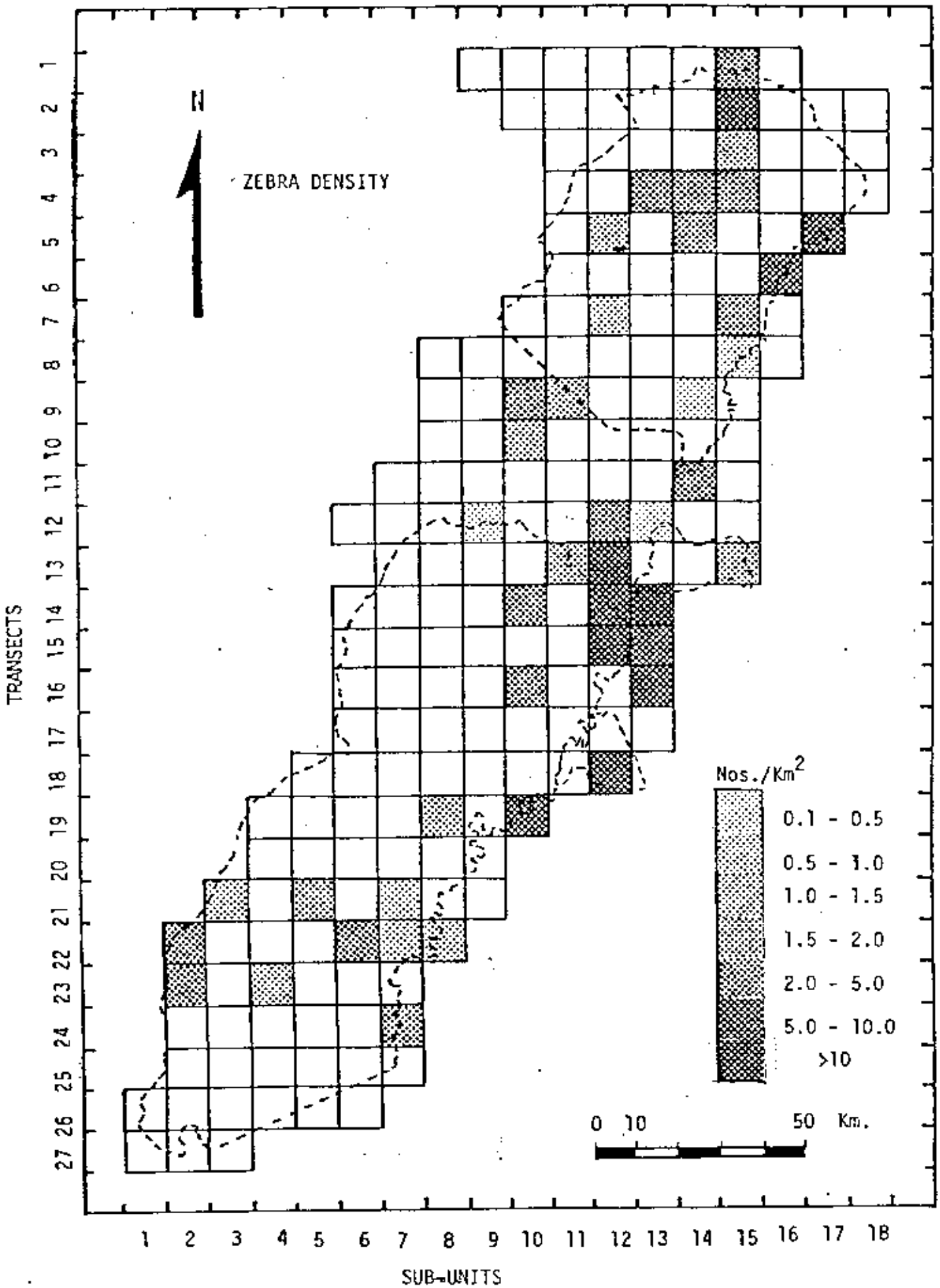
DRY SEASON - OCTOBER 1979




LUANGWA VALLEY - CENSUS ZONE
DRY SEASON - OCTOBER 1979
N
WILDEBEESTE DENSITY
TRANSECTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
SUB-UNITS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Nos./Km²
0.1 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 5.0
5.0 - 10.0
>10
0 10 50 Km.

LUANGWA VALLEY - CENSUS ZONE

DRY SEASON - OCTOBER 1979



NSEFU NATIONAL PARK - Higher Intensity Count

Introduction

Rhinos are notoriously difficult to count accurately from the air (Goddard, 1967, 1969). Their solitary habits and tendency to seek shade during the day lead to undercounts of magnitudes varying with time of day and sampling intensity. Goddard (1967) and Hitchens (1968) have carried out tests of aerial total counts on known populations of rhinos, but the standard systematic, low intensity, aerial sample count method widely used throughout East Africa, and employed in this count has seldom been tested against a known population. In the limited time available, a single higher intensity sample count was carried out over Nsefu National Park (212.5 km^2, 83 mi^2), as a test of the accuracy of the method for counting rhinos. Nsefu carries a relatively high density of rhinos, and the frequency of visits by staff of Norman Carr safaris, together with an individual recognition monitoring system established by them, enabled Norman Carr to make an estimate of 40-50 rhinos in the area.

Method

The basic method was exactly the same as that employed for the rest of the count, but the inter-transect interval was reduced to 2 kms, and the transects were run north-south to aid navigation. Half-minute, instead of minute, intervals were called by the pilot. The count was carried out between 16.30 and 17.30, to be comparable to the overall count. Three approaches were made to analysing the data (using Jolly, method 2, as for the main count):

(a) Standard population estimates from all the data at 15.8% sampling intensity.

(b) Population estimates at 8% sampling intensity by taking:

  i. Even numbered transects only
  ii. Odd numbered transects only

(c) Stratification into the Capparis plains area and the Mopane woodland and mosaic area.

Results and Discussion

(a) The overall estimate for the area was 60 rhinos, which is not radically different from the ground estimates and with a standard error of ±29 is well within the same limits. Ground estimates are usually found to be on the low side, unless every single individual is know, and 5 rhinos were seen in the woodland mosaic, an area less frequented by the safari vehicles.

(b) The two analyses of the 8% sampling intensity indicate the wide variation in estimates that can be obtained using this method (see Table) at relatively low intensity. Comparison between the overall count and the Nsefu count emphasises this point, since in the main count, the one transect that passed over Nsefu counted no rhinos, as compared with 9 seen and an estimate of 60 in the higher intensity count.

(c) Ground observation and the distribution obtained from the air both indicate the Capparis plains as a preferred rhino habitat, while rhinos in the woodland were associated with the area of woodland/grass clearing/waterhole mosaic, as appears in the Rhino Distribution Map.

(d) The main count produced an estimate of zero for the Nsefu block, since no rhinos were seen on the single transect that passed across it. This demonstrates the wide sampling error obtained by aerial census of rhinos, particularly at low intensity.

Overall, the count indicates a rhino population for Nsefu of around 60, with limits of 31 to 89. But most of all it indicates the amount of variation in rhino population estimates that can be obtained using this method, which is designed for most cost-effective monitoring of a multi-species system, but is least effective for cryptic, single individuals. It shows that the overall population estimate for rhinos, obtained from the main count, can only be a rough indication of the true population.

NSEFU NATIONAL PARK - HIGH INTENSITY COUNT

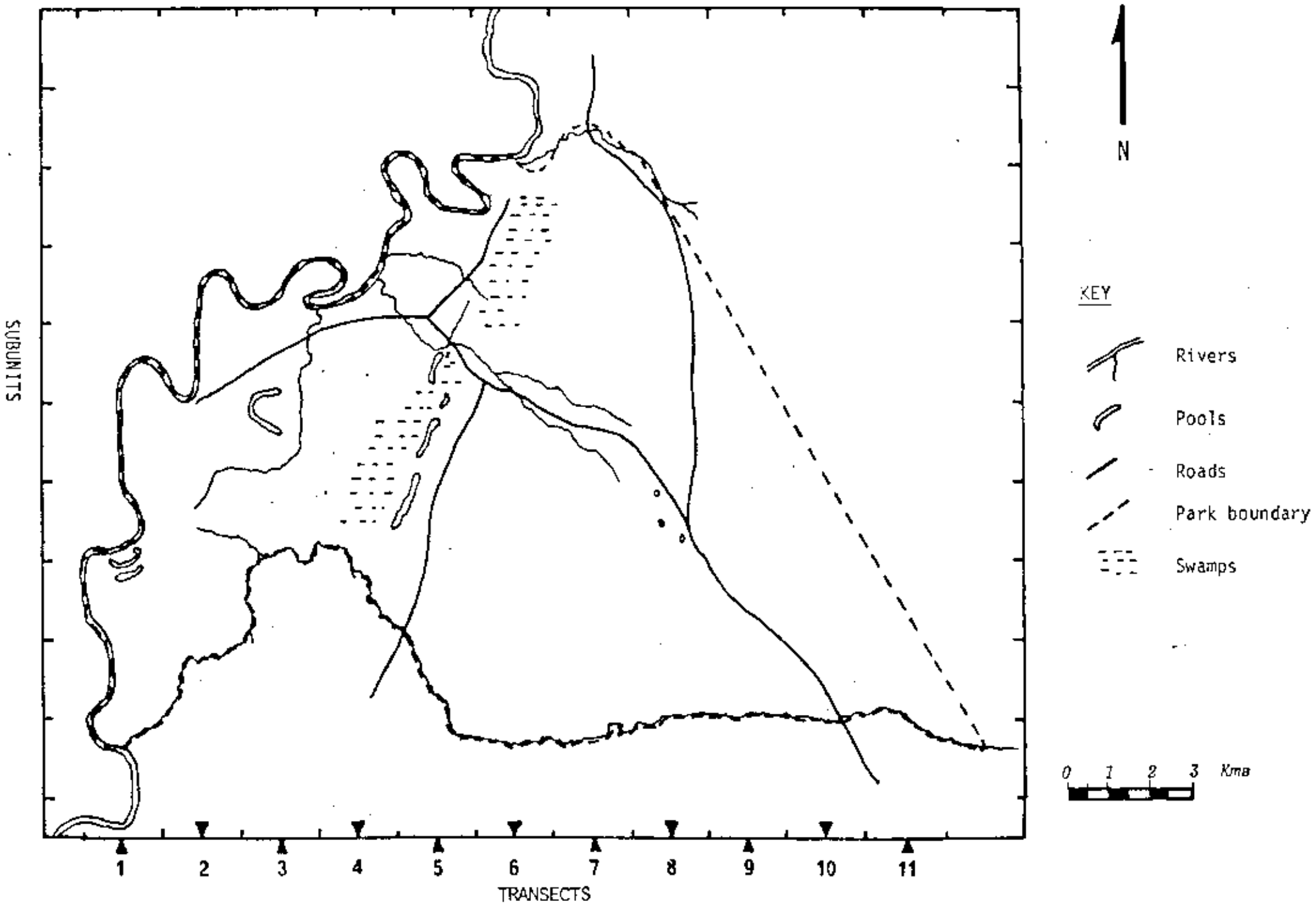
Dry Season, October 1979

Area: 212.5 km^2 Sampling intensity: 15.8%

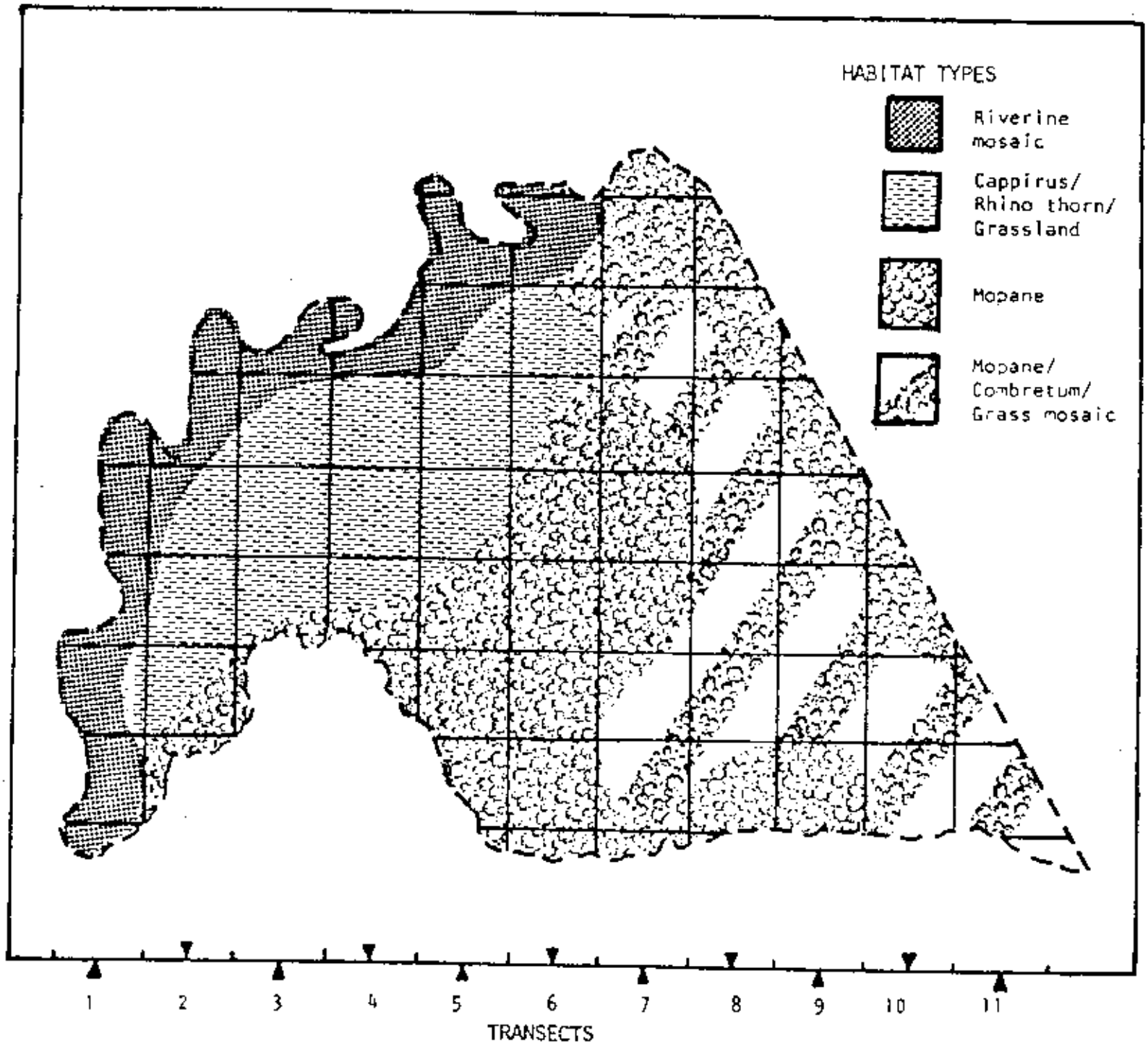
Species	Population Estimate	Density (Nos/km^2)	Standard Error	Confidence Limits (95%)
Rhino	60	0.28	29	66
Elephant	1088	5.12	313	699
Impala	621	2.92	289	644
Puku	372	1.75	172	384
Waterbuck	176	0.83	103	300

Rhino population estimates obtained by analysing at different sampling intensities

Sample Intensity	Transect Separation	Population Estimation	Standard Error	Confidence Limits (95%)
15.8%	2 kms	60	29	66
8% (Odds)	4 kms	12	12	26
8% (Evens)	4 kms	113	61	135


SUBUNITS
1
2
3
4
5
6
7
8
9
10
11
TRANSECTS
N
KEY
Rivers
Pools
Roads
Park boundary
Swamps
0 1 2 3 Kms

NSEFU N.P. – LUANGWA VALLEY



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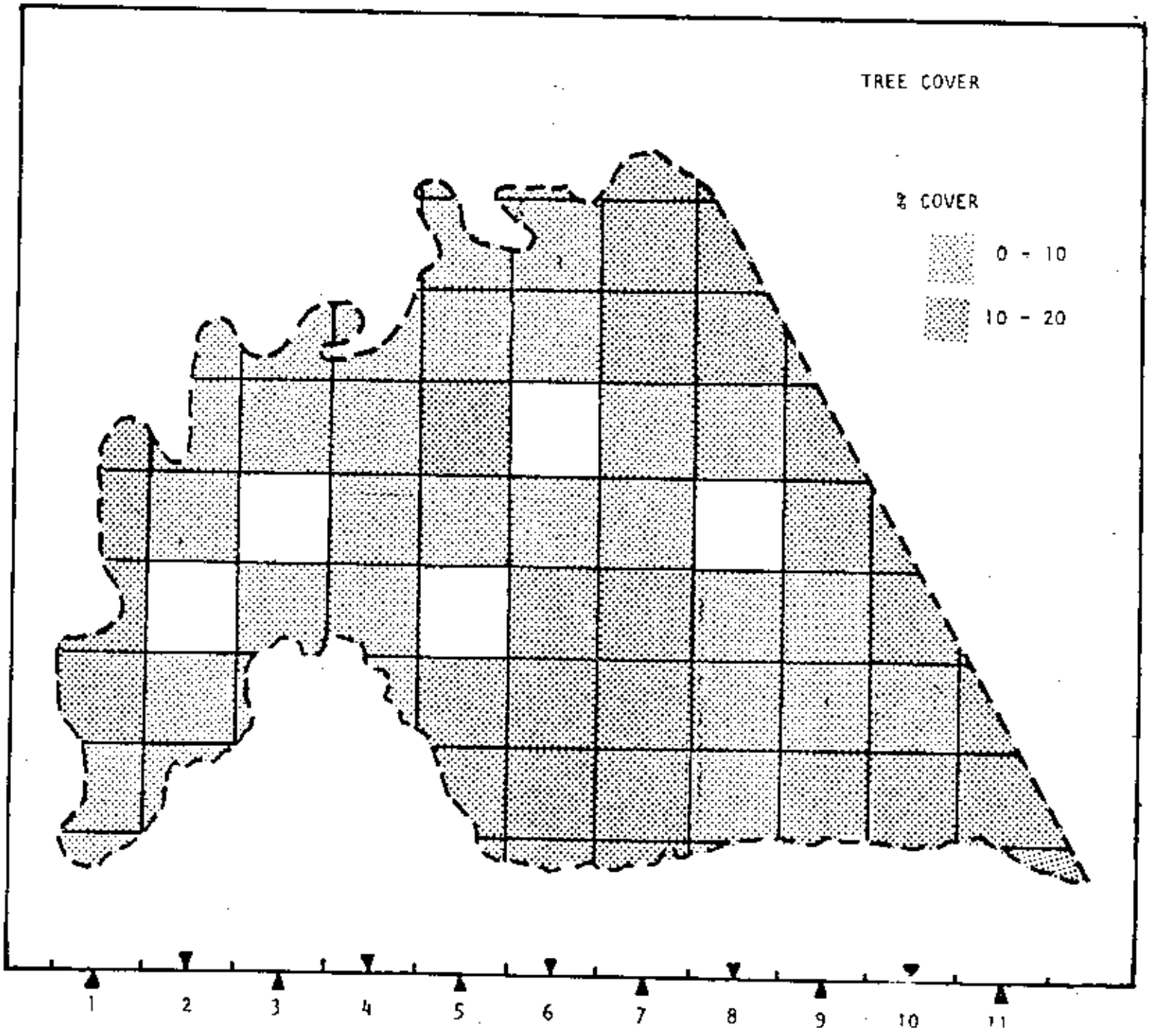

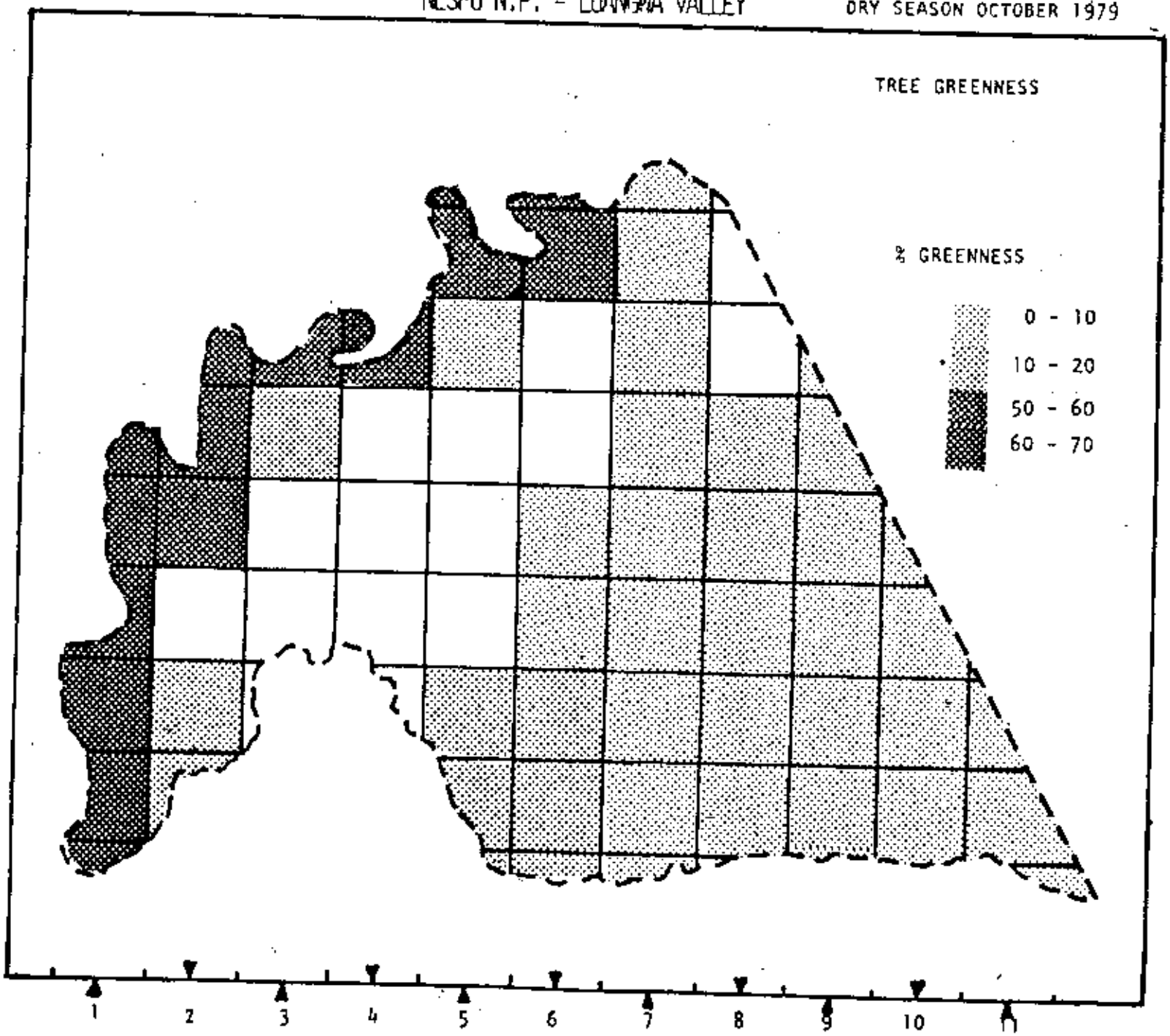
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DRY SEASON OCTOBER 1979
TREE GREENNESS
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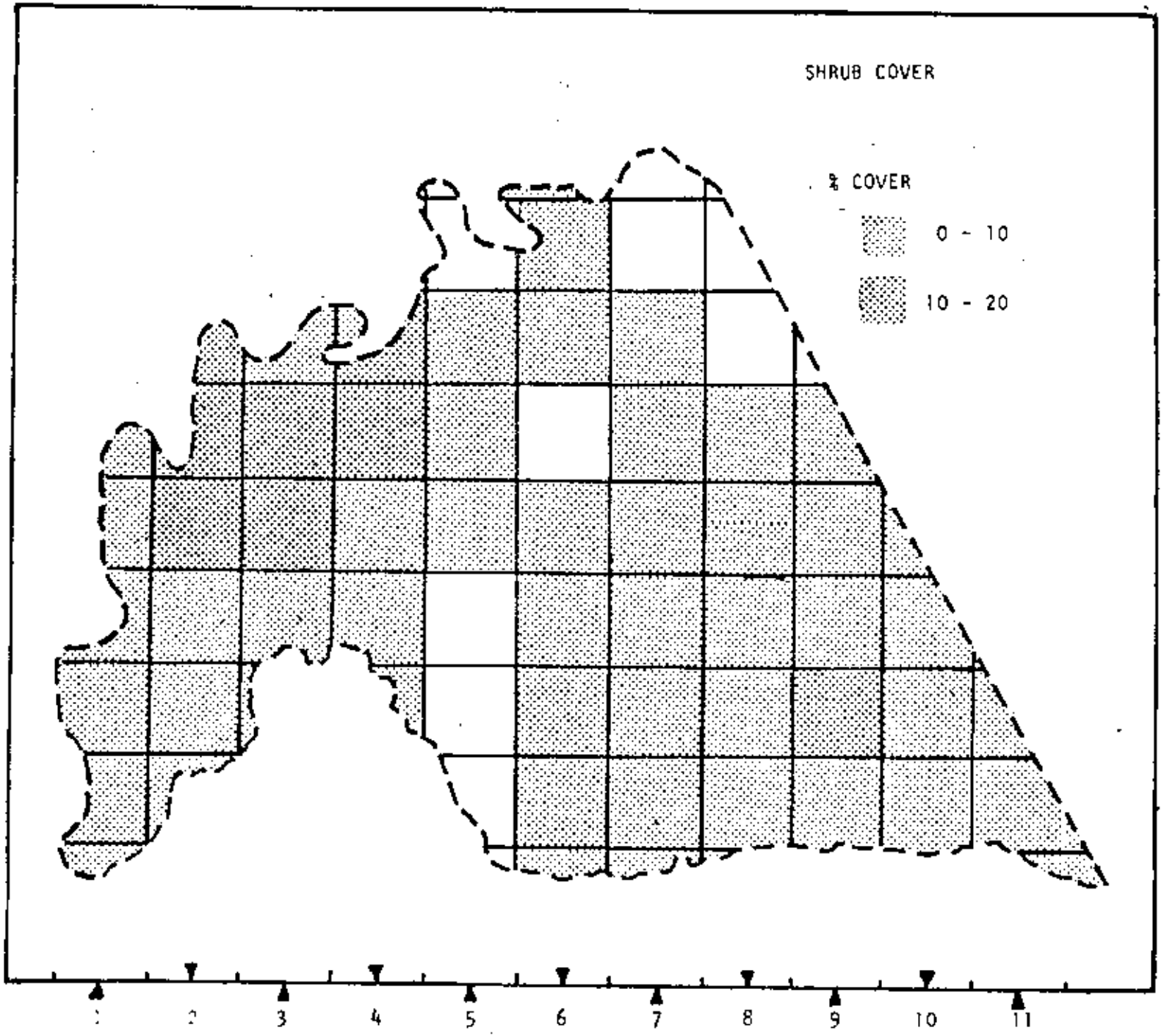

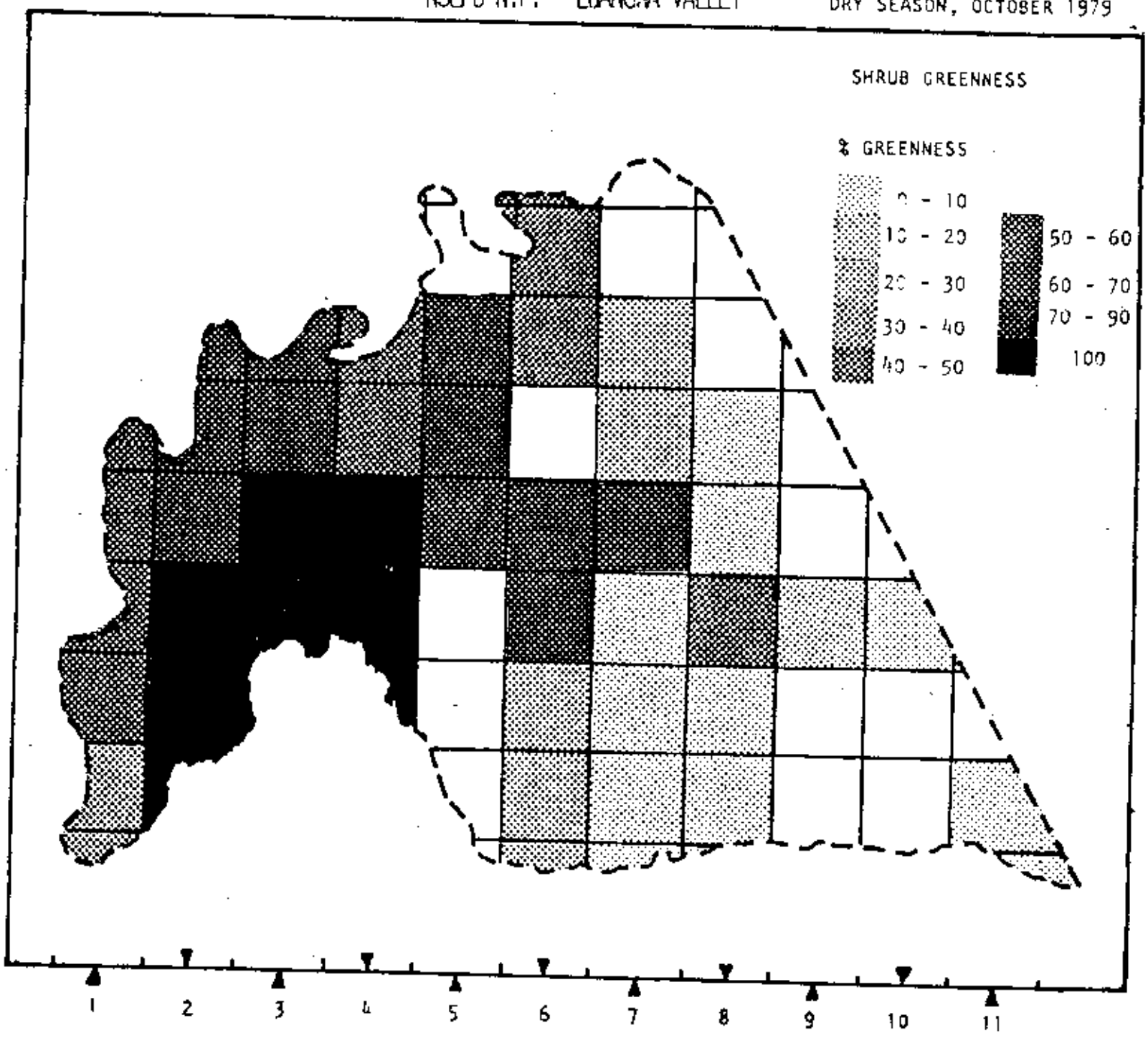
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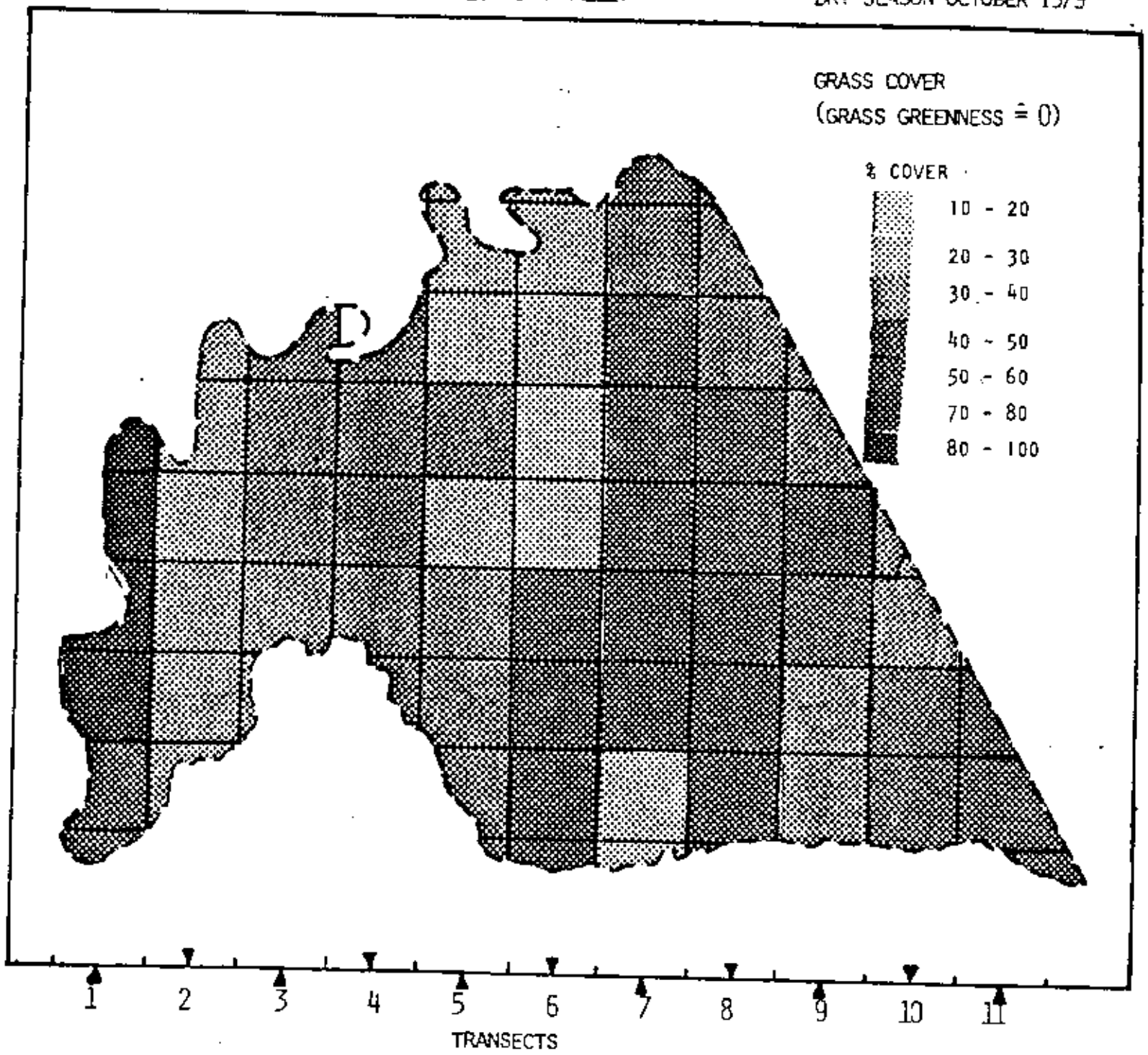

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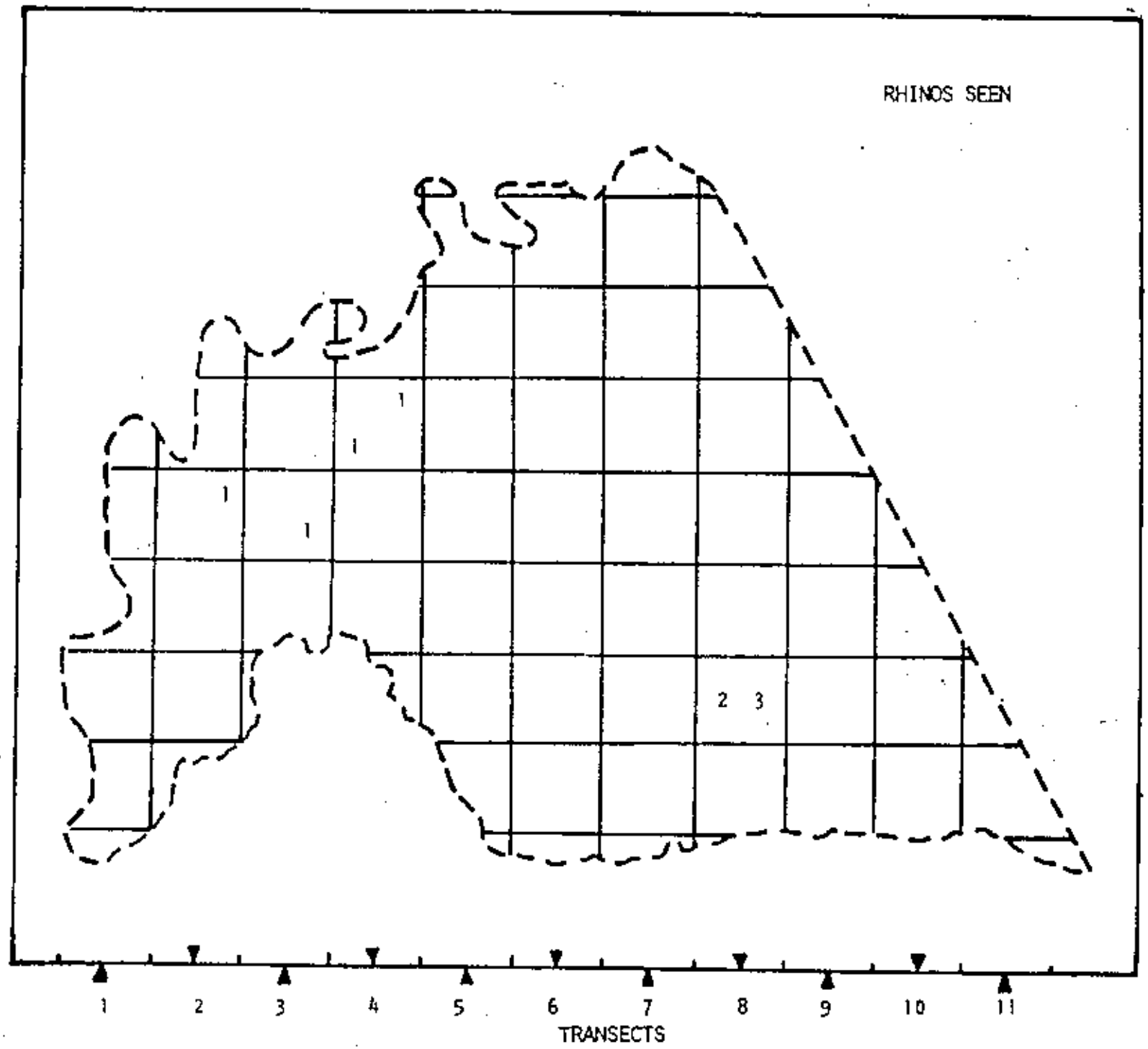

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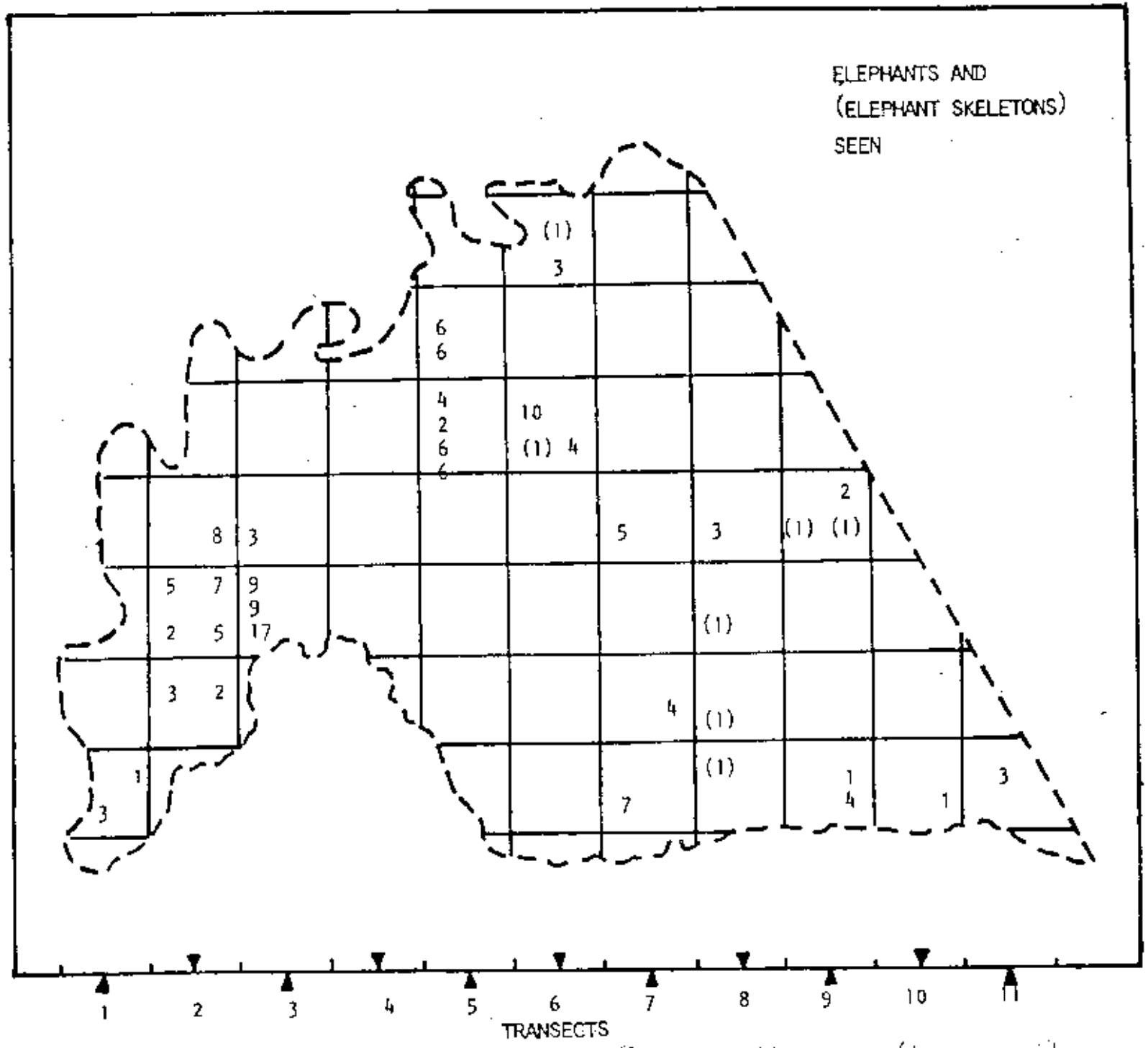

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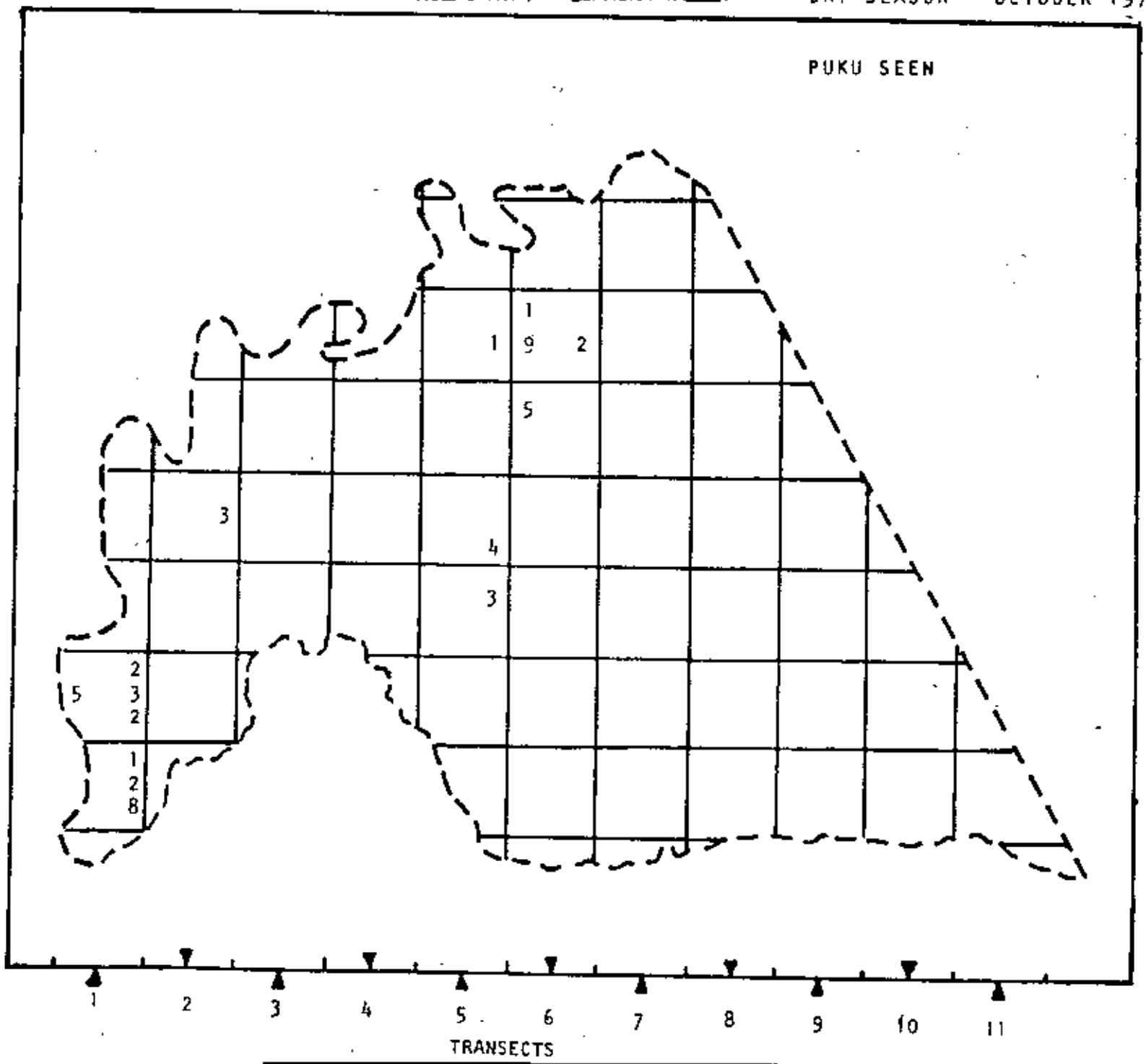

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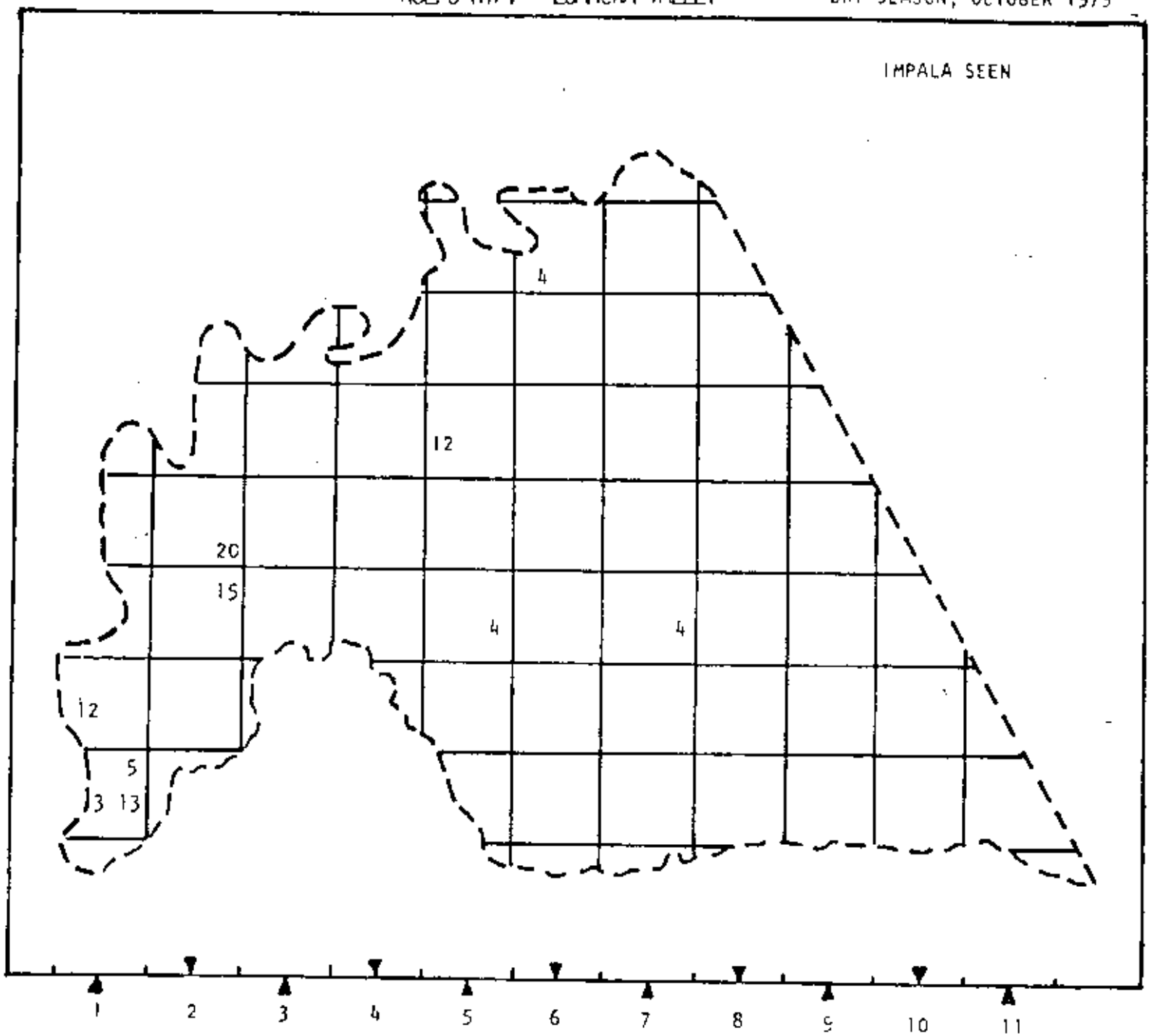

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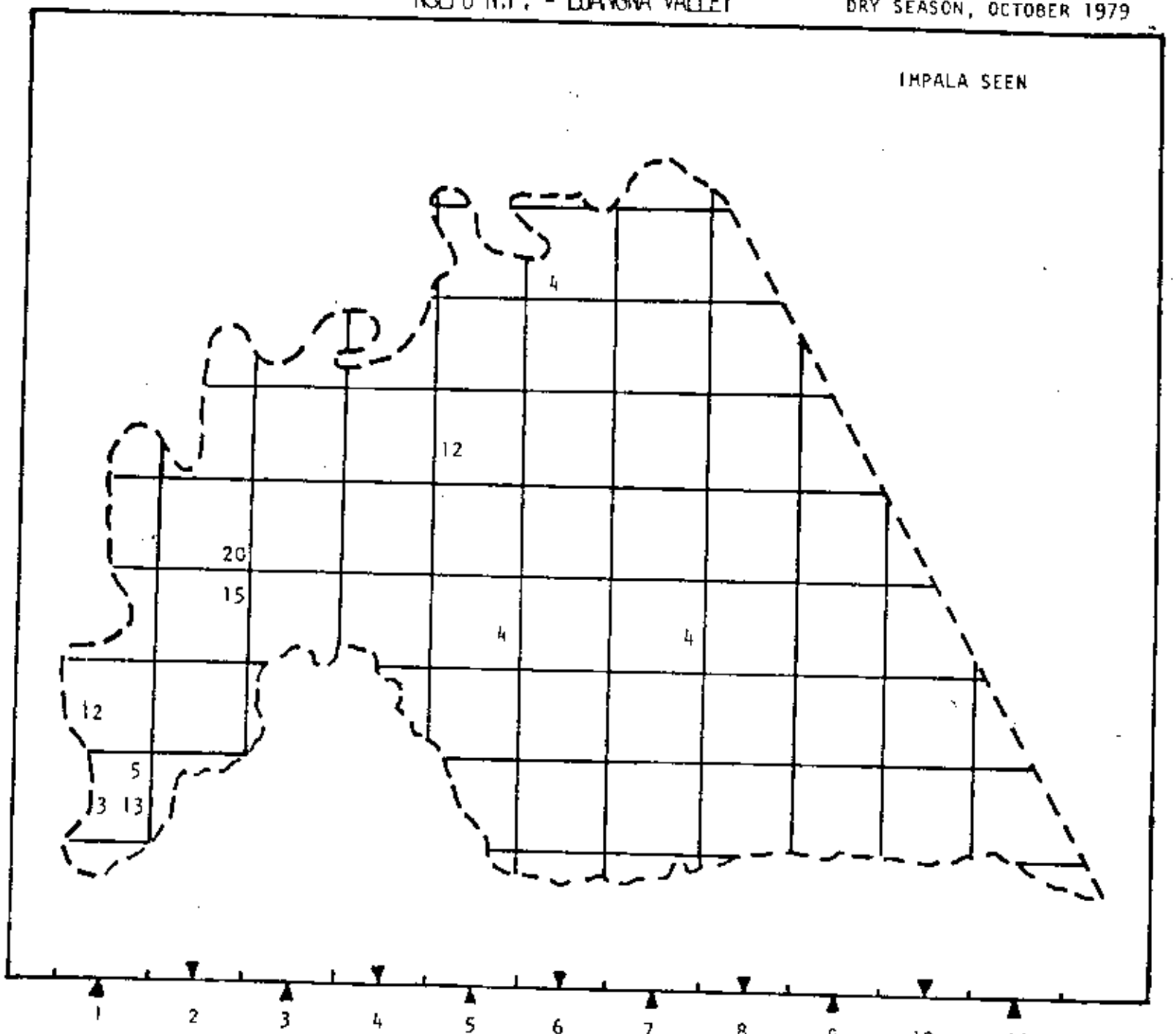

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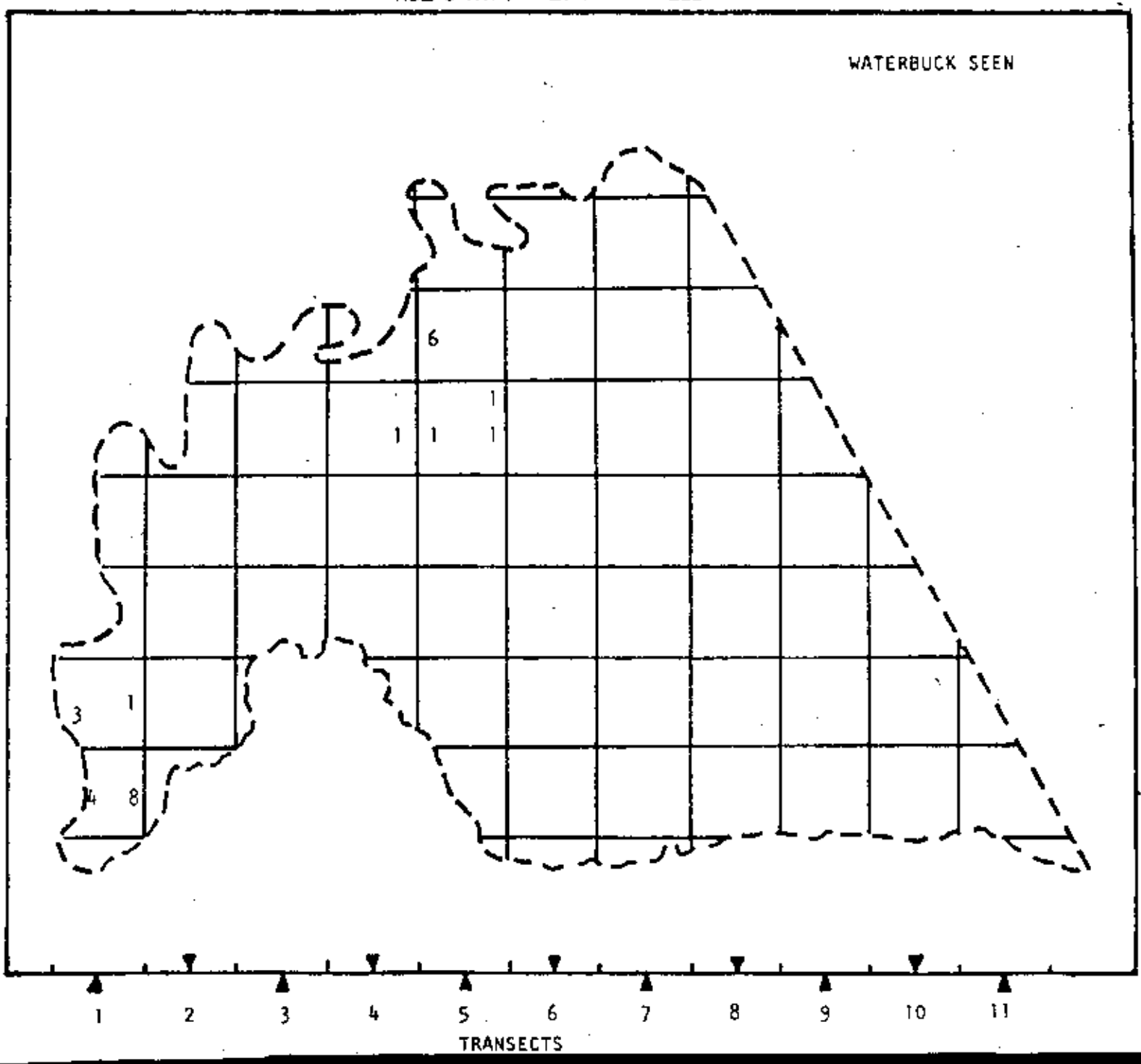

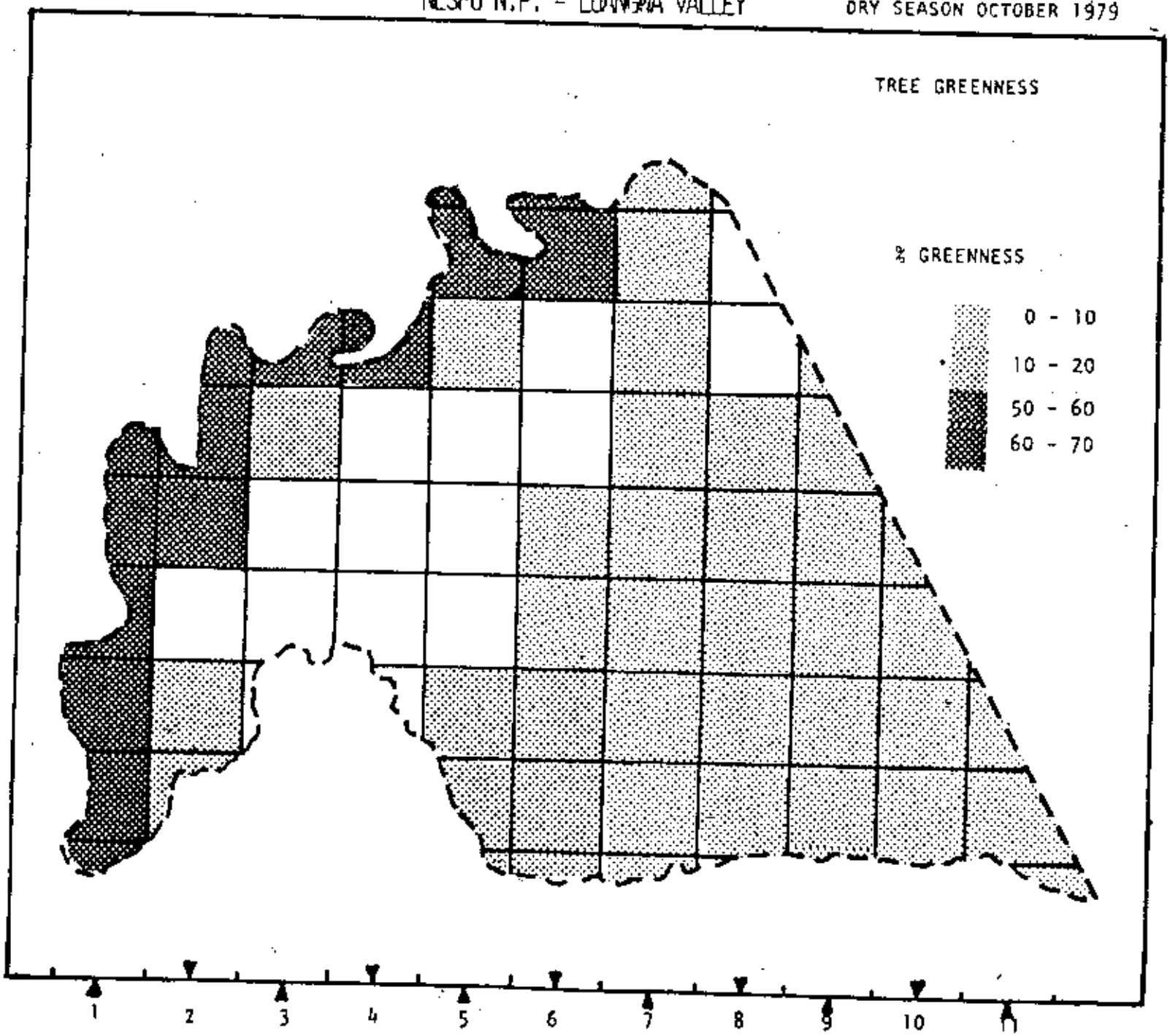
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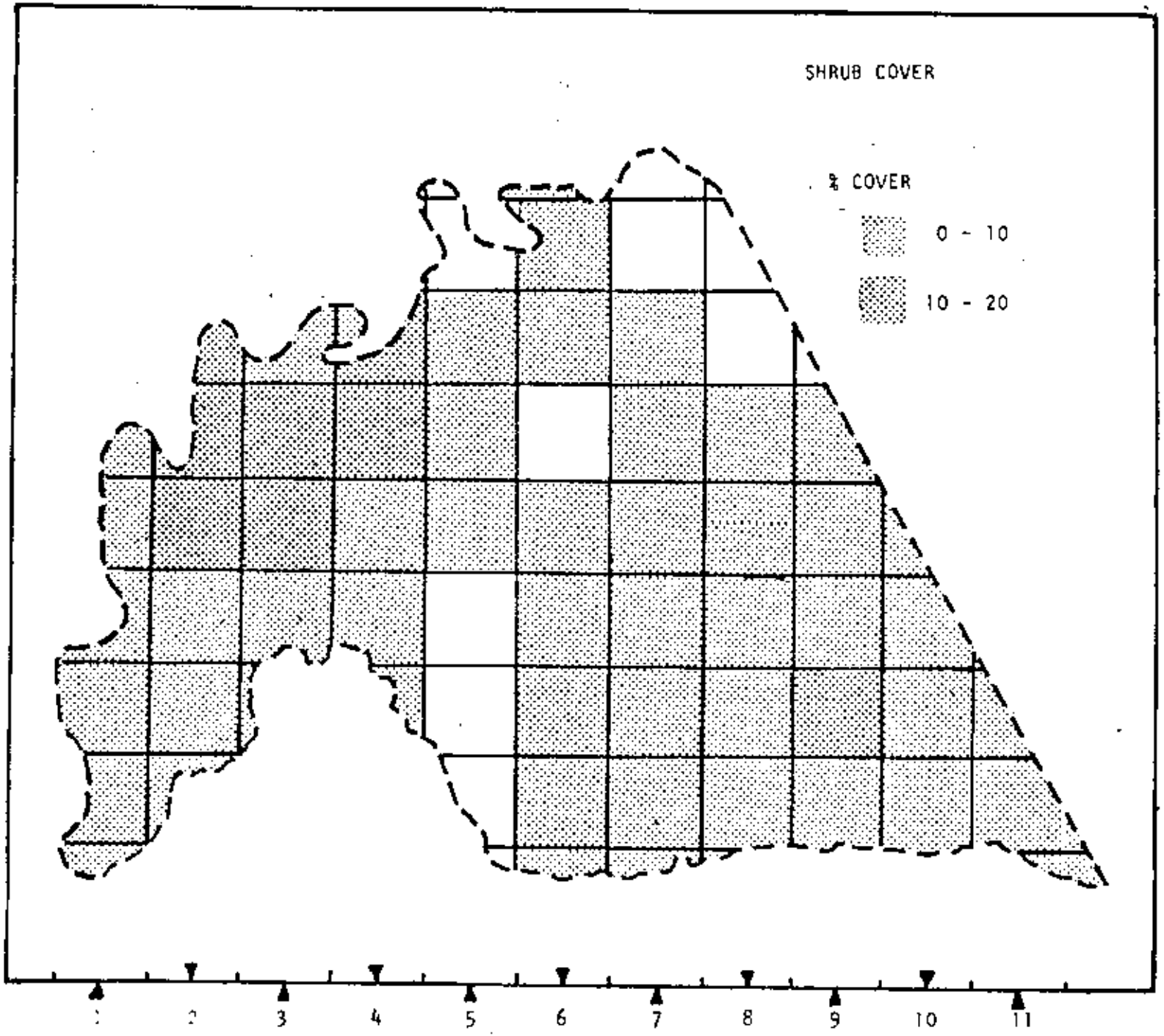

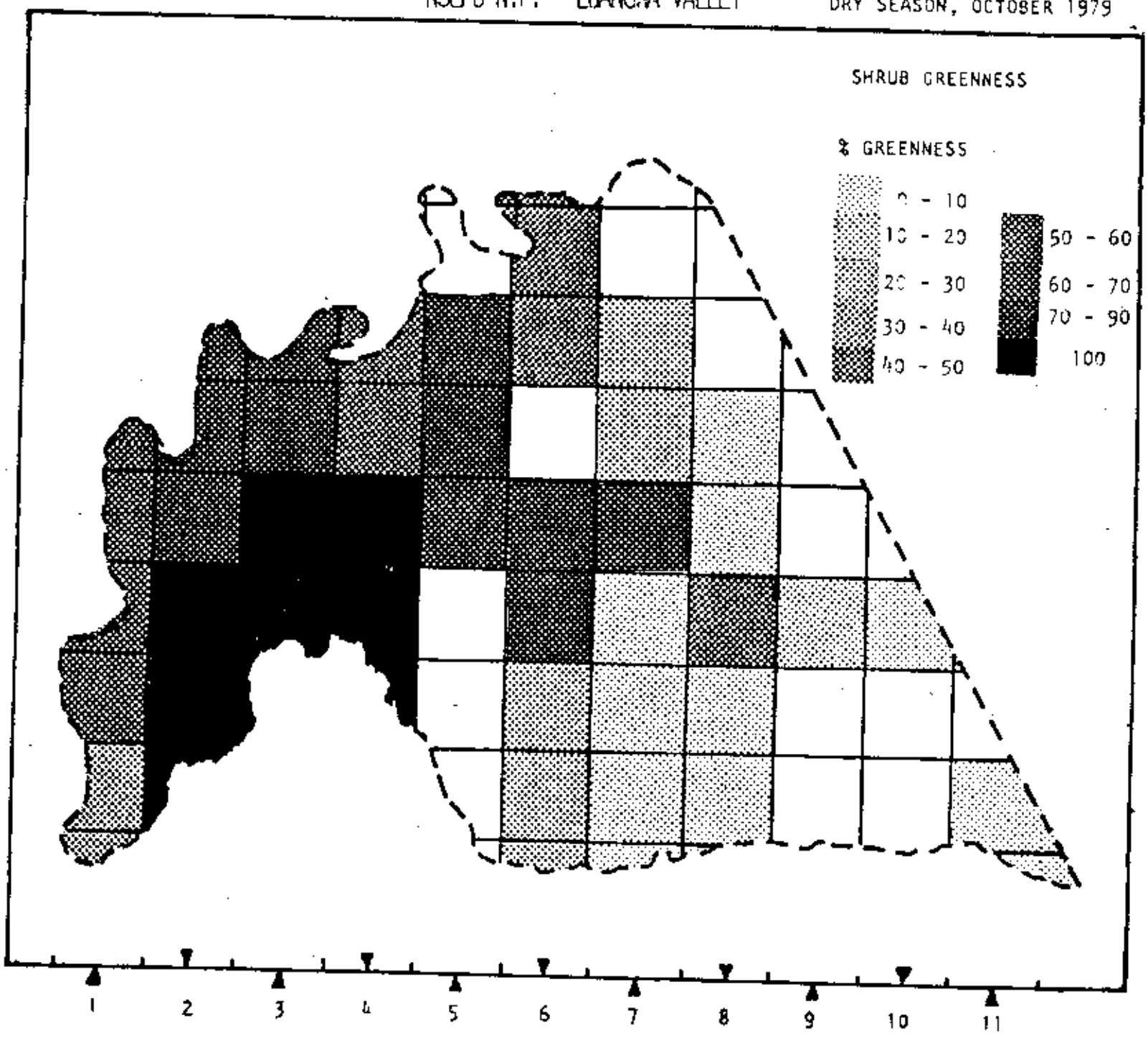
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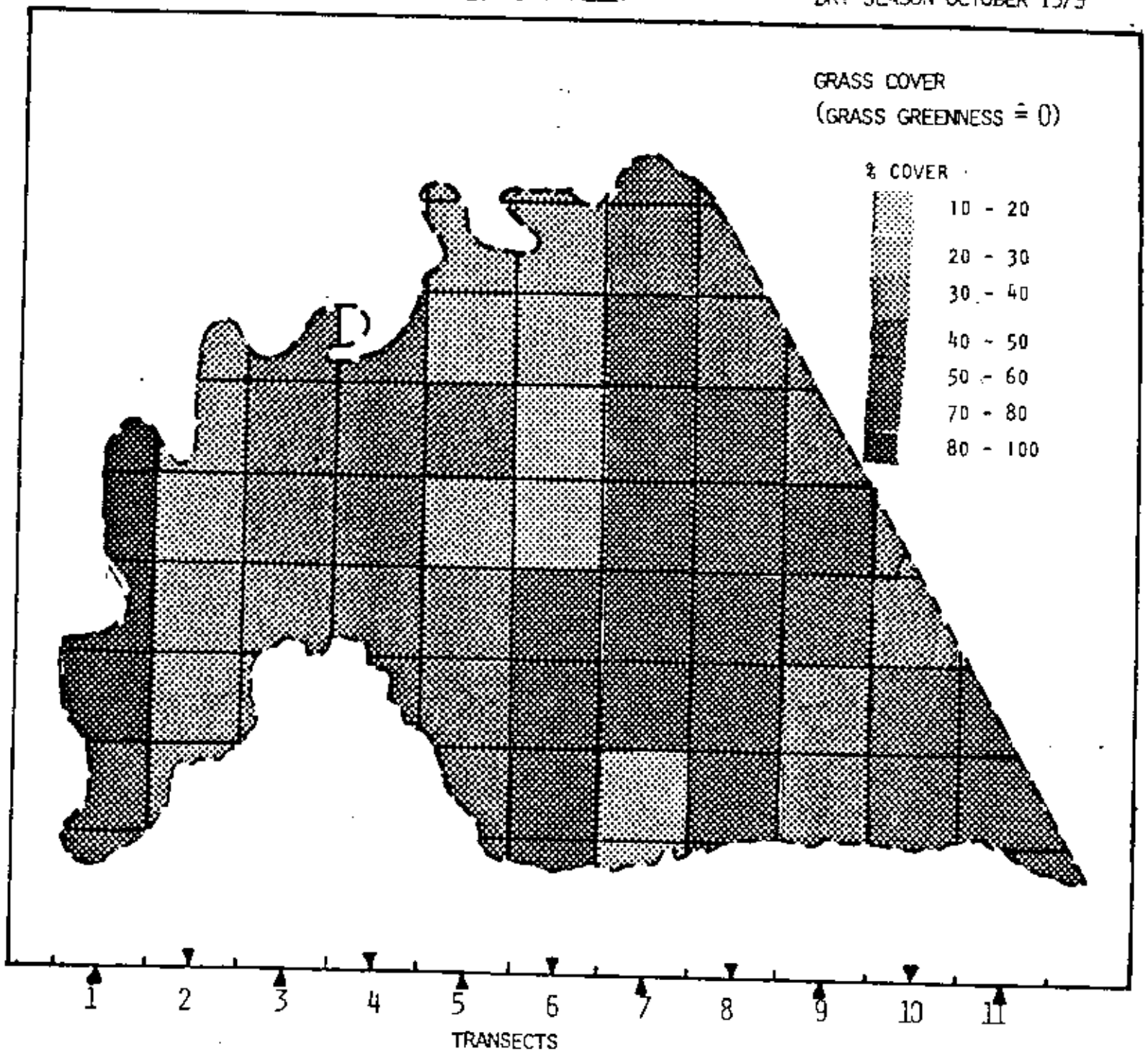

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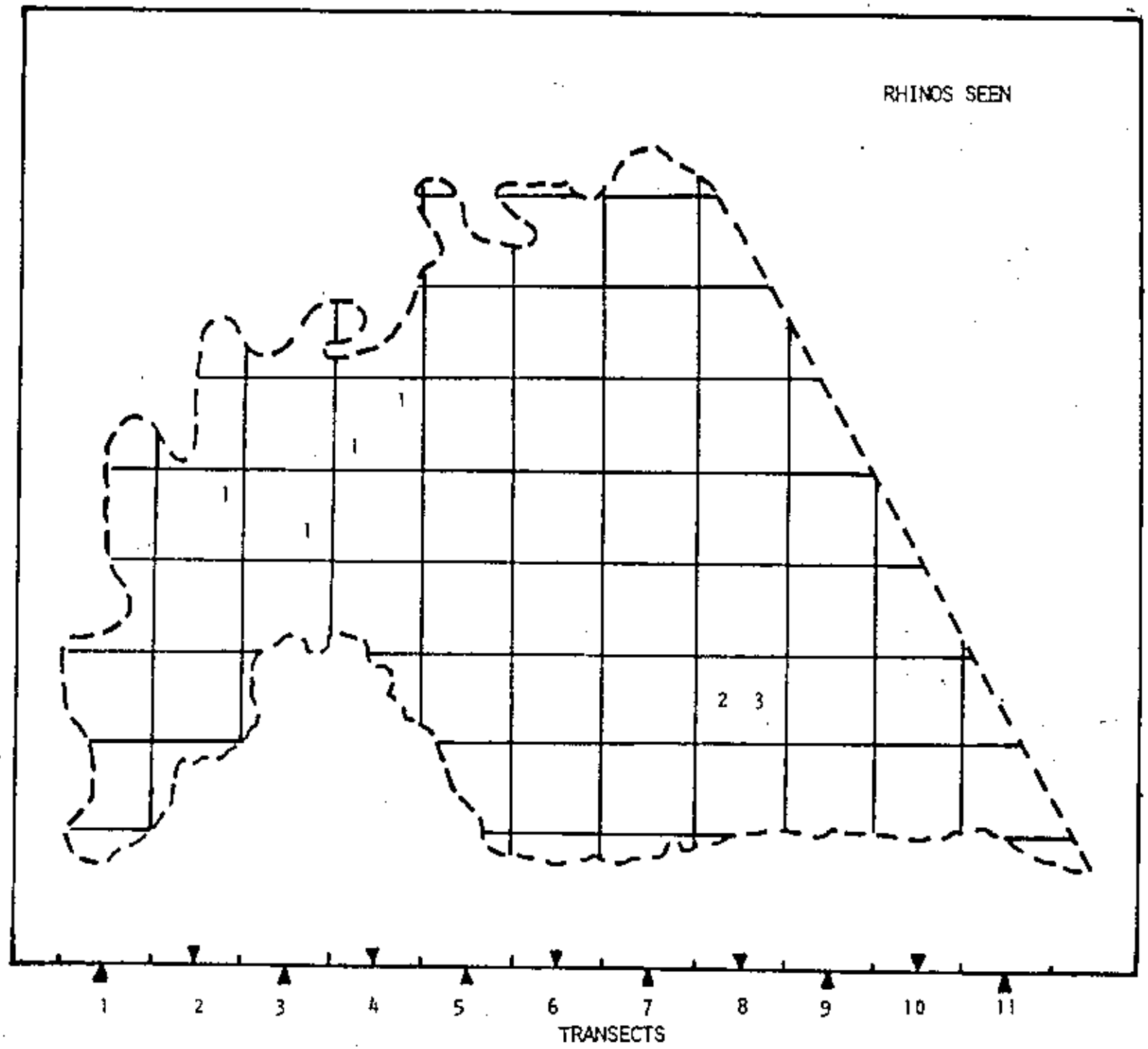

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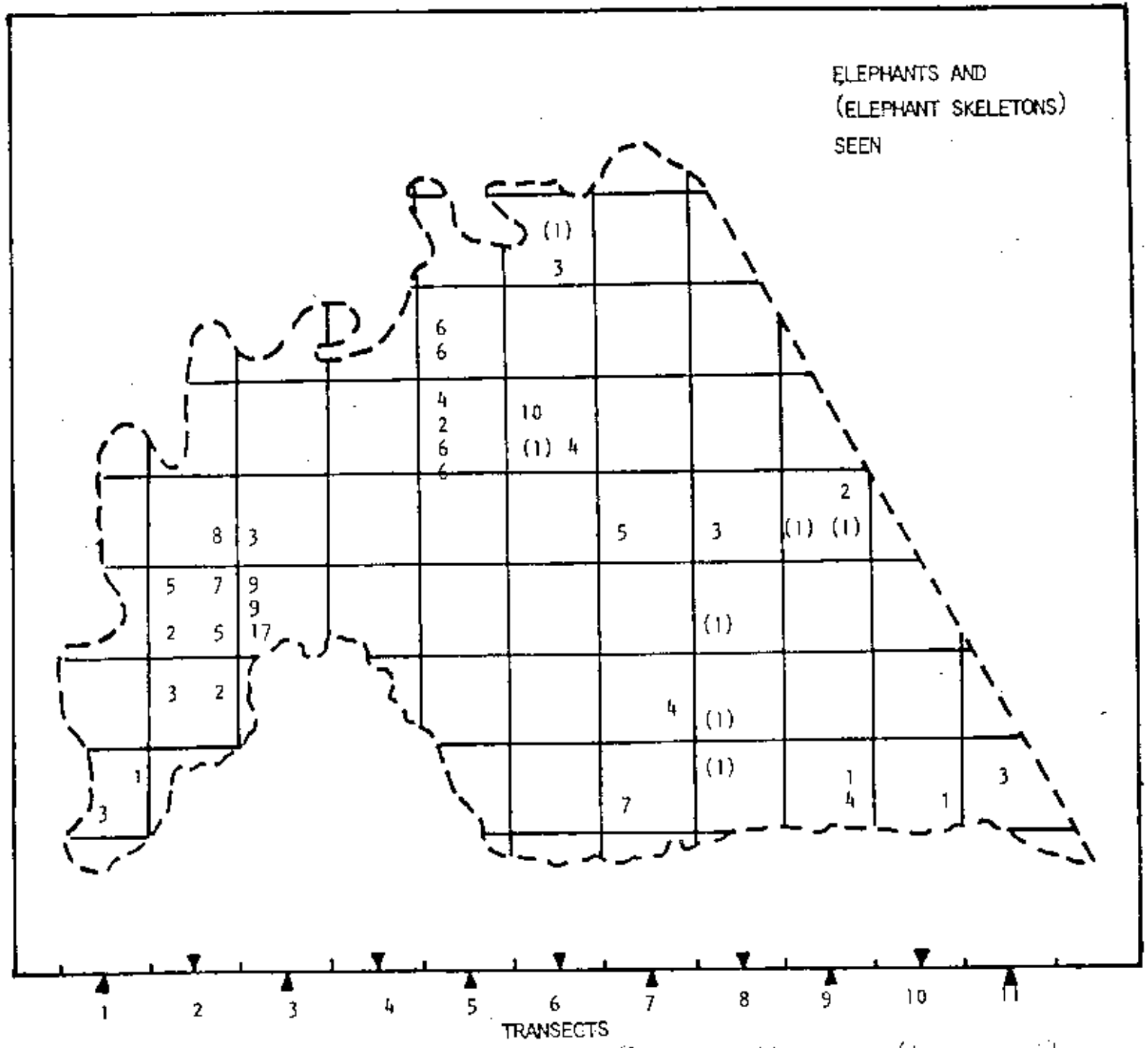

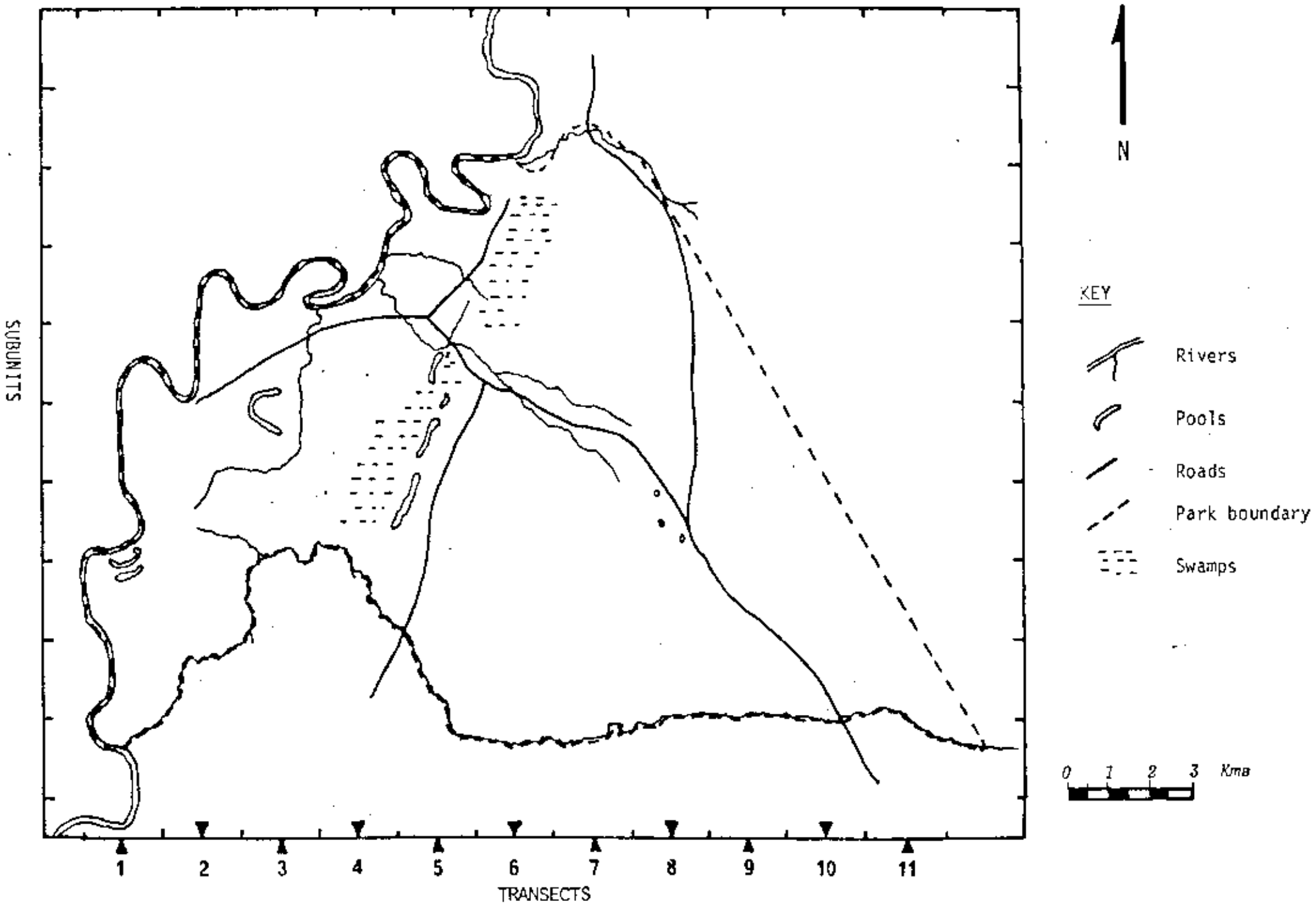
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KEY
Rivers
Pools
Roads
Park boundary
Swamps
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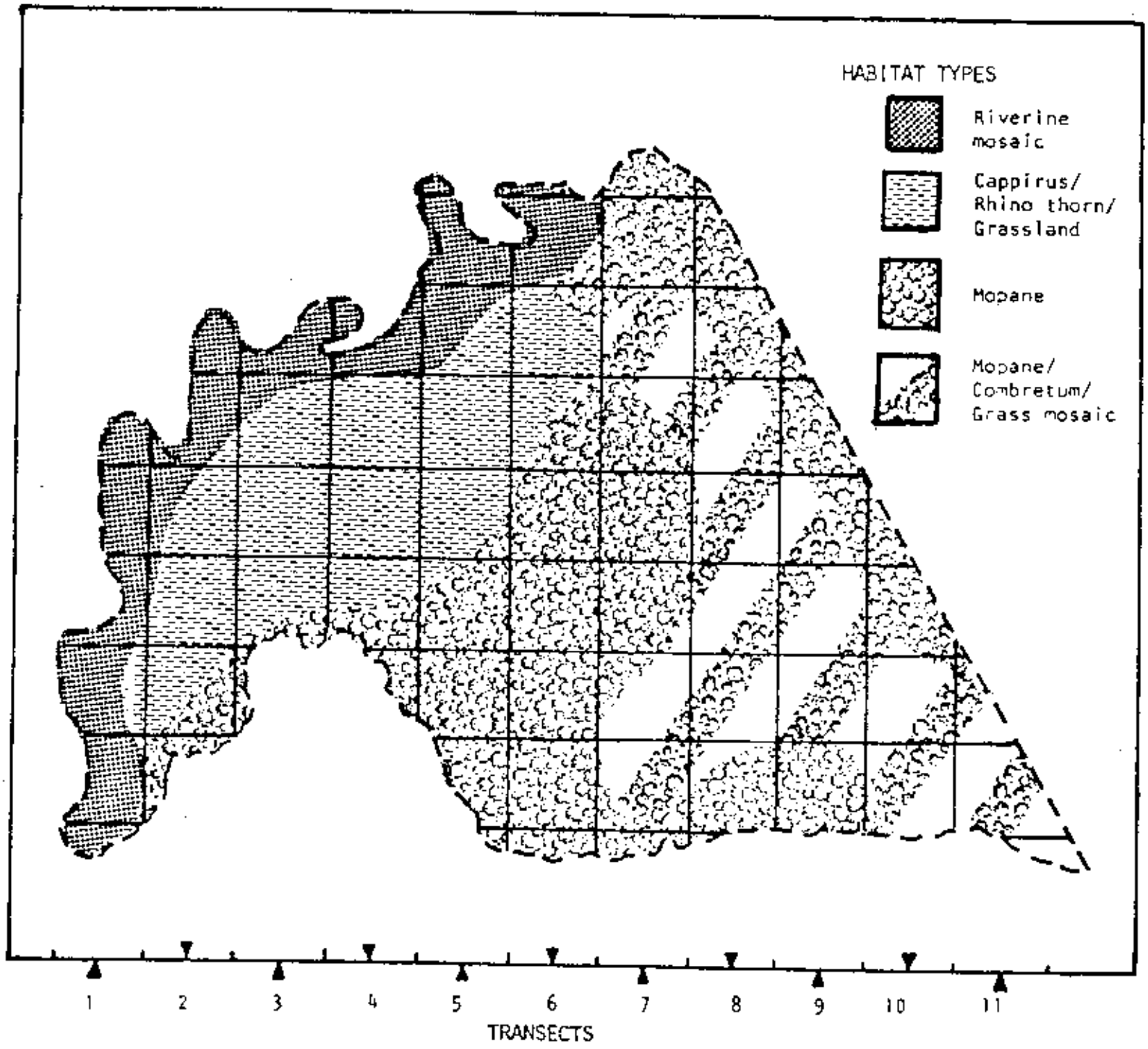
NSEFU N.P. – LUANGWA VALLEY



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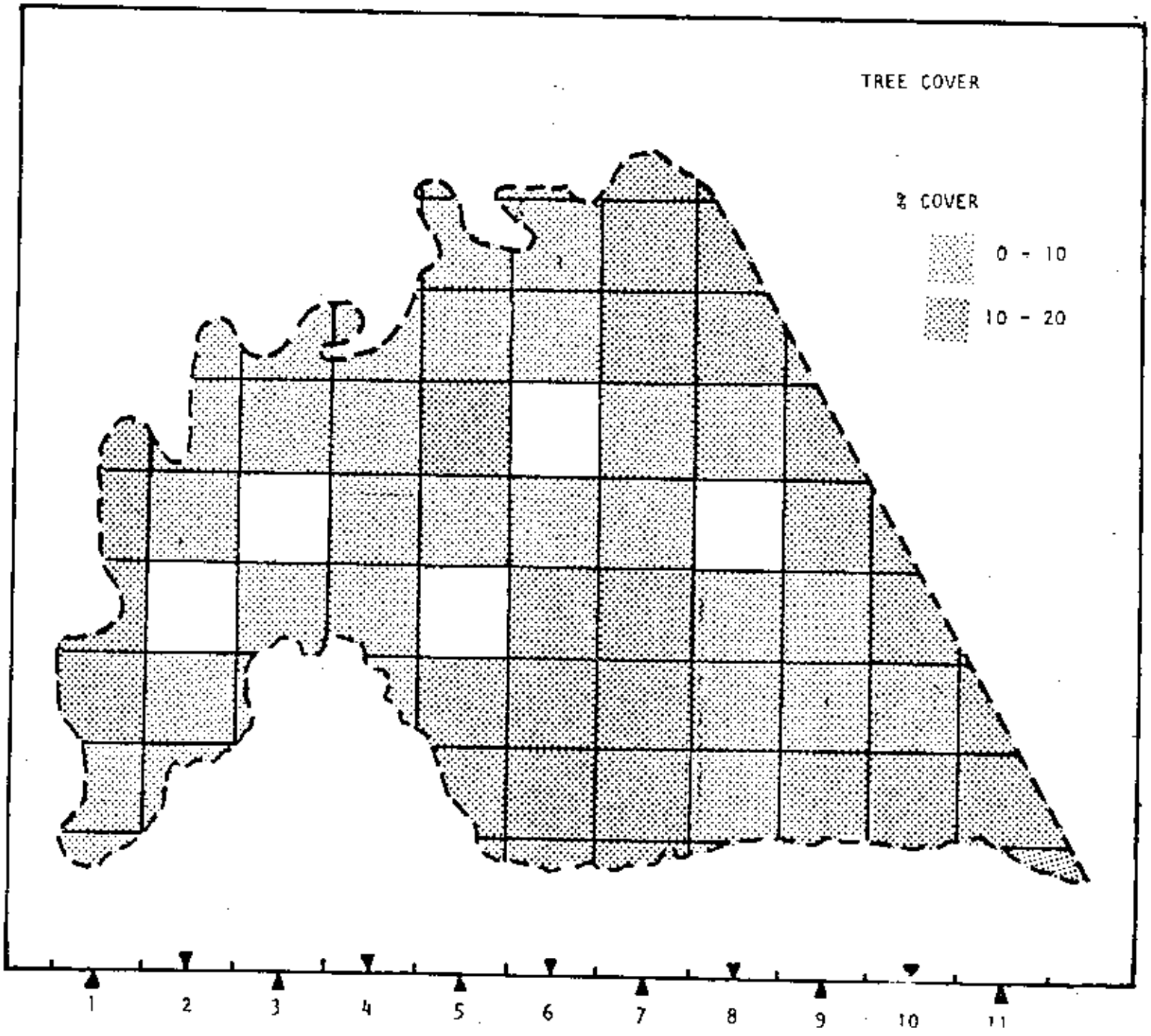

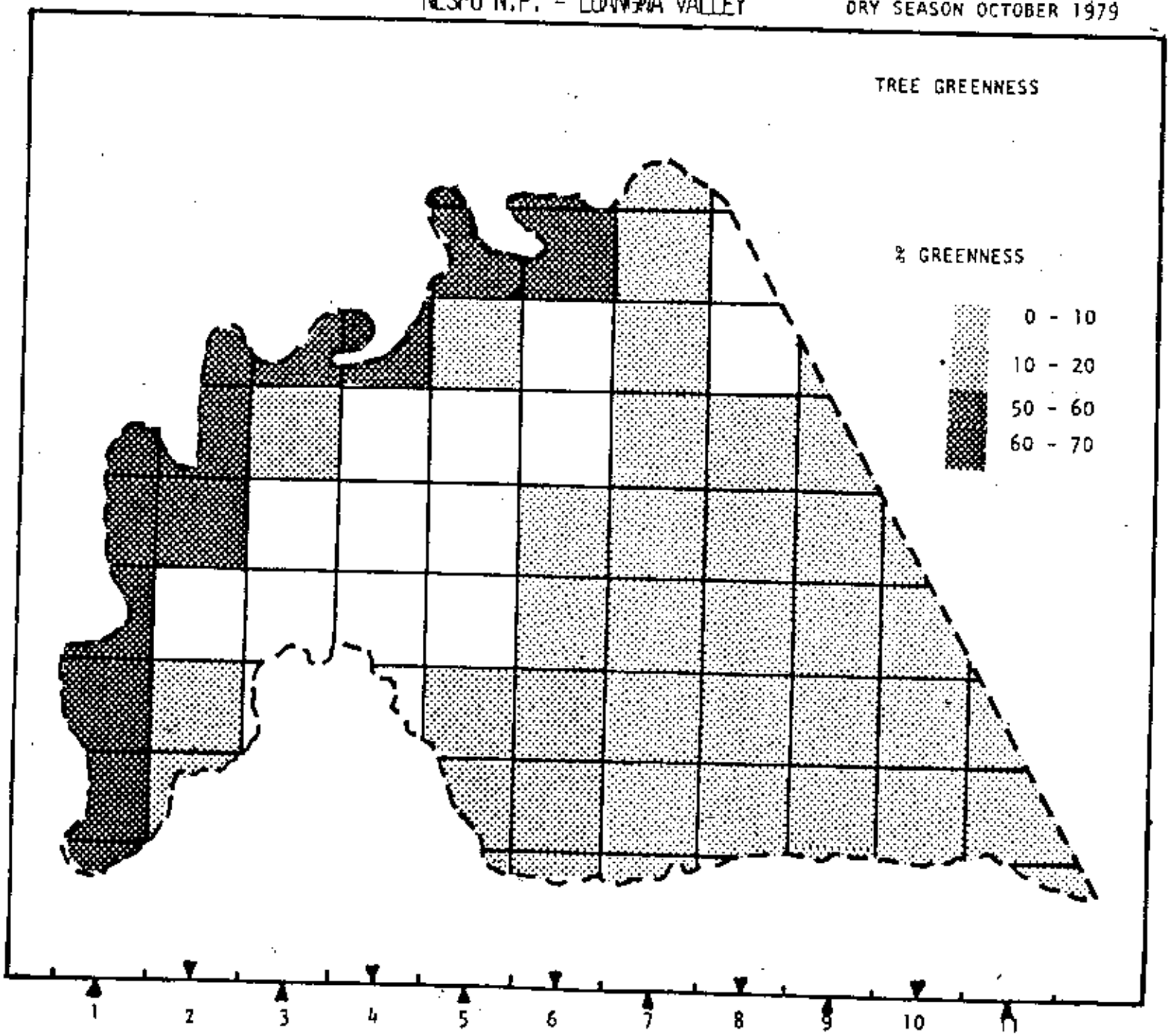
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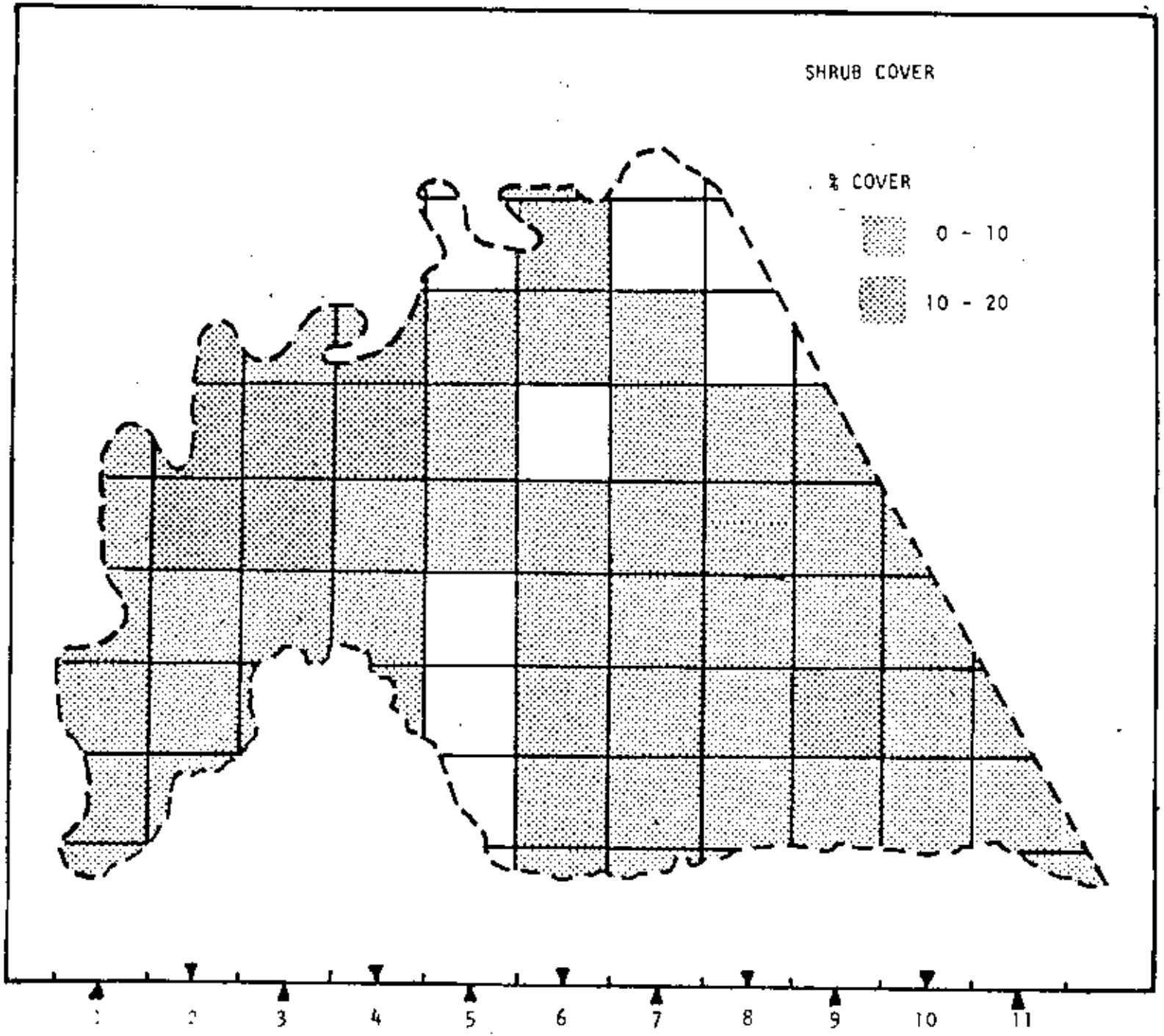

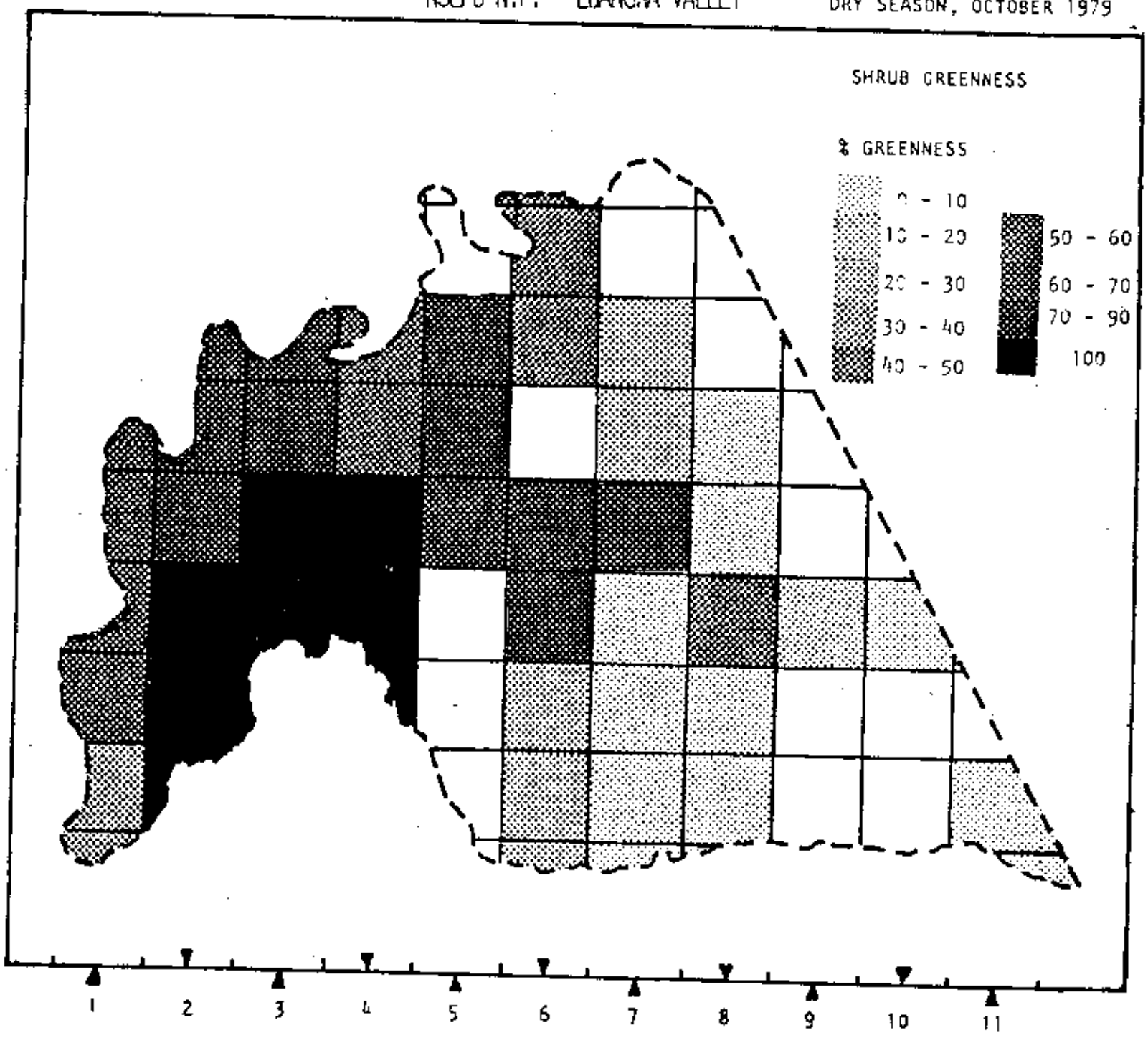
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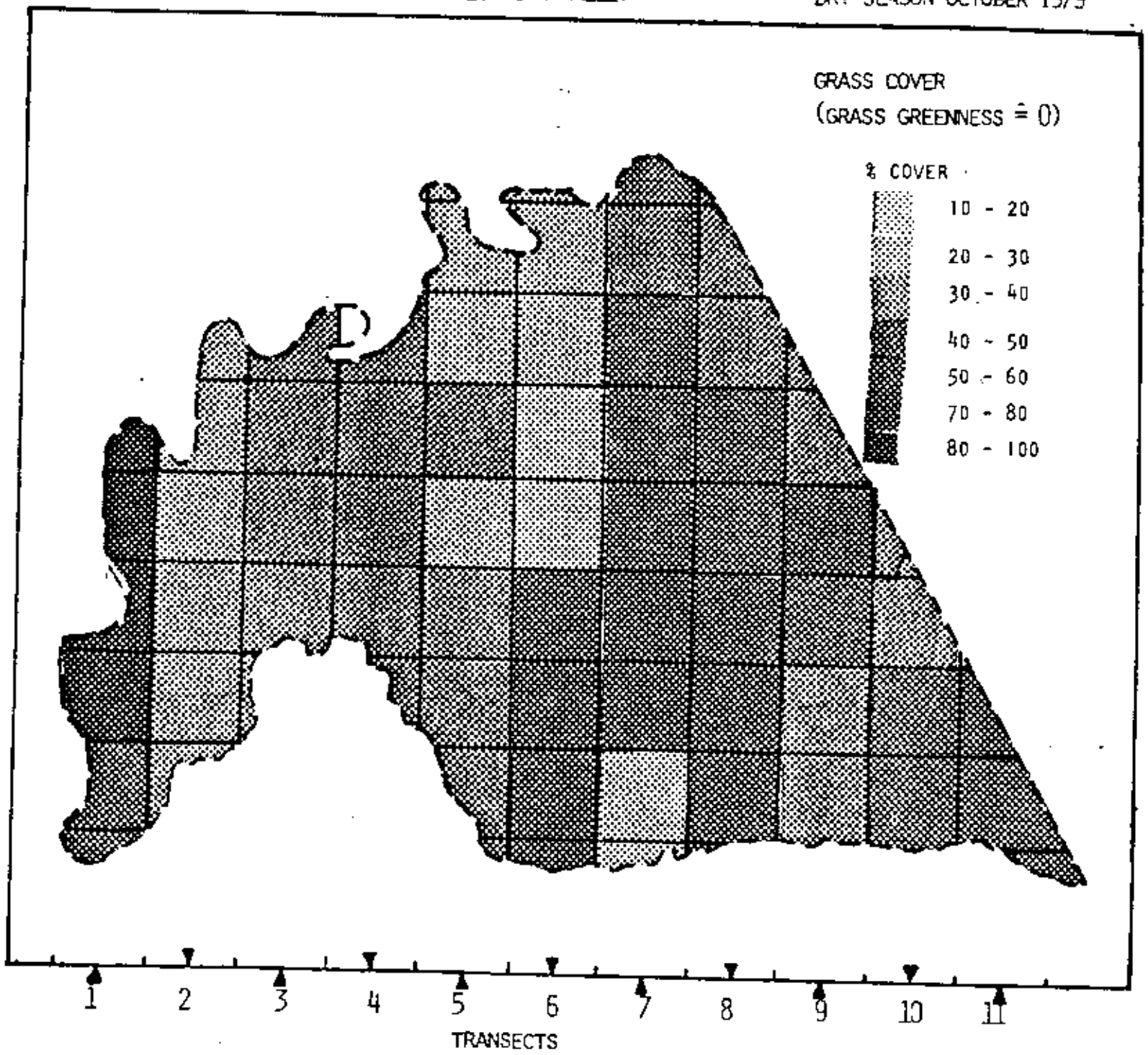

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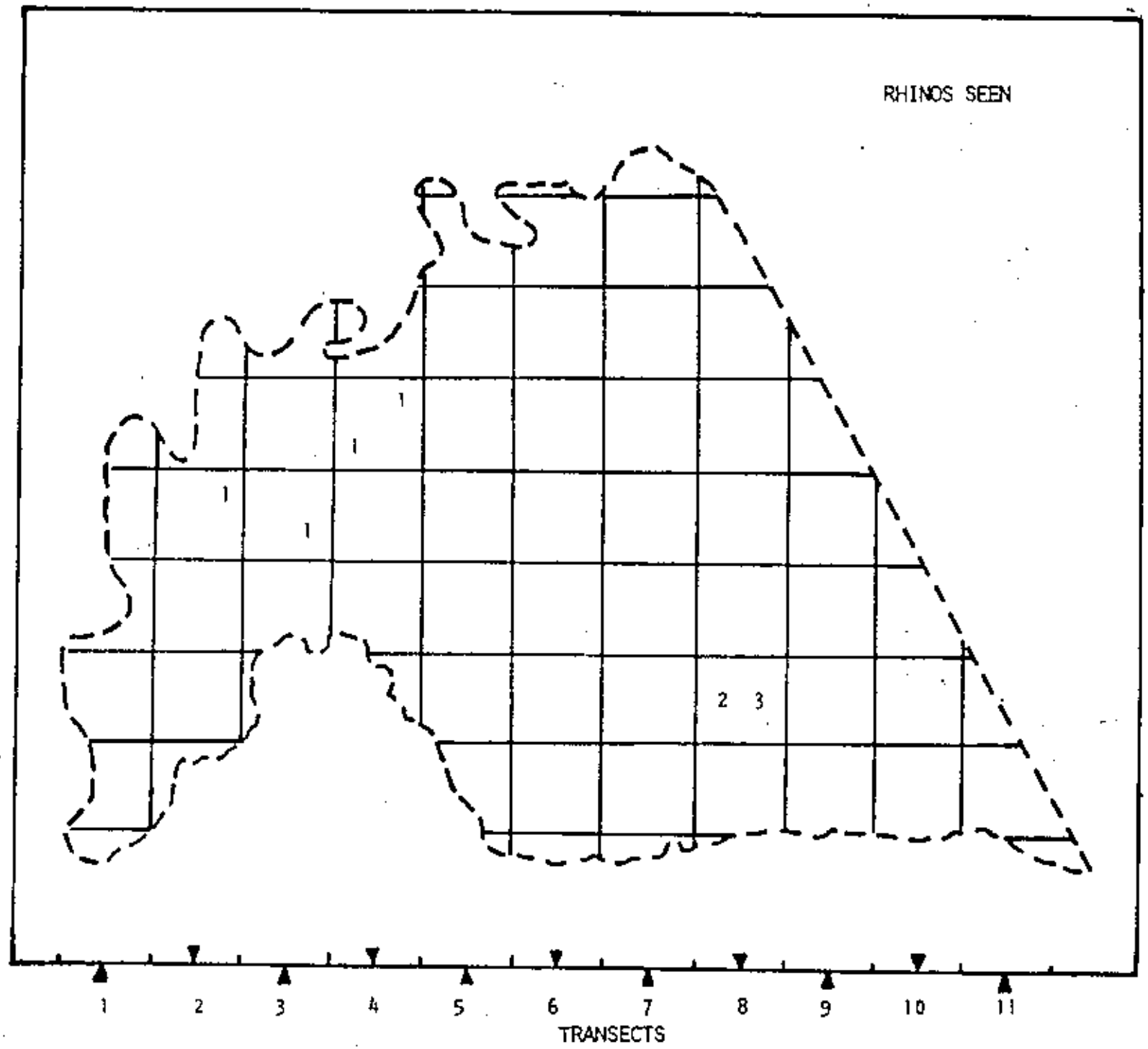

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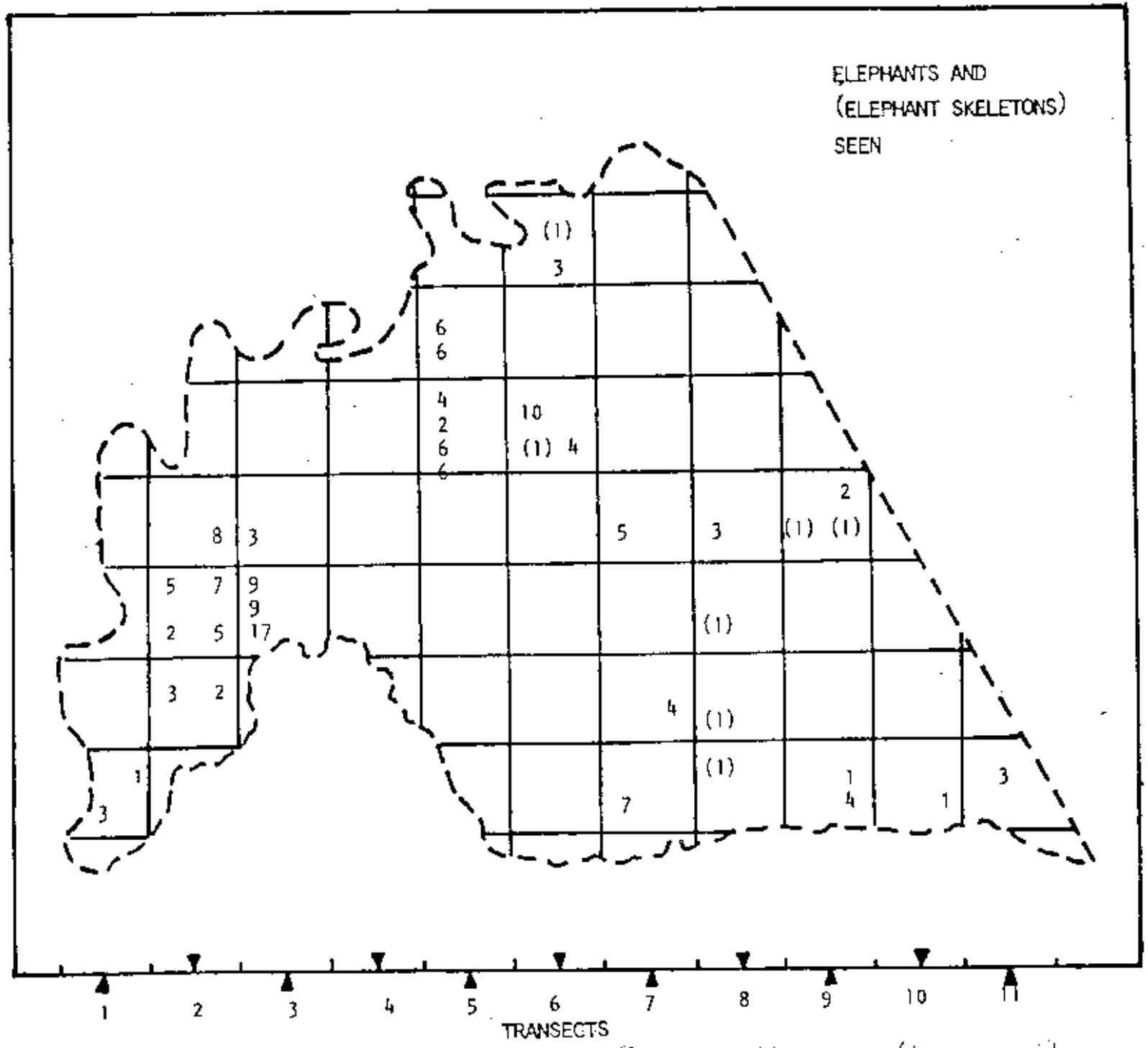

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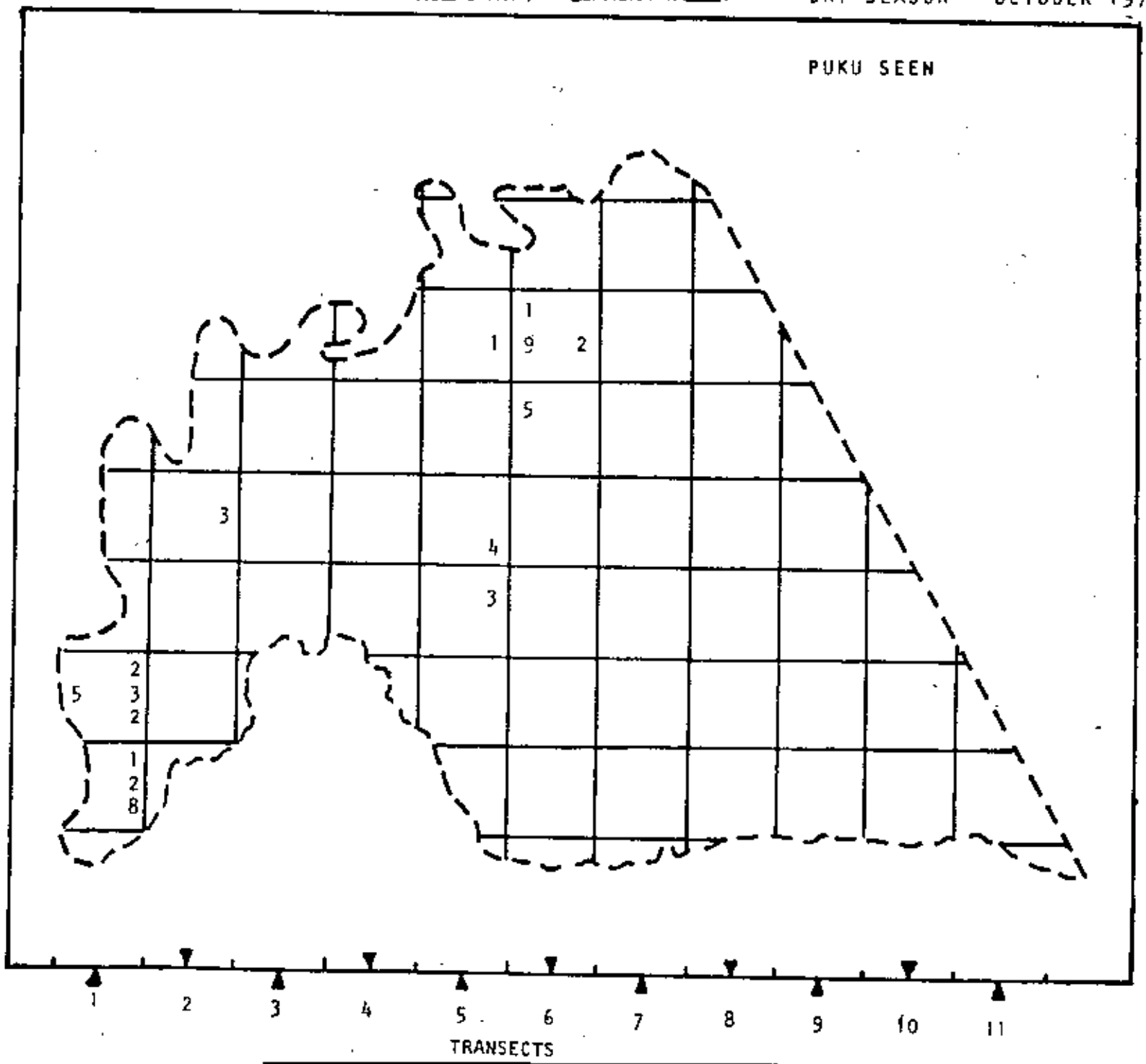

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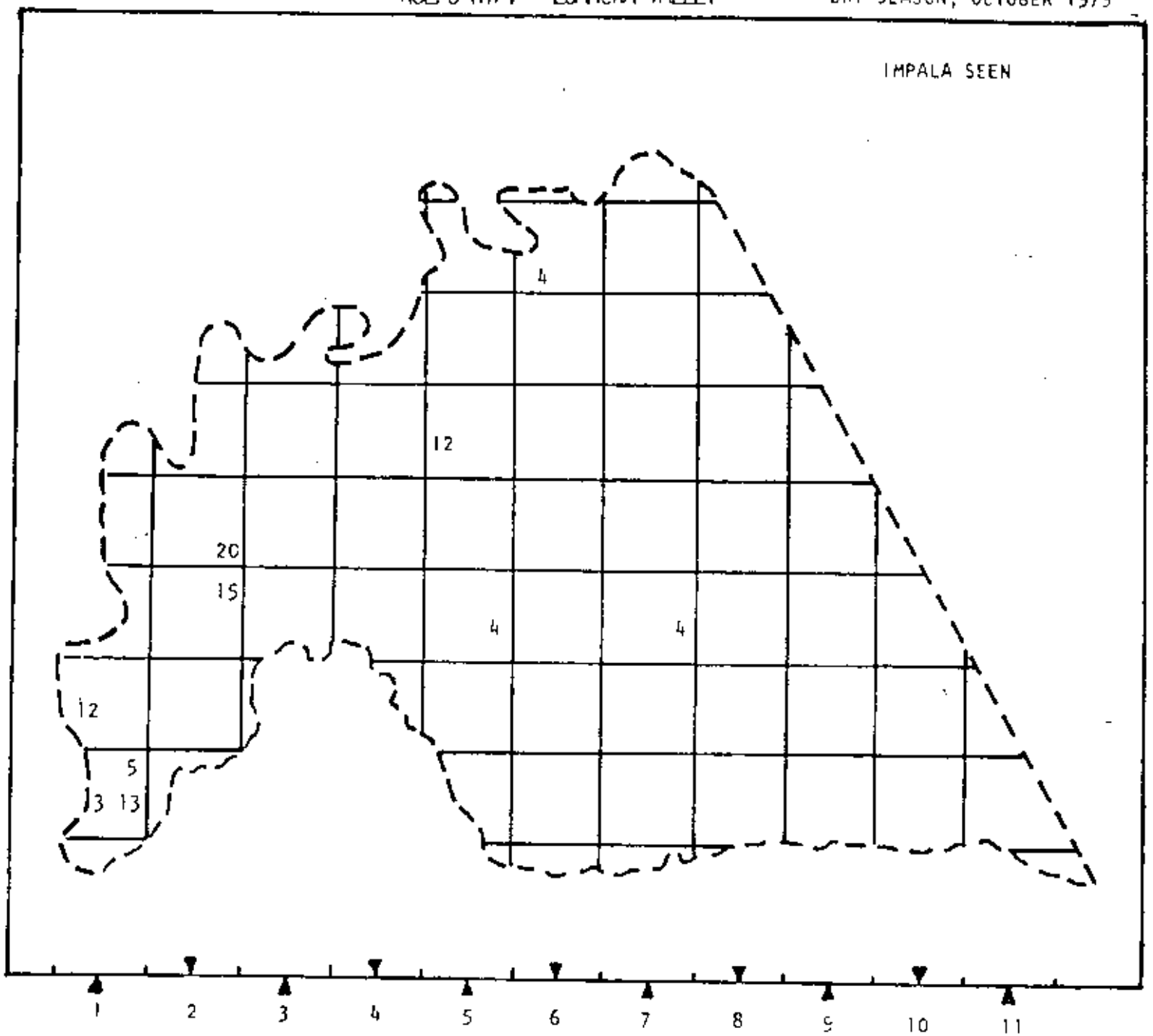

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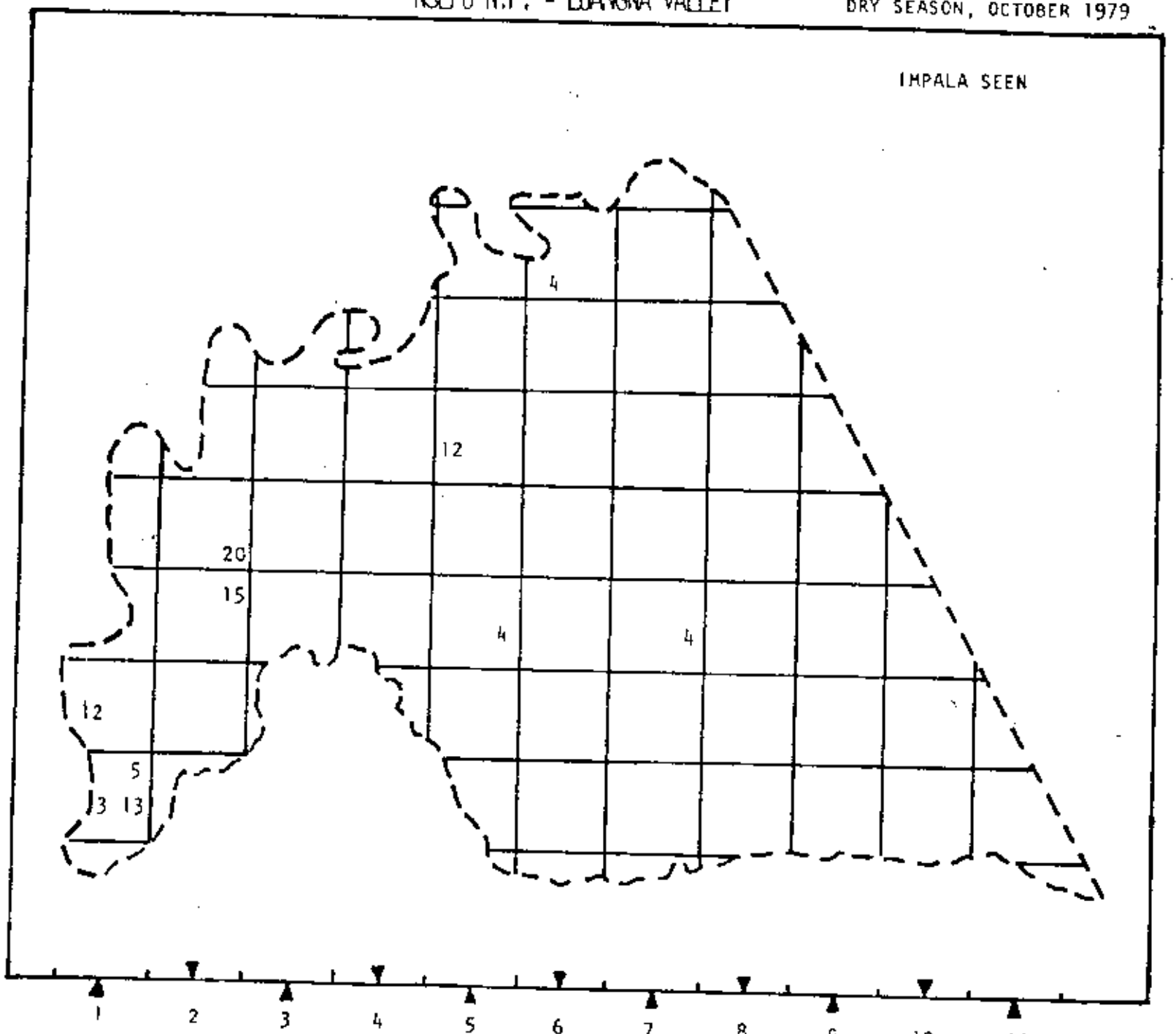

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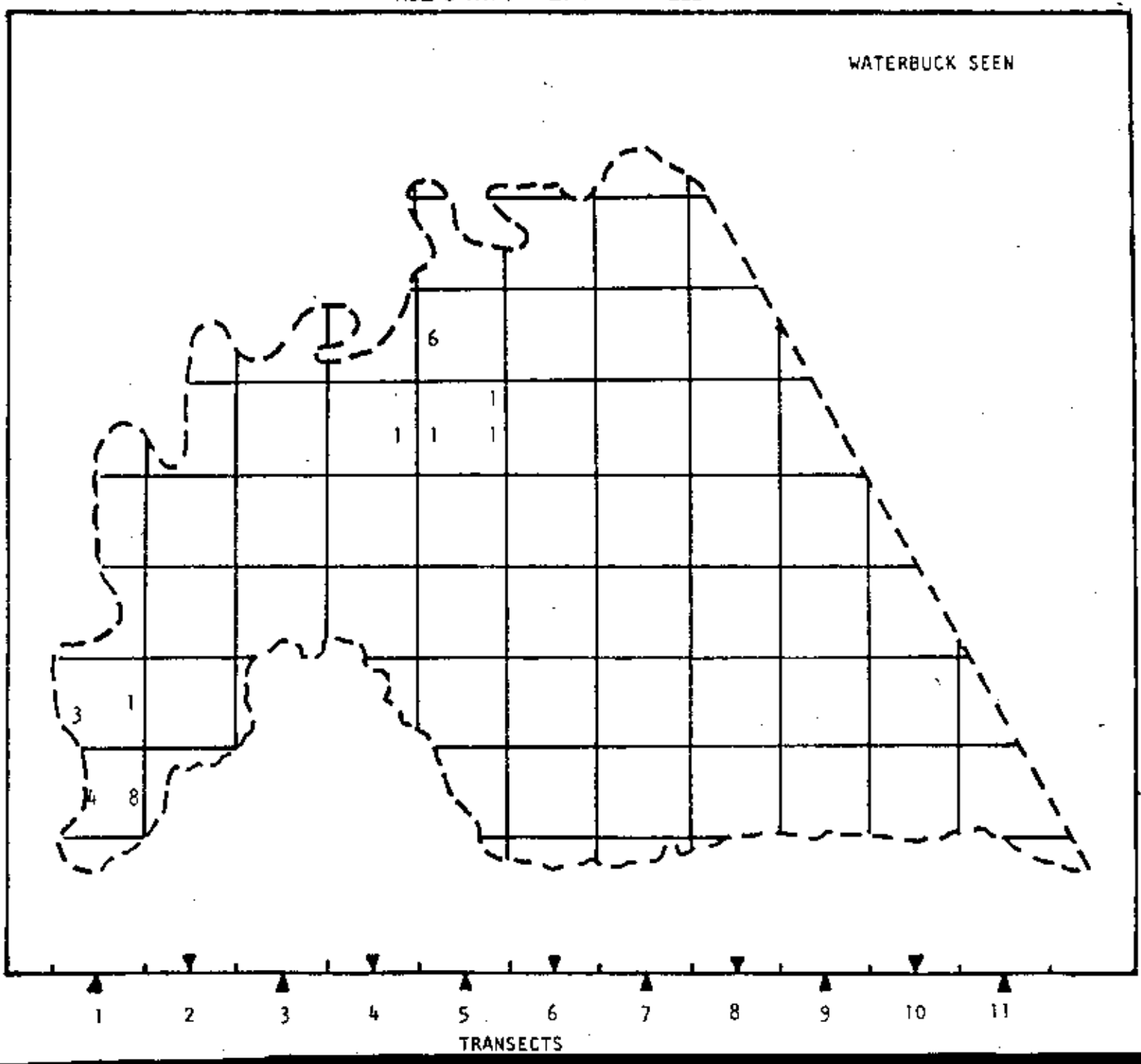

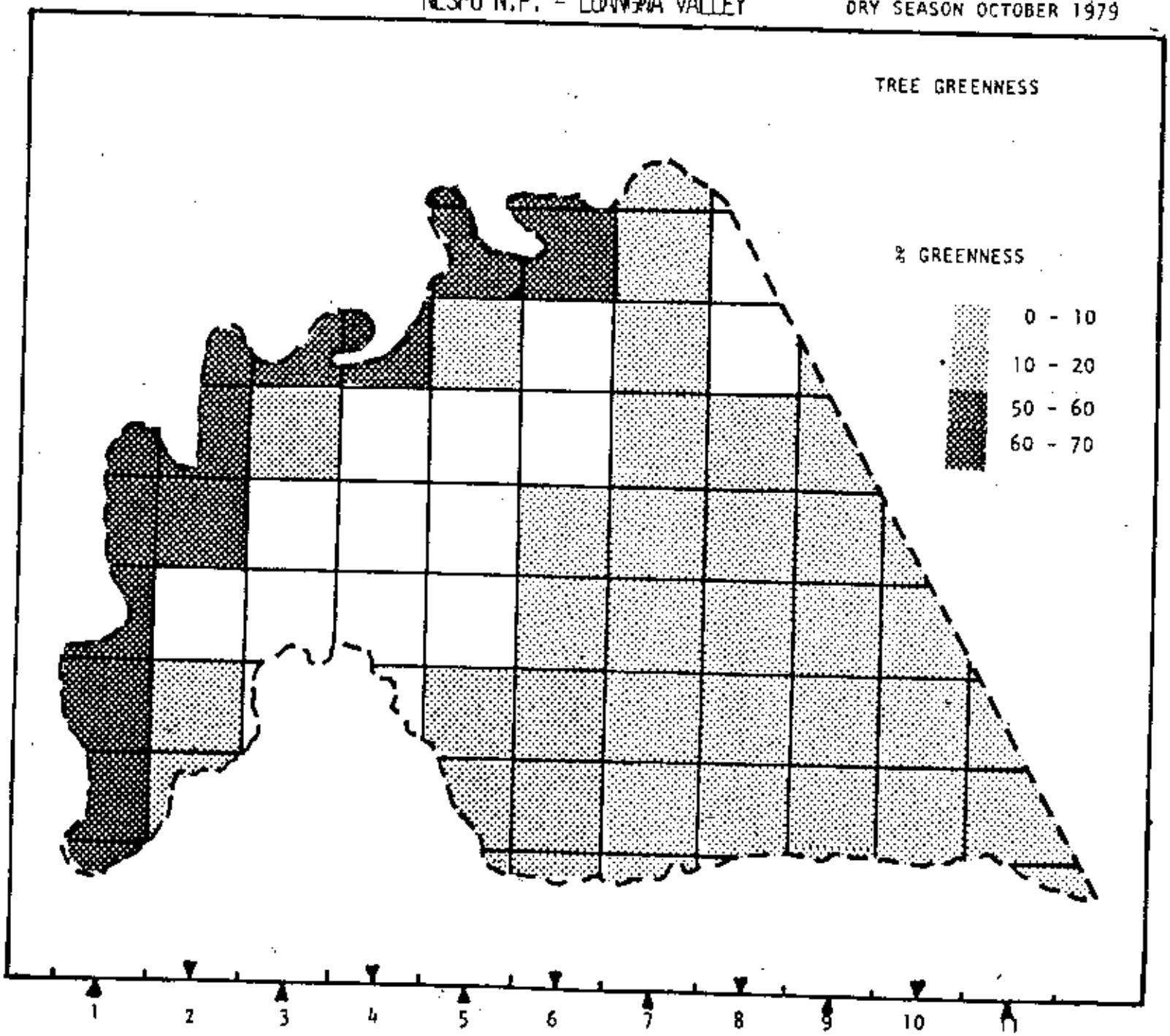
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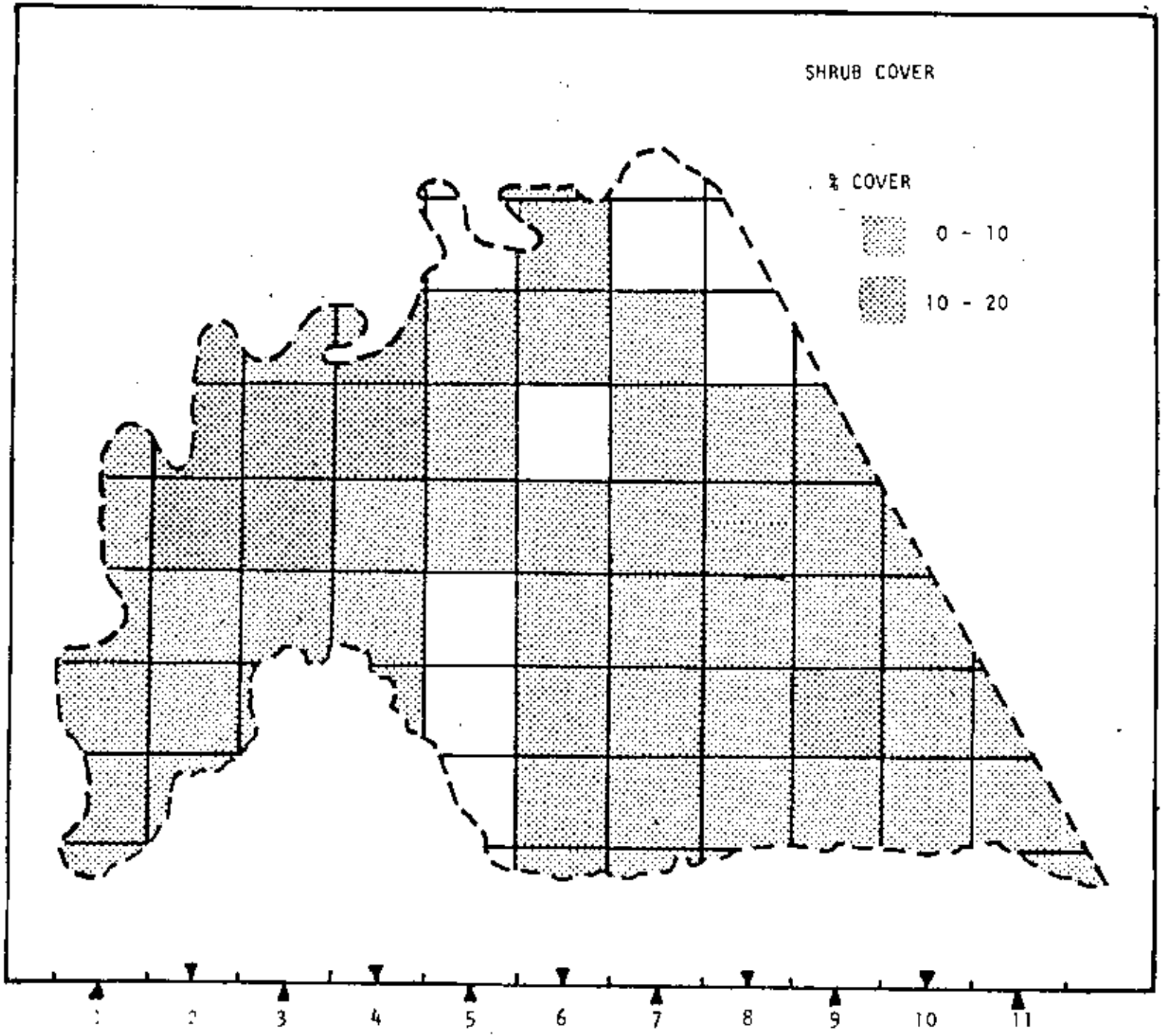

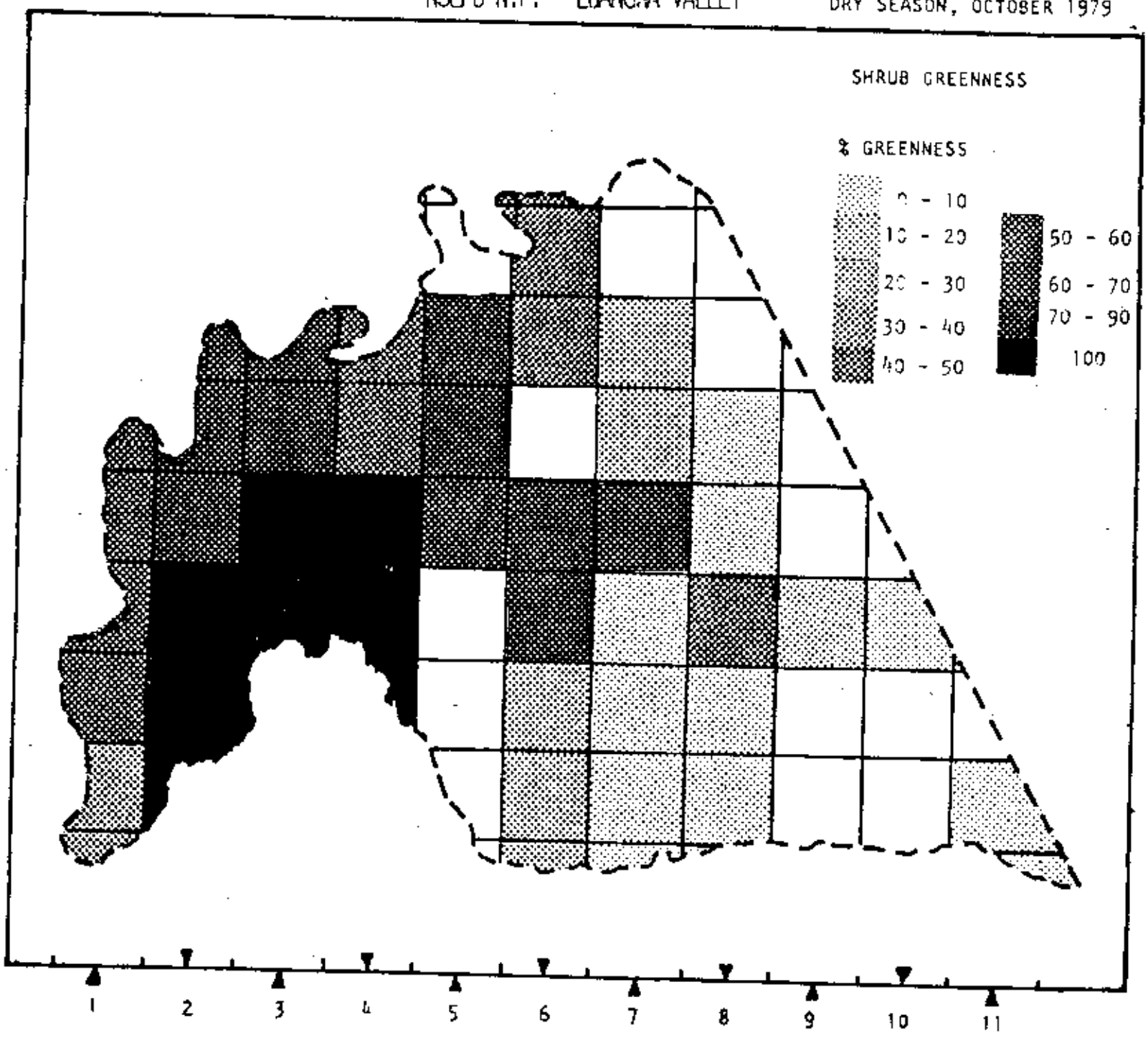
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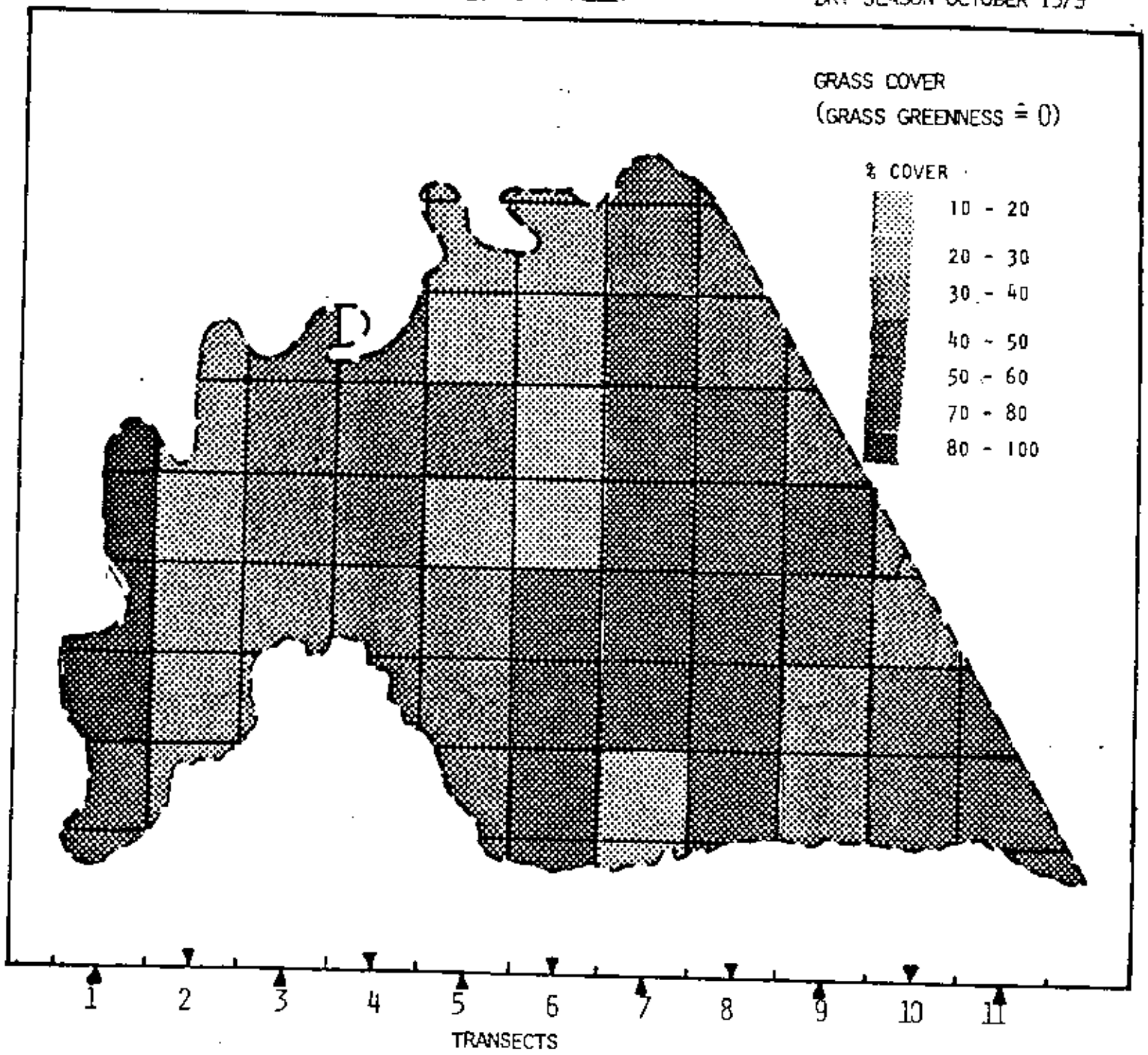

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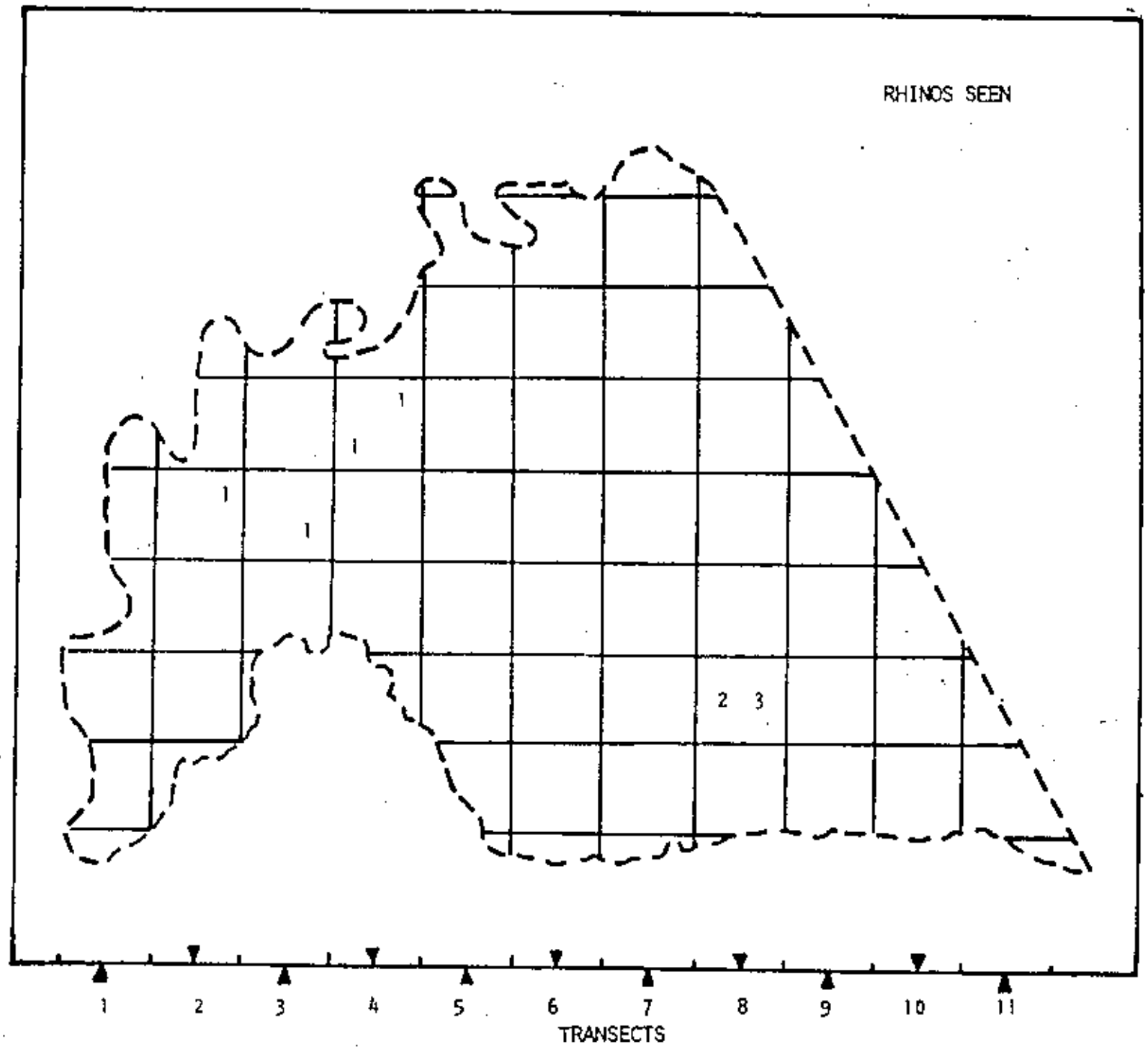

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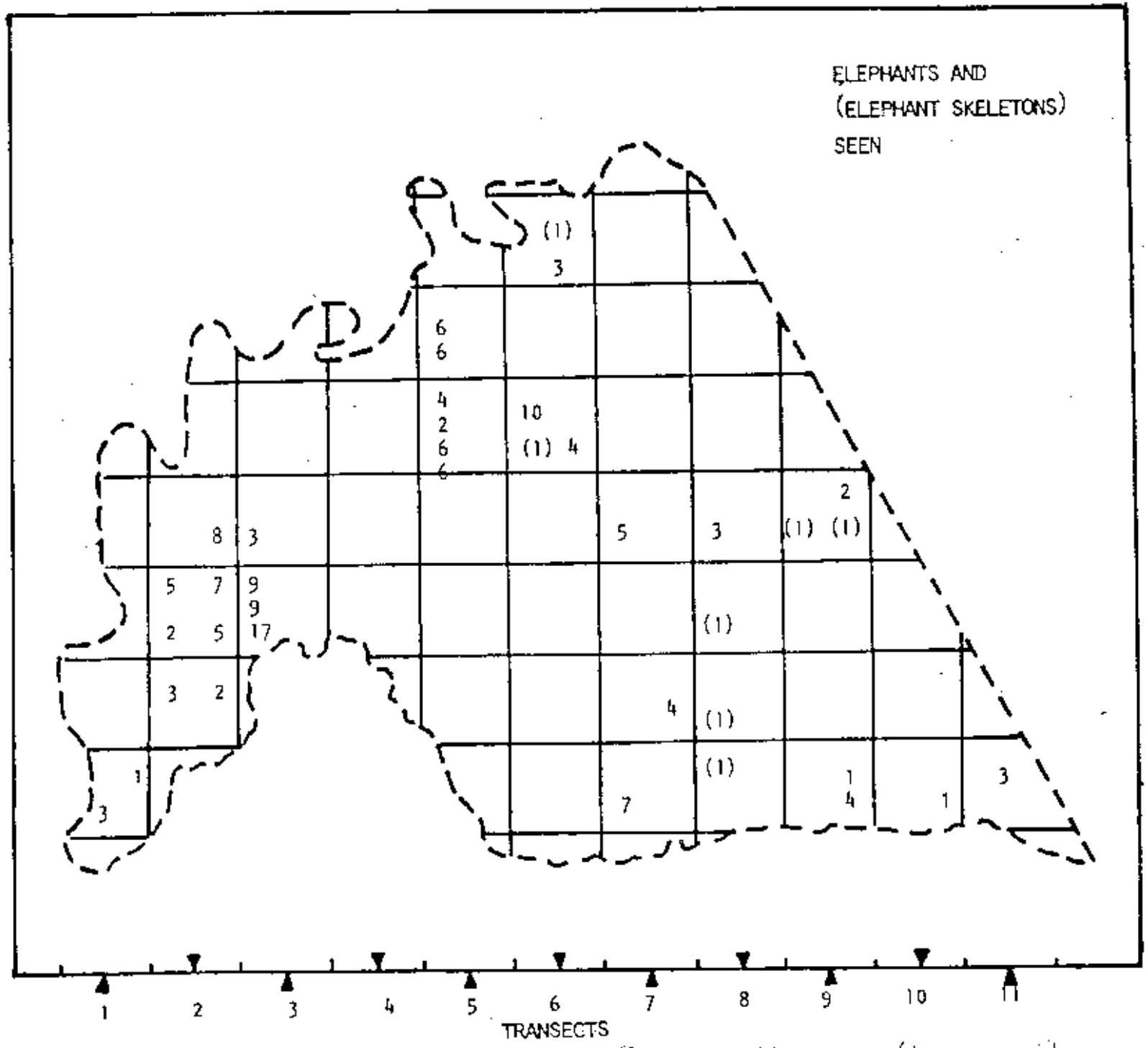

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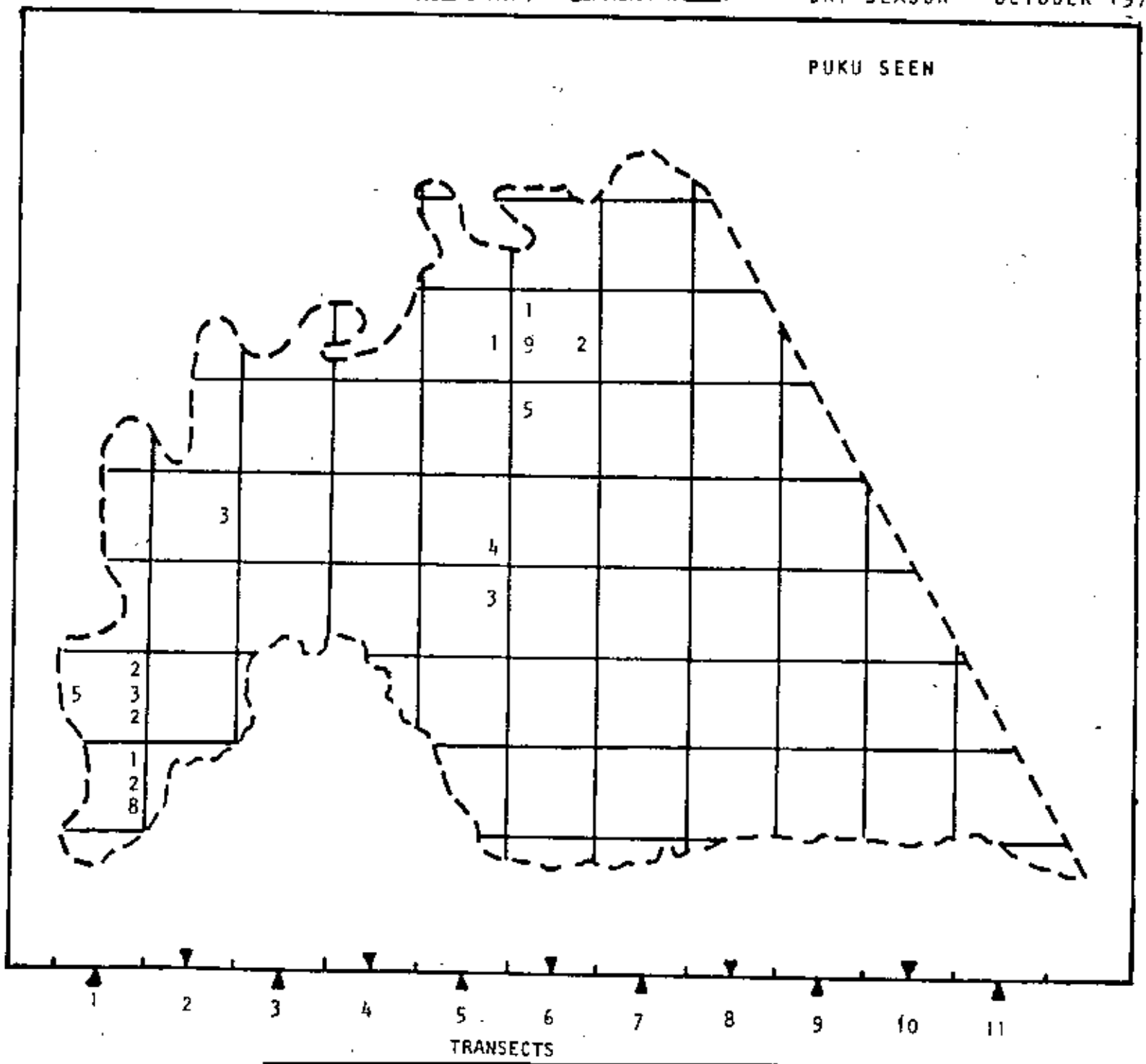

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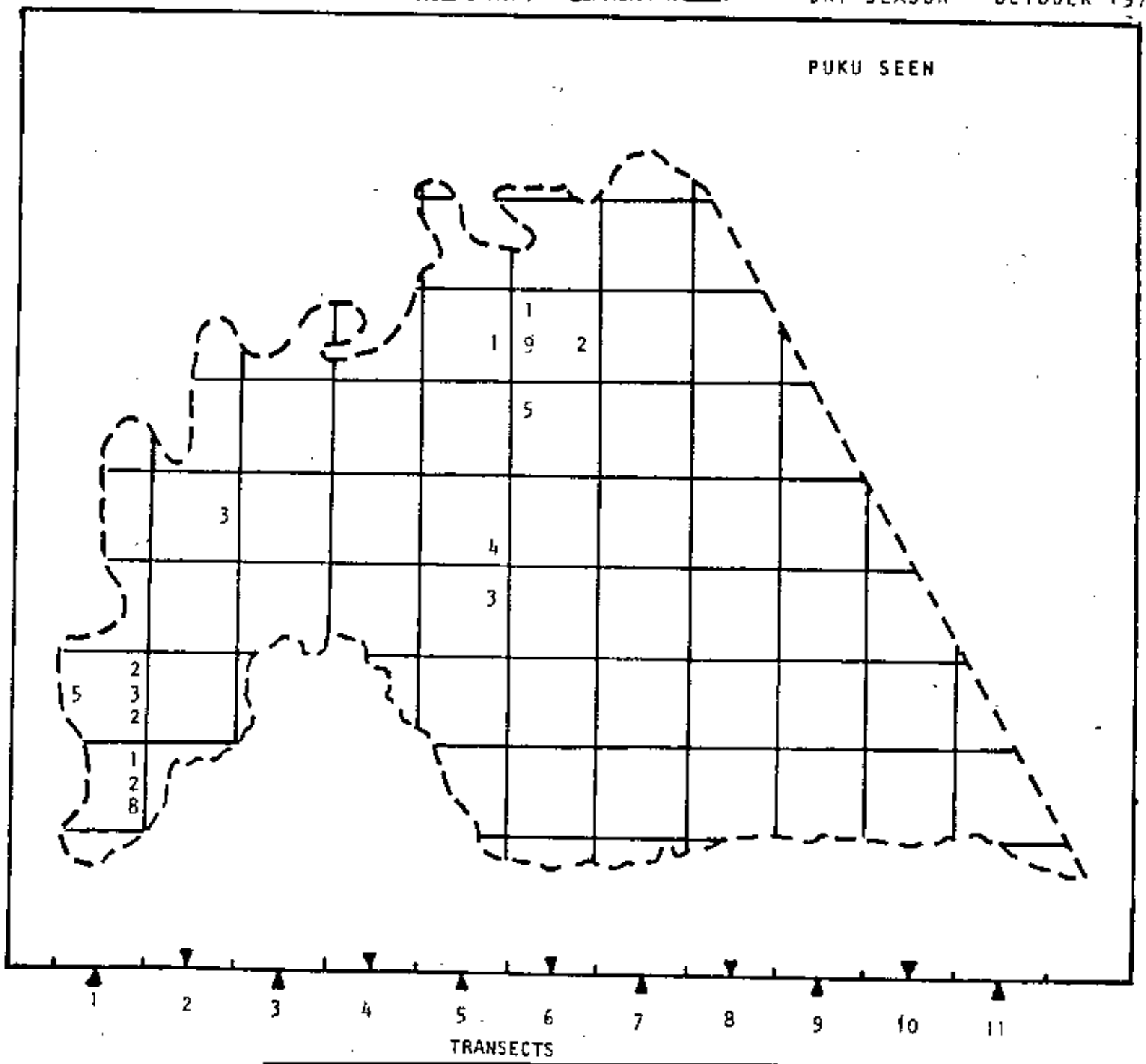

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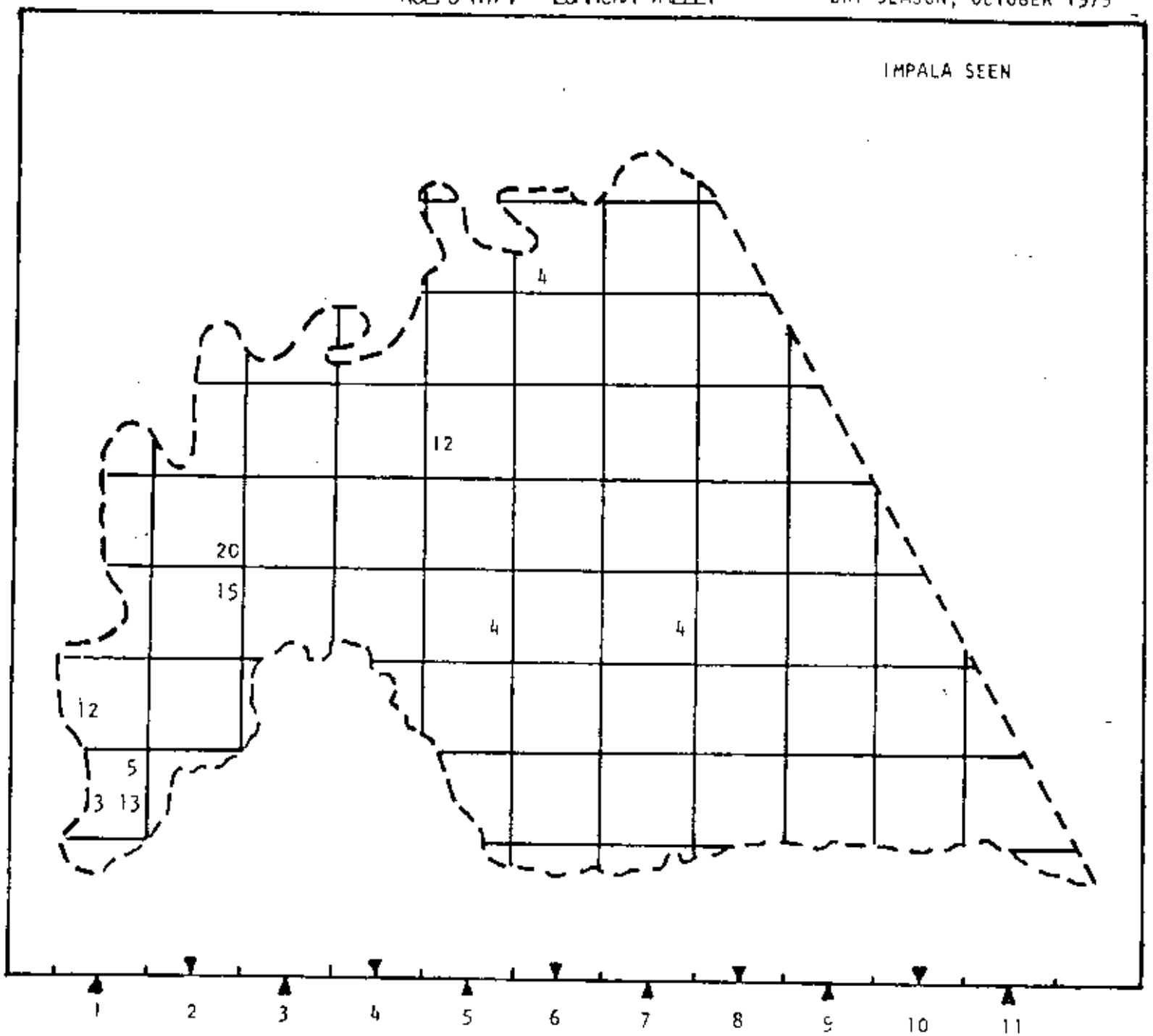

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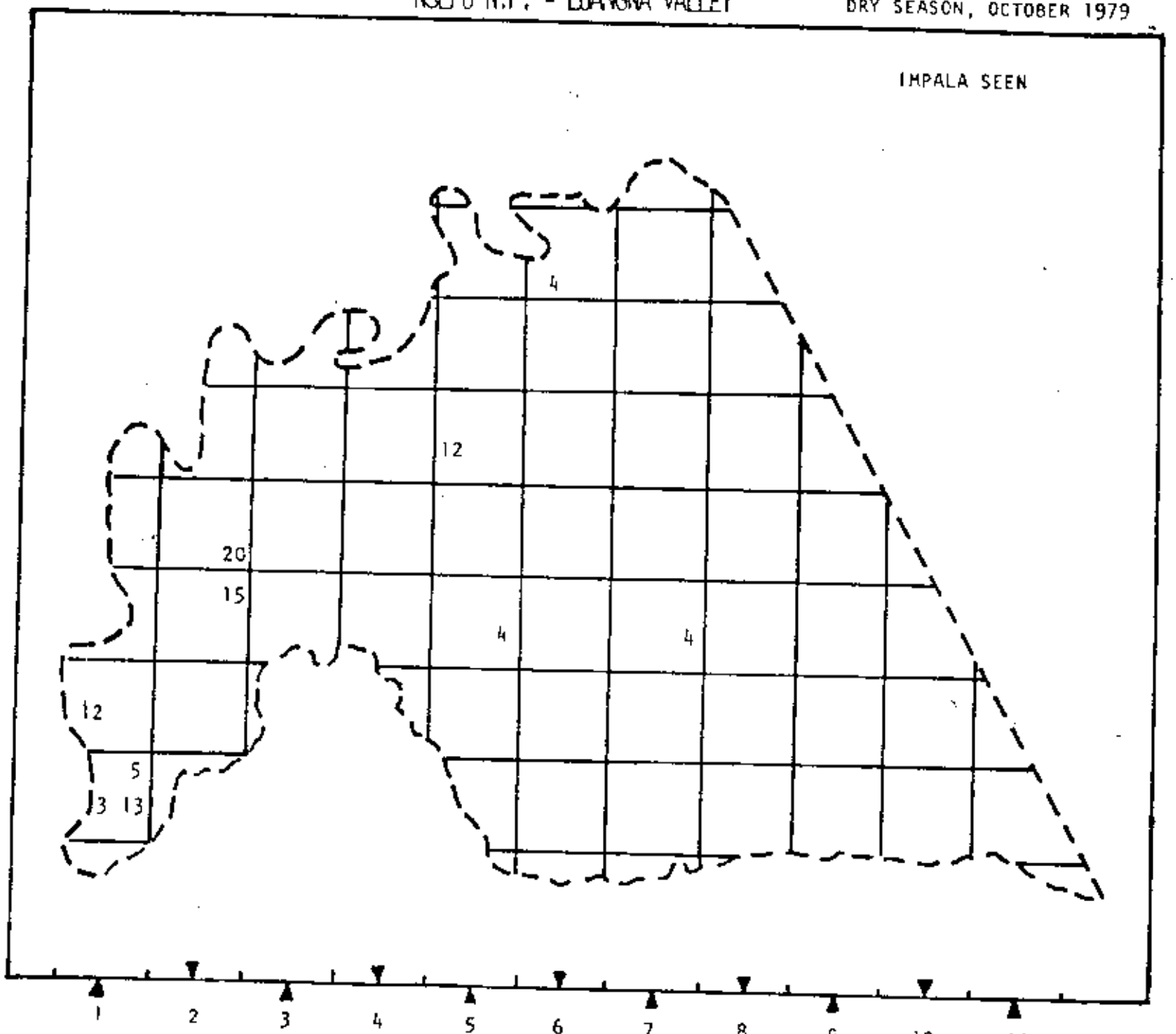

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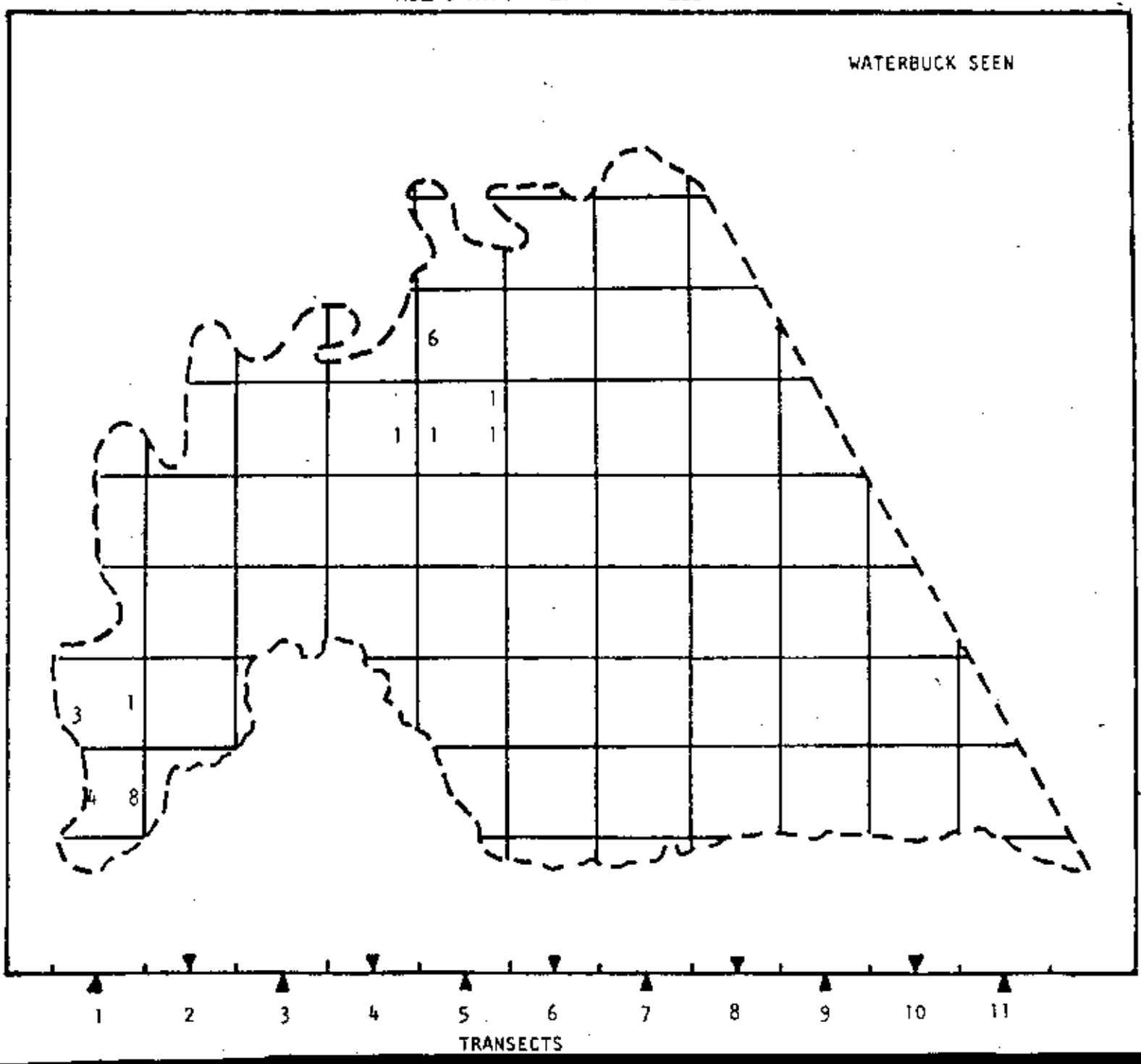

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HABITAT TYPES

Luangwa River - Riverine mosaic, Mopane, Combretum.

Riverine mosaic

Mopane - 30%recumbent, 20%coppiced.

Mopane, drowned by changing river course.

Capparis/ rhino thorn grassland (Nsefu)

Elephant skeleton &meat drying racks. (Category 2)