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SUMMARY.

This report describes a wet season aerial survey of livestock populations, human habitation and environmental conditions over some 81,300 square kilometers of the Gourma Region of Mali in the West African Sahel Zone. The survey was carried out during August and September 1984, using the technique of low level systematic reconnaissance flights and oblique photography, with experienced observers who were familiar with local conditions.

Results are presented in the form of computer drawn distribution maps, accompanied by a series of tables which provide estimates of total population abundance, with stratified sub-population estimates by Administrative Region and Department, Rainfall Zone, Ecological Region and degree of Pastoral Pressure.

The region supported an estimated 1.14 million head of sheep and goats, 463,000 cattle, 8,700 camels and 4,500 donkeys, at stocking rates of 7, 18, 940 and 1,500 hectares per head, respectively. All livestock populations were much more widely dispersed in the wet season, and occurred in substantially greater numbers than found in previous dry season surveys - sheep and goat population estimates almost doubled in size, and cattle estimates increased by almost a third. The combined wet season livestock populations were equivalent to some 454,000 Tropical Livestock Units, of which cattle contributed some 72%, with sheep and goats making up a further 25%.

Human habitation in the region amounted to an estimated total of some 65,000 dwellings. Six distinct types of human habitation were recognised from the air. Those of the Sonrai style were most abundant, representing 38% of the total; the next most common being the Peuhl (Fulani = FulBe) and Tamashek (Touareg) styles, each of which accounted for 19 - 20%; followed by the Bella, Dogon and Maure (Arab) styles, which represented 15%, 5% and 3%, respectively.

PREFACE AND ACKNOWLEDGEMENTS.

Following the tragic death of Dr. Kevin Milligan in May 1984, the International Livestock Centre for Africa (ILCA) and Resource Inventory and Management Limited (RIM) entered into a collaborative agreement in order to fulfill existing aerial survey commitments in Mali and Nigeria.

The results of the wet season aerial survey of the Gourma region of Mali described in this report compliment those of an earlier survey carried out by the ILCA Aerial Survey Unit, previously reported by Milligan (1983). We gratefully acknowledge the assistance of the following personnel, who took part in the wet season aerial survey:

Captain Jacques Meunier	Pilot:
M. A. Alkaouri	Observer:
M. G. Sidibe	Observer.

In addition we would like to thank Dr. Diakete - Director General, Operation Development L'Elevage du Mopti (ODEM), and his deputy Dr. Kiata, for their help and encouragement on the ground. We would also like to express our appreciation for the support given by ILCA staff at Bamako, in particular Mr. A. Tall - Acting Team leader, and Dr. P. Hiernaux - Rangeland Ecologist. In Britain, we are indebted to Christine Windridge and Bill Campbell for their assistance in data preparation, statistical analysis and computer graphics.

WET SEASON DISTRIBUTION AND ABUNDANCE OF LIVESTOCK POPULATIONS
AND HUMAN HABITATION IN THE GOURMA REGION OF MALI

1 INTRODUCTION.

The Gourma region of the Republic of Mali (Figures 1 and 2) was selected by the International Livestock Centre for Africa as a demonstration site for rapid multidisciplinary assessment of pastoral conditions in a representative region of the West African Sahel. The findings of that study were described in a series of documents edited by Cisse (1983). Amongst those papers Milligan (1983) presented the preliminary results of two low level aerial surveys of the region carried out by the ILCA Aerial Survey Unit in the early and late dry season - January and March 1983. A follow up aerial survey was planned, for the subsequent wet season, but because of technical problems with the aircraft this had to be postponed until 1984.

This report presents the results of that wet season aerial survey, which took place during the last two weeks of August and the first week of September 1984. A characteristic of the Sahelian climate is its variability, and it must therefore be emphasised that although August and September would normally coincide with the height of the rains, the 1984 wet season was exceptionally late in starting and low in rainfall. Thus, the extreme northern and eastern regions of the survey zone had received little or no rainfall at the time of the survey, while in more southerly and westerly regions the wet season was less advanced than otherwise might have been expected.

The Gourma aerial survey zone occupies a total land area of some 81,300 square kilometers, lying between latitudes 14 - 17 North and longitudes 3 West - 1 East. To the north and east the survey boundaries were provided by the Niger River, and in the south by the

international border with Burkina Faso (formerly Upper Volta). The zone forms part of the Fifth, Sixth and Seventh Administrative Regions of north-eastern Mali (Figure 1).

The region is sparsely inhabited, with little cultivation. There are only four towns of any significant size in the region: Tombouctou to the north-west; Gao in the east; Douentza in the west; and Hombori in a south-central position. A single major tarmac road links Gao, Hombori and Douentza and continues further westward to Mopti.

The terrain is relatively flat to gently undulating, except for a mountainous zone in the south-west, between Douentza and Hombori, which was not surveyed. A rainfall gradient exists across the region with mean annual rainfall being in the order of 150 mm in the north east, increasing to 600 mm in the extreme south-west (Figure 2).

2 METHODS.

2.1 Flight and Sampling Procedure.

The aerial survey was conducted from three bases: Gao, Mopti and Tombouctou, using the same technique of low level systematic reconnaissance flights used in the the dry season aerial surveys (Milligan, 1983). More detailed descriptions of the methodology are given by Norton-Griffiths (1978) and Milligan and de Leeuw (1983).

Essentially the region was evenly covered by a regular series of 44 flight lines 5 nautical miles apart (5' of latitude, equivalent approximately to 9.25 kilometers). Each flight line was divided into sectors 5 nautical miles in length, to create a sampling grid containing a total of 992 5'x5' cells, each of which occupied approximately 82 square kilometers (Figure 3).

With the aid of externally mounted viewing frames the two experienced back-seat observers recorded the type, and estimated the number, of all forms of livestock and human habitation falling within defined ground strips on each side of the aircraft. Whenever possible a 35 mm colour slide photograph was taken of each herd, flock, camp or settlement, containing more than 10 components, using a hand-held camera loaded with 200 ASA film and fitted with a 200 mm telephoto lens. Subsequently, accurate photo-count values were substituted for visual estimates, and used to determine levels of observer bias, in order to correct those estimates for which no adequate photographic coverage was available.

At a designated flying altitude of 800 feet above ground level the sample strip width on each side of the aircraft was set to be 400 meters. However, as determined by regular radar altimeter measurements, the average flying altitude for the whole survey was 810 feet, which gave an overall sampling intensity of 9.0%.

2.2 Information Collection.

2.2.1 Livestock Populations.

Cattle, camels and donkeys could easily be identified from the air; however it was not always possible to distinguish sheep from goats, and these small stock were therefore combined under the single category "shoats".

2.2.2 Human Habitation.

Seven types of human habitation were recognised from the air on the basis of their general structure, shape, colour, material and method of construction:

"Bella Style": Relatively small circular structures of grass/straw matting laid over wooden framework.

"Maure (Arab) Style": Tents usually white or gray in colour, similar in general shape to those of the Touareg, but made of cloth, with only a central supporting pole and no lateral poles.

"Peuhl (Fulani = FulBe) Style": Larger circular structures of grass/straw laid over wooden framework.

"Sonrai Style": Oval structures made of grass/straw matting laid over a wooden framework, frequently with a dark/black longitudinal stripe.

"Tamashek (Touareg) Style": Tents usually red in colour, made of a patchwork of hides, with both central and lateral supporting poles.

In addition to these five distinctive styles of temporary habitation, two much more permanent forms of construction were distinguished: the well-dispersed, rectangular, flat-roofed, mud-block structures on the banks of the Niger River, considered to be typical of settled Sonrai; and the small, densely packed, rectangular, flat-roofed dwellings of the Dogon people, generally associated with the mountainous regions to the south-west.

2.2.3 Environmental Conditions.

In addition to the information collected by the two back-seat observers, the navigating front-seat observer was responsible for assessing and recording general environmental conditions within each grid cell, including:

Cultivation: the percentage of land within the cultivation cycle;

Vegetation Types: the relative proportions of each of four major vegetation types: Dense Savanna Woodland; Light Savanna Woodland; Scrub/Bushland; and Grassland;

Grass Cover: the proportion of ground covered by grass;

Greenness: the overall level of greenness of vegetation on a five point scale: 0 = No Indication of Greenery; 1 = Trace of Greenery; 2 = Patchy Green Flush; 3 = General Green Flush; 4 = Dense and Widespread Greenery.

Water Availability in terms of the visible presence or absence of surface water, standing pools, lakes, streams, or rivers.

2.3 Data Analysis and Presentation.

After photo-interpretation, and correction for individual observer bias, the data collected by each observer was merged and coded for each grid cell, together with additional cartographic information extracted from published maps. This data-base was then subjected to a series of validity statistical tests and the necessary corrections made prior to more detailed analysis and population estimation on a VAX 11-750 computer. Three closely related, but distinct, software packages were used concurrently for handling data files and analysis:

A purpose built programme for population estimation using the Ratio Method of Jolly (1969) incorporating additional statistical facilities;

The Minitab (1982) software package for statistical summaries and tabulations;

The Mapics (1984) data handling and graphics system for data manipulation, selection and mapping facilities.

Distribution maps were produced using a proportional symbolism form of point mapping on a HP 7221 flat-bed plotter.

3 RESULTS.

The results of the wet season aerial survey of the Gourma region of Mali are presented in a series of figures and tables which indicate the general distribution pattern and overall level of abundance of each of the parameters recorded. Additional tables provide stratified estimates of livestock populations and human habitation on a regional basis.

3.1 Livestock Populations.

The distribution and overall levels of abundance of livestock populations during the August/September period of the 1984 wet season are shown in Figures 4-8 and Table 1. Other than a few small antelope little wildlife was seen. None of the elephants, previously observed in the vicinity of the lake at Gossi during the dry season survey, were encountered.

In numerical terms sheep and goats were by far the most abundant livestock, with a combined population of 1.14 million, followed by some 463 thousand head of cattle; 8,700 camels, and 5,400 donkeys. Overall livestock densities were 140 sheep and goats, 57 cattle, 1 camel and 1 donkey for each 10 square kilometers; representing stocking rates of: 7; 18; 939; and 1,497 hectares, respectively. However, in terms of Tropical Livestock Units* a total of 454,000 were estimated, of which cattle represented some 72% of the livestock biomass, compared with: only 25% for sheep and goats; 2% for camels; and 0.6% for donkeys.

The wet season distribution of cattle is shown in Figure 4. Cattle were widespread and relatively abundant over much of the survey area, except in an extensive broad belt lying immediately to the south of the Niger river. Sheep and goats (Figure 5) were also common and showed a very similar widespread distribution, except in the broad

* Conversion factors: Camels = x1; Cattle = x0.5;
Donkeys = x0.5; Sheep and Goats = x0.1; after: Jahnke (1982)

band to the north and east bordering the Niger River. In contrast, Camels (Figure 6) and Donkeys (Figure 7) were rare and thinly distributed over the Gourma, with virtually no camels being found in the south western portion, or south of latitude 15 N. Figure 8 is a composite map of livestock distribution in terms of Tropical Livestock Units.

The broad tract of land adjoining the Niger River to the north and north-east of the survey zone, in which so few livestock were found, form the northern part of Gourma Rharos Administrative Department and the western parts of Bourem, Gao and Ansango, all of which, at the time of the survey, had received little or no rainfall. As can be seen in Figures 16, 17 and 23, these regions correspond with areas of very low grass cover, zero green biomass and an absence of water.

Tables 2-5 provide further stratifications of livestock population estimates, broken down into Administrative Departments, rainfall zone, ecological region, and degree of pastoral pressure, respectively. The stratification boundaries used were derived from maps presented in Hiernaux and Cisse, (1983) and Wilson et al., (1983). (This paragraph to be expanded.)

3.2 Human Habitation.

The distribution and overall levels of abundance of human habitation during the August/September period of the 1984 wet season are shown in Figures 9-14 and Table 4.

The most abundant form of human habitation was the 24,300 dwellings of the Sonrai type, accounting for some 38% of all dwelling units; the next most common were the Peuhl (Fulani = FulBe) and Tamashek (Touareg) types, each of which amounted to some 12-13,000 dwellings, or 19-20% of the total; followed by Bella, Dogon and Maure type dwellings representing 15%, 5% and 3%, respectively of all human habitation. The mean size of settlement ranged from 38 dwellings of Dogon Style; 20 for Sonrai Style; 10 for Peuhl (Fulani = FulBe) and 4

- 6 for Tamashek (Touareg), Bella and Maure (Arab) Style camps.

As indicated in Figure 9, Bella Style dwellings were scattered at low density over much of the region, but in particular appeared to be more generally associated with the south-east and north-west. Dogon Style dwellings (Figure 10) were found only in the south-west of the survey region. Maure (Arab) Style dwellings (Figure 11) were found scattered at low density over a wide north-central area of the Gourma region. Peuhl (Fulani = FulBe) Style dwellings (Figure 12) were largely confined to the western and particularly the south-western portions of the survey zone. Sonrai Style habitation (Figure 13) is almost exclusively confined to a narrow band on along the Niger River. Tamashek (Touareg) style (Figure 14) dwellings are widely distributed over the north-central region of the the Gourma.

Tables 7-10 provide further stratifications of human habitation estimates, broken down into administrative area, rainfall zone, ecological region and degree of pastoral pressure, respectively. The stratification boundaries used were derived from maps presented in Hiernaux and Cisse, (1983) and Wilson et al., (1983). (~~This paragraph~~ to be expanded.)

3.3 Environmental Conditions.

Cultivation, as shown in Figure 15, is generally sparse or absent. Cultivated land is concentrated in the south-west where rainfall is highest; along the seasonally flooded banks of the Niger River; and in the intermittently inundated lakeland areas to the north-west of the survey region.

Percentage Grass Cover and the general Greenness of Vegetation are shown in Figure 16 and 17. Levels are generally very low, given the time of year at which the survey took place. This reflects the late start to the wet season and the limited amount of rain that had fallen.

Figures 18, 19, 20 and 21, respectively, show the distribution of the four major Vegetation Types recognised from the air: Dense Savanna Woodland; Light Savanna Woodland; Scrub/Bushland; and Grassland: in terms of the proportion of land occupied by each category. Not surprisingly the distribution patterns reflect those of rainfall, with the Denser Savanna Woodland concentrated in the south-west; the Lighter Savanna Woodland reaching further north and east; and the Scrub/Bushland, together with Grassland, predominating to the north, north-east and east. The extensive grasslands on the fossilized dunes to the north and west of Hombori are also evident.

A composite Vegetation Density Index map, based on the summated weighted proportions of each of the major vegetation types, is presented in Figure 22 and clearly illustrates the declining density of vegetation from south-west to north-east, in line with the rainfall gradient. The weights used were 1.5 for Dense Savanna Woodland; 1.0 for Light Savanna Woodland; 0.5 for Scrub/bushland; and 0 for Grassland.

Finally, Figure 23 indicates the wet season Availability of Water in the Gourma region in terms of its visible presence or absence from the air, either as surface flooding, standing pools, lakes, streams or rivers. In more southerly regions water is widely available, but the limited northward penetration and patchy nature of rainfall distribution in the 1984 wet season is clearly reflected in the absence of visible water in the northern and north-eastern regions, neighbouring the Niger River.

4 DISCUSSION.

The aerial survey described in this report is the third to be carried out by the International Livestock Centre for Africa over some 81,300 square kilometers of the Gourma region in the Malian Sahel. The distribution patterns and population estimates represent the situation during the August/September period of the 1984 wet season, which was late in starting and low in rainfall.

The two previous surveys were conducted during January and March 1983, corresponding to the early and late dry season respectively (Milligan, 1983*). The former constituted an exploratory low intensity sample survey of 4.5%, while in both the late dry season and wet season surveys twice as many flight lines were flown, which provided a 9% sample intensity.

In passing it is perhaps worth pointing out that there is no inherent reason why different intensities of sampling using the same technique should be any more or less accurate. However the larger the sample size, or the more flight lines flown, the more precise the estimates should be. With this proviso, Table 11 provides a comparison of the livestock population estimates from the three aerial surveys of the Gourma region.

Total cattle population estimates ranged from 357,000 in the late dry season, to 463,000 in the wet season, with the early dry season representing an intermediate level of some 397,000. Equivalent estimates for the number of cattle herds were 11,100, 7,700 and 10,000. A substantial seasonal movement of cattle to and from the Gourma region is therefore indicated, with a 30% increase from the late 1983 dry season to the middle of the 1984 wet season. This is reflected in the overall distribution of cattle which, as expected, were far more widely dispersed in the wet season, with less concentration along the banks of the Niger river. As the dry season

* Milligan gives figures of 82,612 and 83,300 square kilometers for the early and late dry season survey areas.

advanced, the mean size of cattle herds increased from 36 to 46, but no difference was found between the late dry and wet season surveys.

Small stock also showed a substantial seasonal increase in overall number. The wet season sheep and goat population, of 1.14 million head in 12,000 herds, being almost twice that estimated in the two dry season surveys: 583,000 in 11,400 flocks; and 581,000 in 8,200 flocks (early and late respectively). The wet season distribution of sheep and goats was far more widely dispersed than in the dry season, with less concentration along the banks of the Niger river. The mean size of sheep and goat flocks showed a progressive increase over the three surveys: from 51 in the early dry season; to 71 in the late dry season; to 95 in the wet season.

While remaining comparatively low in total population size and density, both camels and donkeys showed a seasonal increase in number, and a wider wet season distribution. Total camel estimates ranged from 4,800 in the late dry season, to 8,700 in the wet season (representing an 80% increase), with the early dry season representing an intermediate level of some 7,300. The largest number of donkeys (7,100) was estimated for the early dry season; by the late dry season this had fallen to 4,900; but by the wet season the number had increased by 11% to 5,400. The mean group size for both camels and donkeys did not change appreciably with season: 3-4 for camels, and 6-7 for donkeys.

In terms of Tropical Livestock Units (after Jahnke, 1982) the Gourma region supported an estimated 347,400 TLU in the early dry season; 315,000 TLU in the late dry season; and some 454,000 TLU in the wet season. There was thus a 42% increase between the late dry and wet season surveys, with density values ranging from 3.8 to 5.5 TLU per square kilometers, and equivalent stocking rates varying from 26 to 19 hectares per TLU.

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TABLE 1 : WET SEASON LIVESTOCK POPULATIONS IN THE GOURMA REGION OF MALI.

	CATTLE	SHEEP/GOATS	CAMELS	DONKEYS	TLU
No. Animals (% S. E.)	462,801 (13)	1,138,437 (10)	8,657 (17)	5,432 (15)	453,787 (6%)
As % Total TLU	72.1	25.3	1.9	0.6	99.9
Stocking Rate ha/hd	18	7	939	1,497	17.9
Density /10 sq. km.	56.9	140.0	1.1	0.7	55.8
No. Herds (% S. E.)	10,060 (5)	11,938 (6)	2,026 (9)	860 (11)	
Herd Density /10 sq. km.	0.1	1.4	0.2	0.1	
Mean Herd Size	46.0	95.4	4.3	6.3	

Notes: All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

TABLE 2 : WET SEASON LIVESTOCK POPULATIONS BY ADMINISTRATIVE REGION AND DEPARTMENT*.

	AREA	CATTLE	SHOATS	DONKEYS	CAMELS	TLU
FIFTH REGION	19,014	154,456 (13) 81.2	286,233 (11) 150.5	713 (37) 0.4	113 (51) 0.1	39,223 (10) 73.2
Koro	4,917	40,195 (26) 81.7	85,155 (25) 173.2	25 (93) 0.5	11 (95) 0.02	37,475 (19) 76.2
Douentza	14,097	114,260 (13) 81.1	201,079 (15) 142.6	464 (37) 0.3	102 (56) 0.07	101,748 (12) 72.2

SIXTH REGION	45,486	265,728 (9) 58.4	818,039 (13) 157.9	3,587 (21) 0.8	5,930 (16) 1.3	267,327 (8) 58.8
Gourma-Rharos	44,585	260,240 (9) 58.4	700,250 (13) 157.1	3,587 (21) 0.8	5,896 (16) 1.3	261,723 (9) 58.7
Niafunke	328	2,976 (18) 90.8	4,504 (8) 137.4	0 0	34 (48) 1.0	2,495 (15) 76.1
Timbouctou	574	2,512 (65) 43.8	13,285 (40) 231.6	0 0	0 0	3,110 (54) 54.2

SEVENTH REGION	16,801	42,617 (15) 25.4	134,166 (18) 79.9	1,132 (29) 0.7	2,614 (39) 1.6	47,238 (12) 28.1
Bourem	3,032	7,141 (42) 23.5	8,272 (31) 27.3	0 0	34 (73) 0.1	5,824 (36) 19.2
Gao	6,311	12,459 (39) 19.7	42,708 (35) 67.7	475 (66) 0.8	656 (49) 1.0	13,965 (34) 22.1
Ansanço	7,458	23,017 (32) 30.9	83,186 (24) 111.5	656 (31) 0.9	1,924 (50) 2.6	27,449 (26) 36.8

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 10 square kilometers. All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

* See Map 1, after: Wilson et al., 1983.

TABLE 3 : WET SEASON LIVESTOCK POPULATIONS BY RAINFALL ZONE*.

	AREA	CATTLE	SHOATS	DONKEYS	CAMELS	TLU
Sahara Sahel 150 - 200 mm	7,048	10,773 (32) 15.3	19,939 (45) 28.3	102 (61) 0.1	192 (55) 0.3	9,713 (30) 13.8
Northern Sahel 200 - 300 mm	31,062	137,119 (14) 44.1	513,339 (16) 165.3	3,157 (24) 1.0	4,889 (18) 1.6	154,522 (13) 49.7
Central Sahel 300 - 400 mm	23,030	140,559 (13) 61.0	266,237 (11) 115.6	1,335 (22) 0.6	3,418 (29) 1.5	130,965 (11) 56.9
Southern Sahel 400 - 500 mm	11,228	115,686 (14) 103.0	200,716 (16) 178.8	509 (33) 0.5	147 (45) 0.1	102,488 (12) 91.3
Sudan Sahel 500 - 600 mm	8,114	53,933 (30) 66.5	104,087 (20) 128.3	272 (73) 0.3	11 (97) 0.01	49,315 (23) 60.8
Sudan >600 mm	820	4,730 (45) 57.7	34,119 (54) 416.3	57 (89) 0.7	0 0	6,784 (47) 82.8

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 10 square kilometers. All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

* See map 2. after: Hiernaux and Cisse, 1983.

TABLE 4 : WET SEASON LIVESTOCK POPULATIONS BY ECOLOGICAL REGION*.

	AREA	CATTLE	SHOATS	DONKEYS	CAMELS	TLU
North-east Dunes	4,999	8,827 (33) 17.7	12,889 (26) 25.8	23 (94) 0.05	272 (49) 0.5	7,754 (26) 15.5
Edjerew	7,376	19,724 (28) 26.7	149,669 (25) 202.9	815 (54) 1.1	724 (39) 1.0	30,223 (20) 41.0
Assalwa North	17,539	71,700 (19) 40.9	211,467 (12) 120.6	1,596 (36) 0.9	2,784 (24) 1.6	75,468 (15) 43.0
Assalwa South	6,884	34,911 (32) 50.7	65,736 (16) 95.5	509 (40) 0.7	894 (27) 1.3	32,672 (25) 47.5
Bodra	8,196	57,317 (23) 69.9	109,700 (20) 133.9	317 (47) 0.4	792 (23) 1.0	52,549 (18) 64.1
Gourma Lakes	2,377	28,064 (36) 118.1	105,524 (33) 443.9	136 (83) 0.6	351 (45) 1.5	30,376 (33) 127.8
Gourma Mountains	9,015	111,714 (15) 123.9	178,955 (13) 198.5	294 (39) 0.3	34 (72) 0.04	97,371 (13) 108.0
Lower Gourma	14,998	75,163 (16) 50.1	176,522 (15) 117.7	1,369 (26) 0.9	2,784 (34) 1.9	74,416 (12) 49.6
Mondoro	2,868	10,558 (30) 36.8	28,822 (32) 100.4	79 (73) 0.3	11 (94) 0.04	10,653 (26) 37.1
Seno Mango	7,048	44,824 (24) 63.6	99,153 (25) 140.7	294 (80) 0.4	11 (96) 0.02	42,304 (18) 60.0

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 10 square kilometers. All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

* See map 2, after: Hiennaux and Cisse, 1983.

TABLE 5 : WET SEASON LIVESTOCK POPULATIONS BY DEGREE OF PASTORAL PRESSURE*.

	AREA	CATTLE	SHOATS	DONKEYS	CAMELS	TLU
Intense	37,700	259,199 (9) 68.8	591,659 (12) 156.9	2,954 (19) 0.8	2,433 (18) 0.6	246,485 (8) 65.4
Average	19,342	76,656 (19) 39.6	246,344 (13) 127.4	803 (37) 0.4	3,259 (31) 1.7	82,386 (14) 42.6
Weak	7,868	27,102 (25) 34.4	86,920 (23) 110.5	554 (51) 0.7	724 (30) 0.9	29,503 (23) 37.5
Very Weak	16,145	98,814 (18) 61.2	180,076 (12) 111.5	1,120 (33) 0.7	2,218 (19) 1.4	91,271 (15) 56.5

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 10 square kilometers. All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

* After: Hiernaux and Cisse, 1983.

TABLE 6: WET SEASON HUMAN HABITATION IN THE GOURMA REGION OF MALI

	Dwellings Units	Settlements/Camps	Mean Size
Bella Style <i>nomad (partisan)</i>	3,418 (24)	371 (19)	3.9
Dogon Style <i>Arable</i>	9,449 (52)	249 (31)	37.9
Maure (Arab) Style <i>camels</i>	2,286 (26)	419 (19)	5.5
Peuhl (Fulani) Style <i>nomad</i>	12,889 (19)	1,335 (15)	9.7
Sonrai Style <i>Ar/Arable</i>	24,296 (30)	1,199 (16)	20.3
Tamashek (Touareg) Style <i>Nomad</i>	12,312 (8)	2,433 (8)	5.1
TOTAL	64,650	6,506	9.9

Figures in parenthesis are percentage standard errors.

$D+S = 33745 = \text{Arable}$
 $\text{rest} = 30905$

TABLE 7 : WET SEASON HUMAN HABITATION BY ADMINISTRATIVE REGION AND DEPARTMENT*.

	AREA	BELLA	DOGON	MAURE	PEUHL	SONRAI	TAMASHEQ
FIFTH REGION	19,014	11 (95) 0.06	9,449 (50) 49.7	57 (68) 0.3	10,671 (17) 56.1	0 0	792 (37) 4.2
Koro	4,917	0 0	4,357 (45) 88.6	23 (95) 0.5	3,327 (31) 66.7	0 0	0 0
Douentza	14,097	11 (96) 0.08	5,092 (86) 36.1	34 (96) 0.2	7,344 (21) 52.1	0 0	792 (37) 5.6
SIXTH REGION	45,486	1,550 (26) 3.4	0 0	2,218 (26) 4.9	2,218 (27) 4.9	3,451 (29) 7.6	10,162 (9) 22.3
Gourma-Rharos	44,585	1,448 (27) 3.2	0 0	2,184 (27) 4.9	1,811 (24) 4.1	2,263 (36) 5.1	9,958 (9) 22.3
Niafunke	328	57 (47) 17.3	0 0	0 0	113 (48) 34.5	0 0	181 (24) 55.2
Timbouctou	574	45 (58) 7.9	0 0	34 (82) 5.9	294 (99) 51.3	1,188 (36) 20.7	23 (81) 3.9
SEVENTH REGION	16,801	1,856 (35) 11.0	0 0	11 (97) 0.07	0 0	20,845 (29) 124.1	1,358 (22) 8.1
Bourem	3,032	215 (77) 7.1	0 0	11 (89) 0.4	0 0	6,088 (22) 20.1	0 0
Gao	6,311	396 (66) 6.3	0 0	0 0	0 0	11,463 (54) 18.2	600 (47) 9.5
Ansango	7,458	1,245 (46) 16.7	0 0	0 0	0 0	3,293 (53) 44.2	758 (33) 10.2

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 100 square kilometers.

* See map 1, after: Wilson et al. (1983).

TABLE 8 : WET SEASON HUMAN HABITATION BY RAINFALL ZONE*.

	AREA	BELLA	DOGON	MAURE	PEUHL	SONRAI	TAMASHEQ
Sahara Sahel 150 - 200 mm	7,048	226 (75) 3.2	0 0	11 (95) 0.2	57 (95) 0.8	8,125 (16) 115.3	79 (68) 1.1
Northern Sahel 200 - 300 mm	31,062	1,482 (30) 4.8	0 0	1,414 (39) 4.6	1,369 (40) 4.4	15,254 (48) 49.1	7,514 (12) 24.2
Central Sahel 300 - 400 mm	23,030	1,697 (35) 7.4	0 0	611 (48) 2.6	679 (38) 2.9	917 (53) 4.0	3,621 (19) 15.7
Southern Sahel 400 - 500 mm	11,228	11 (99) 0.1	4,357 (94) 38.8	226 (84) 2.0	5,307 (29) 47.3	0 0	1,086 (31) 9.7
Sudan Sahel 500 - 600 mm	8,114	0 0	2,094 (38) 25.8	23 (93) 0.3	4,617 (22) 56.9	0 0	11 (96) 0.1
Sudan > 600 mm	820	0 0	2,999 (64) 365.9	0 0	860 (56) 104.9	0 0	0 0

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 100 square kilometers.

* See map 2, after: Hiernaux and Cisse, 1983.

TABLE 9 : WET SEASON HUMAN HABITATION BY ECOLOGICAL REGION*.

	AREA	BELLA	DOGON	MAURE	PEUHL	SONRAI	TAMASHEQ
North-east Dunes	4,999	554 (50) 11.1	0 0	11 (94) 0.2	0 0	16,443 (37) 328.9	45 (72) 0.9
Edjerew	7,376	283 (40) 3.8	0 0	34 (94) 0.5	577 (58) 7.8	3,859 (23) 52.3	758 (23) 10.3
Assalwa North	17,539	136 (79) 0.8	0 0	1,200 (46) 6.8	34 (98) 0.2	0 0	5,239 (16) 29.9
Assalwa South	6,884	294 (64) 4.2	0 0	204 (64) 3.0	543 (55) 7.9	668 (94) 9.7	1,392 (23) 20.2
Bodra	8,196	57 (66) 0.7	0 0	770 (39) 9.4	79 (66) 1.0	0 0	1,618 (31) 19.7
Gourma Lakes	2,377	453 (51) 19.0	0 0	11 (100) 0.5	815 (22) 34.3	0 0	419 (22) 17.6
Gourma Mountains	9,015	11 (97) 0.1	4,379 (94) 48.6	34 (97) 0.4	5,477 (28) 60.8	0 0	544 (33) 6.2
Lower Gourma	14,998	1,630 (36) 10.9	0 0	0 0	0 0	3,327 (56) 22.2	2,003 (21) 13.4
Mondoro	2,868	0 0	0 0	0 0	521 (68) 18.1	0 0	272 (63) 9.5
Seno Mango	7,048	0	4,070 (41) 71.9	23 (93) 0.3	4,243 (26) 68.7	0 0	11 (98) 0

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 100 square kilometers.

* See map 2, after: Hiernaux and Cisse, 1983.

Table 10 : WET SEASON HUMAN POPULATION BY DEGREE OF PASTORAL PRESSURE*.

	AREA	BELLA	DOGON	MAURE	PEUHL	SONRAI	TAMASHEQ
Intense	37,700	2,094 (34) 5.6	8,510 (53) 22.6	996 (43) 2.6	11,056 (19) 29.3	24,262 (32) 64.4	5,522 (16) 14.6
Average	19,342	656 (34) 3.4	600 (67) 3.1	396 (49) 2.0	600 (58) 3.1	0 0	2,953 (23) 15.3
Weak	7,868	351 (47) 4.5	0 0	0 0	543 (38) 6.9	34 (96) 0.4	292 (21) 10.1
Very Weak	16,145	317 (35) 2.0	339 (94) 2.1	894 (34) 5.5	690 (70) 4.3	0 0	2,784 (16) 17.2

Notes: Upper figures of triads are population estimates, together with percentage standard errors in parenthesis; lower figure is density per 100 square kilometers.

* After: Hiernaux and Cisse, 1983.

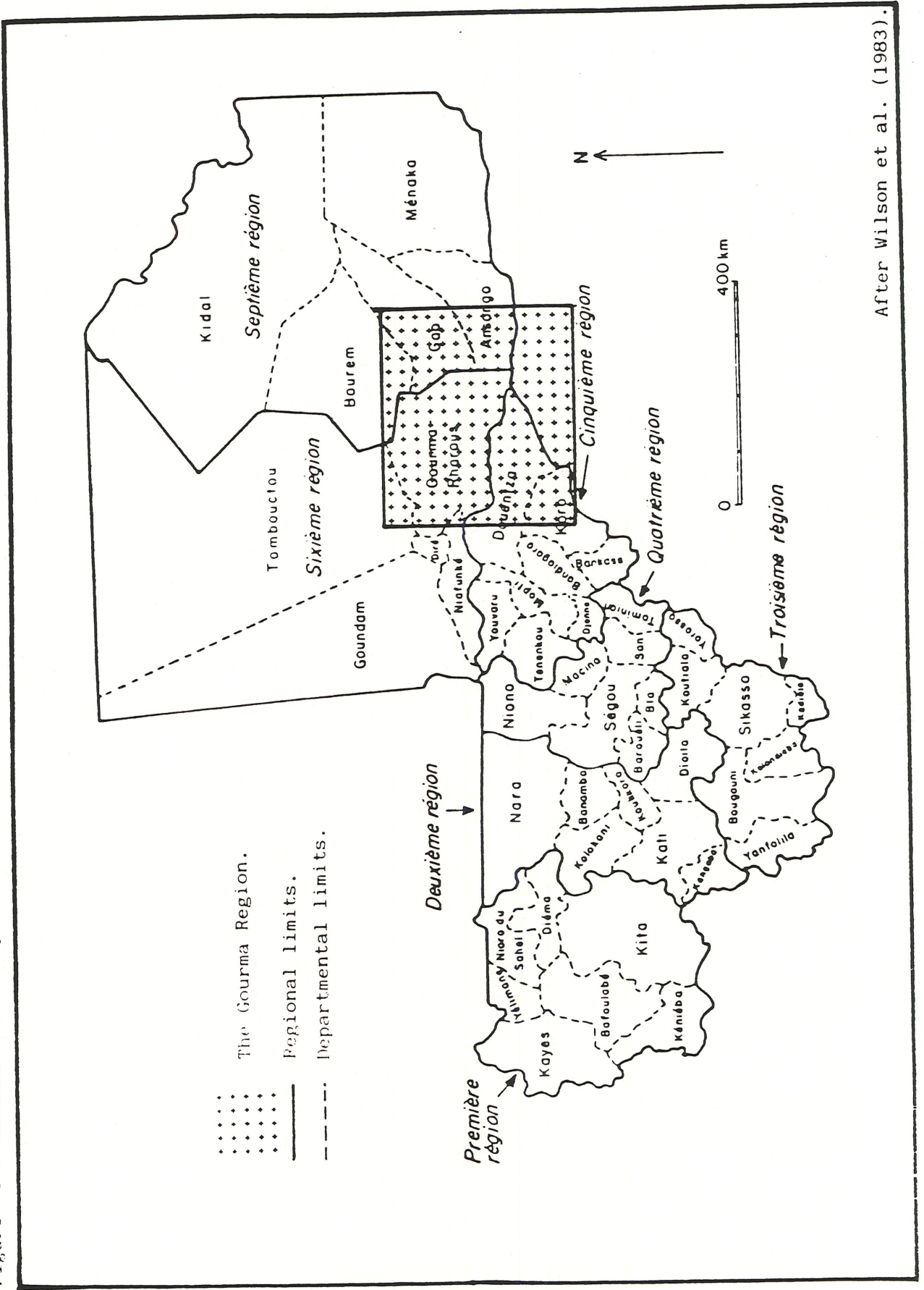
TABLE 11 : COMPARISON OF LIVESTOCK POPULATION ESTIMATES FROM THREE AERIAL SURVEYS OF THE GOURAMA REGION OF MALI.

	Early Dry Season January 1983*	Late Dry Season March 1983*	Mid Wet Season Aug/Sept 1984	Early Dry Season January 1983*	Late Dry Season March 1983*	Mid Wet Season Aug/Sept 1984
Area Surveyed	82,612	83,300	81,300	7,319 (19)	4,801 (15)	8,657 (17)
Sample Intensity %	4.5	9.1	9.0	1,129	1,735	939
CAMELS:						
N. Animals (% S. E.)	397,423 (13)	356,644 (10)	462,801 (13)	2,503 (14)	1,762 (10)	2,026 (9)
Stocking Rate ha/hd	21	23	18	0.3	0.2	0.2
Density /10 sq. km.	48.1	42.8	56.9	2.9	2.7	4.3
DONKEYS:						
N. Animals (% S. E.)	11,116 (10)	7,749 (10)	10,060 (5)	7,144 (21)	4,891 (20)	5,432 (15)
Herd Density /10 sq. km.	1.3	0.9	1.2	1,156	1,703	1,497
Mean Herd Size	35.7	46.0	46.0	0.9	0.6	0.7
SHEEP AND GOATS:						
N. Animals (% S. E.)	583,311 (9)	581,028 (7)	1,138,437 (10)	1,043 (12)	723 (12)	860 (11)
Stocking Rate ha/hd	14	14	7	6.8	6.8	6.3
Density /10 sq. km.	70.6	69.8	140.0	0.1	0.1	0.1
N. Flocks (% S. E.)	11,427 (10)	8,156 (7)	11,938 (6)	23.8	36.4	17.9
Flock Density /10 sq. km.	1.4	0.1	1.4	4.2	3.8	5.6
Mean Flock Size	51.0	71.2	95.4	347,418	315,000	453,787 (6)
TROPICAL LIVESTOCK UNITS:						
Total TLU				23.8	36.4	17.9
Stocking Rate ha/TLU				4.2	3.8	5.6
Density /sq. km.						

Notes: All figures are subject to rounding effects. TLU conversion based on following factors: Camels = 1 TLU; Cattle = 0.7 TLU; Donkeys = 0.5 TLU; Sheep/Goats = 0.1 TLU (Jahnke, 1982).

* Million, 1983.

Figure 1 : Administrative Map of Mali.



After Wilson et al. (1983).

Figure 2 : Ecoclimatic Map of the Gourma Region.

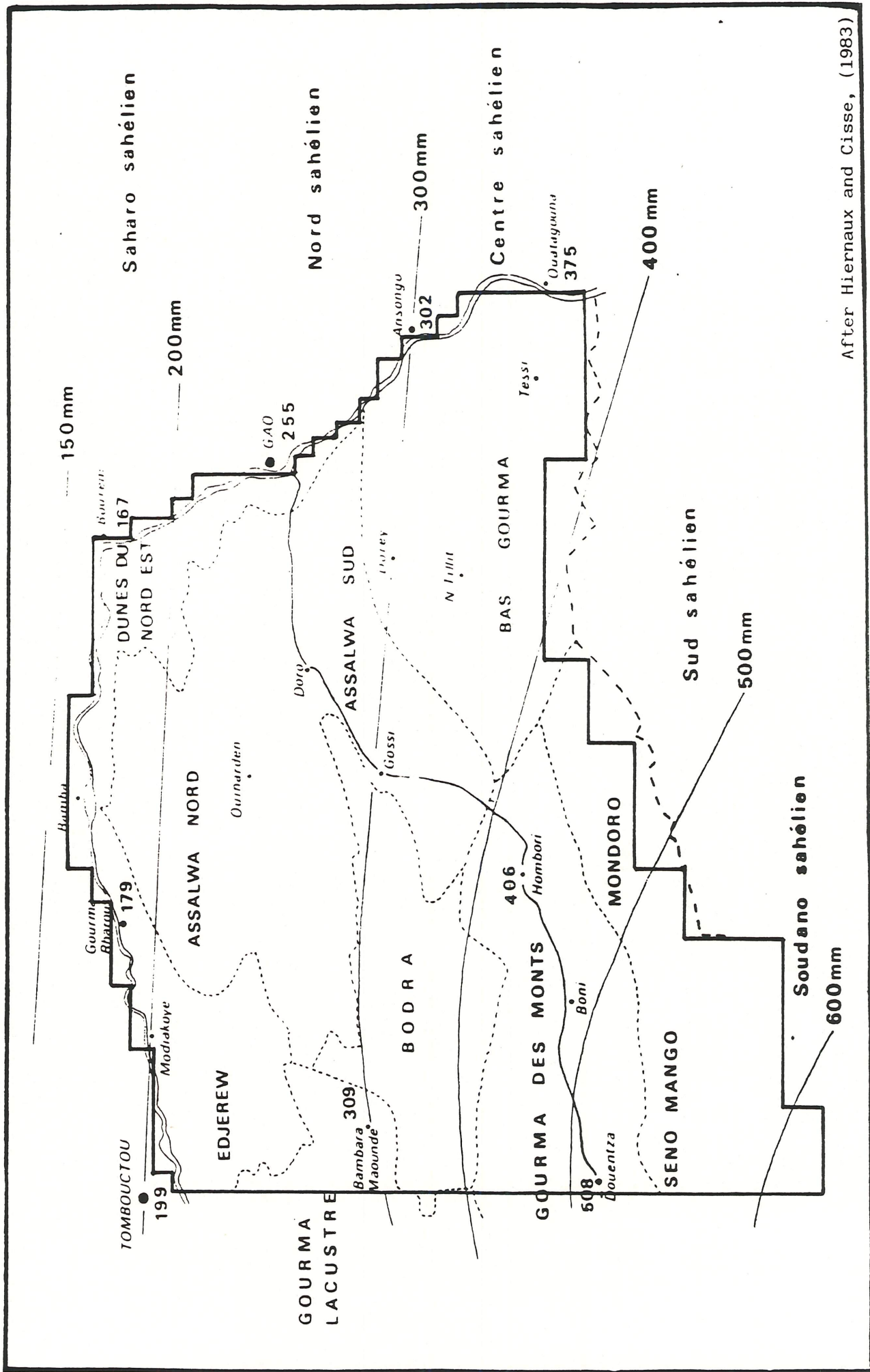


Figure 3 : Aerial Survey Systematic Sampling Grid of the Gourma Region.

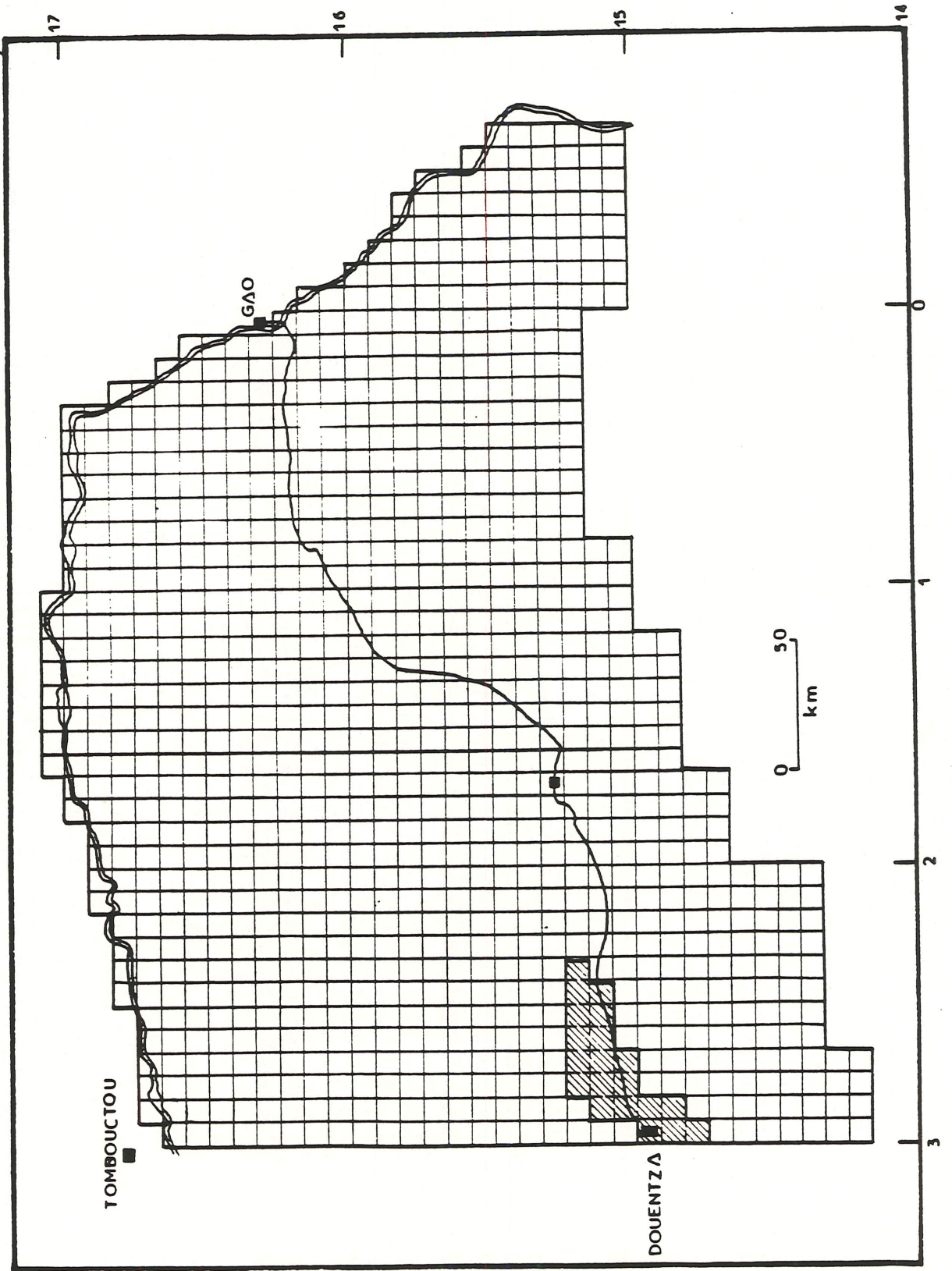


Figure 4 : Wet Season Distribution of Cattle.

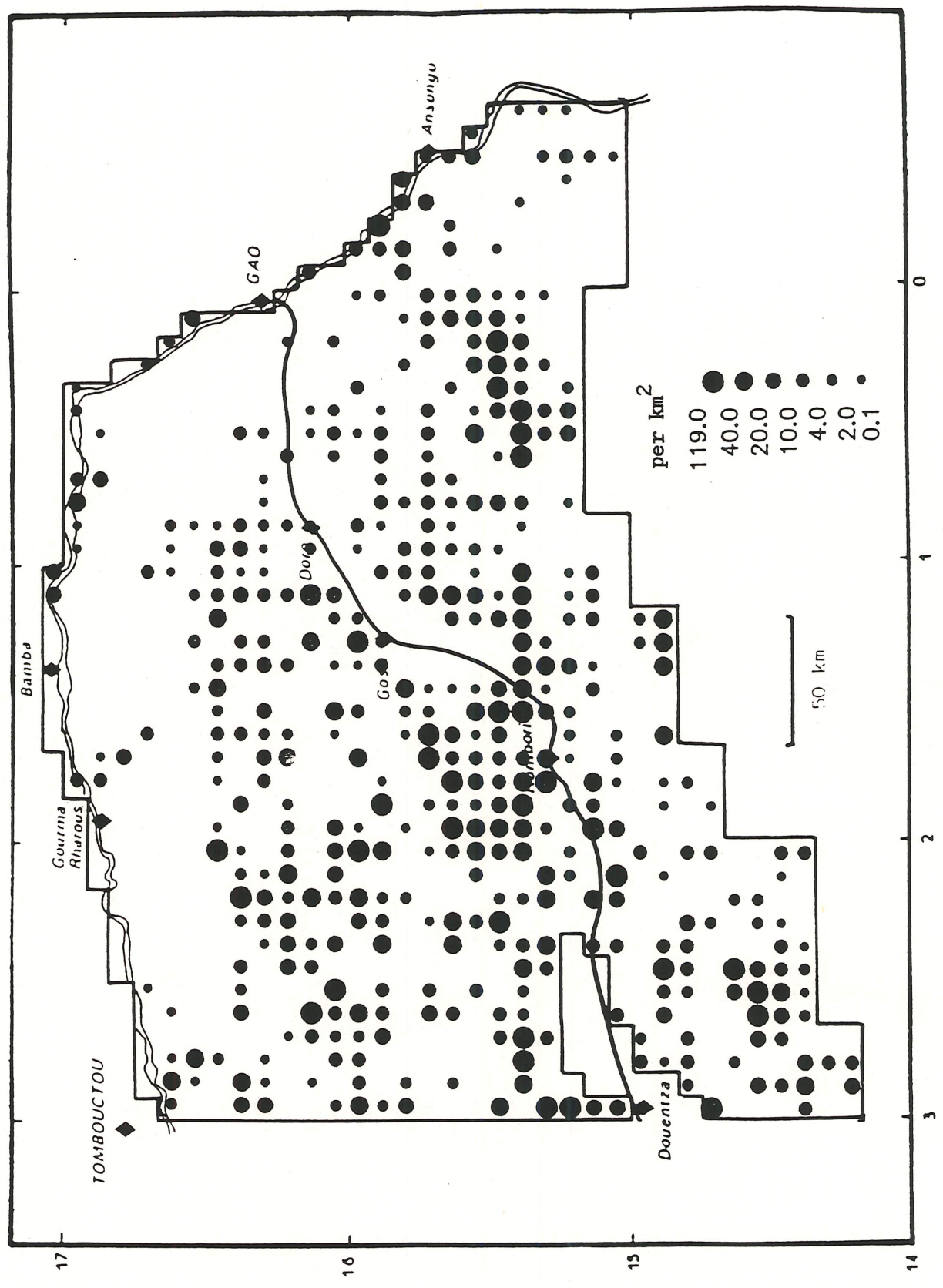


Figure 5 : Wet Season Distribution of Sheep and Goats.

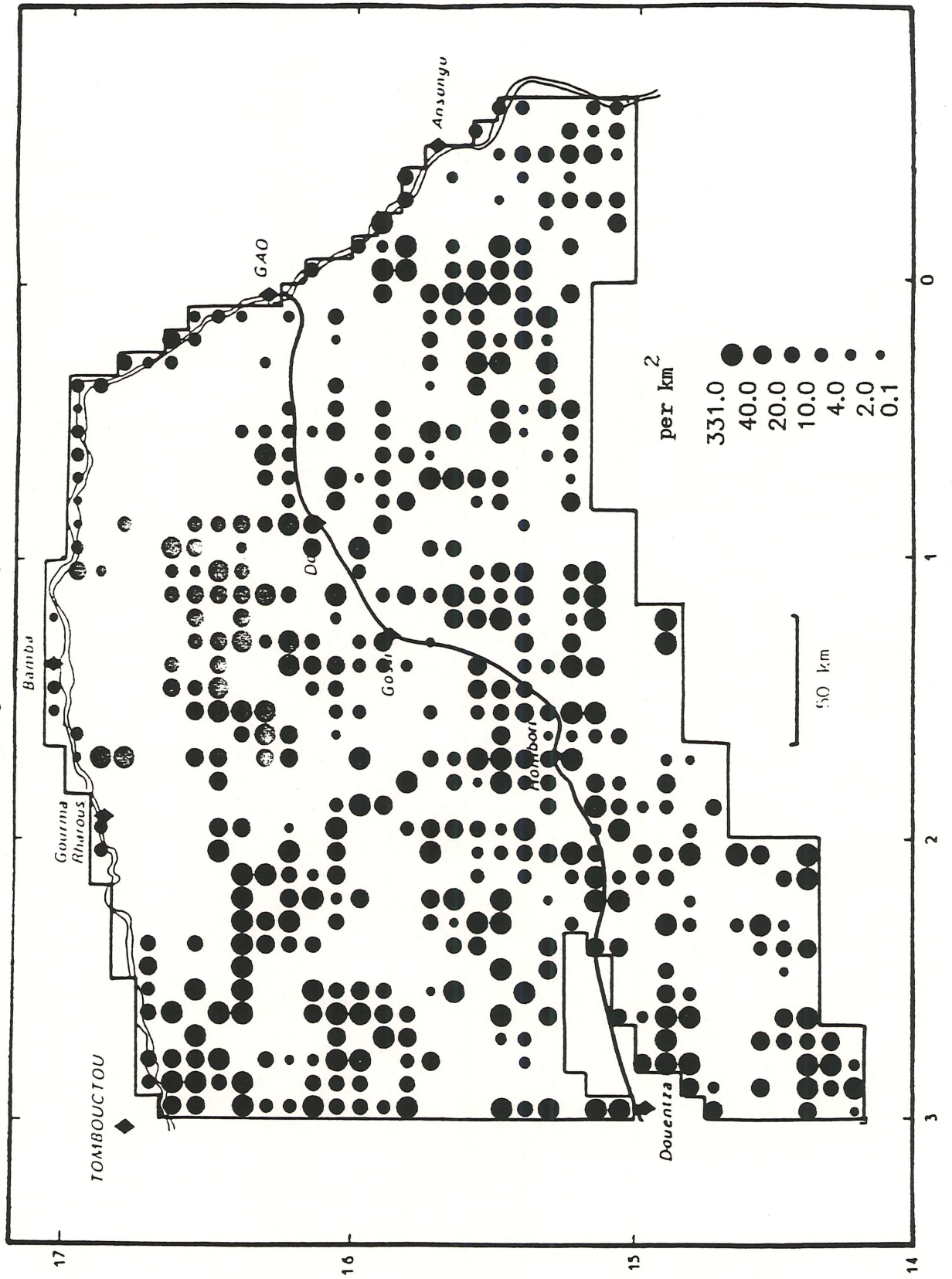


Figure 6 : Wet Season Distribution of Camels.

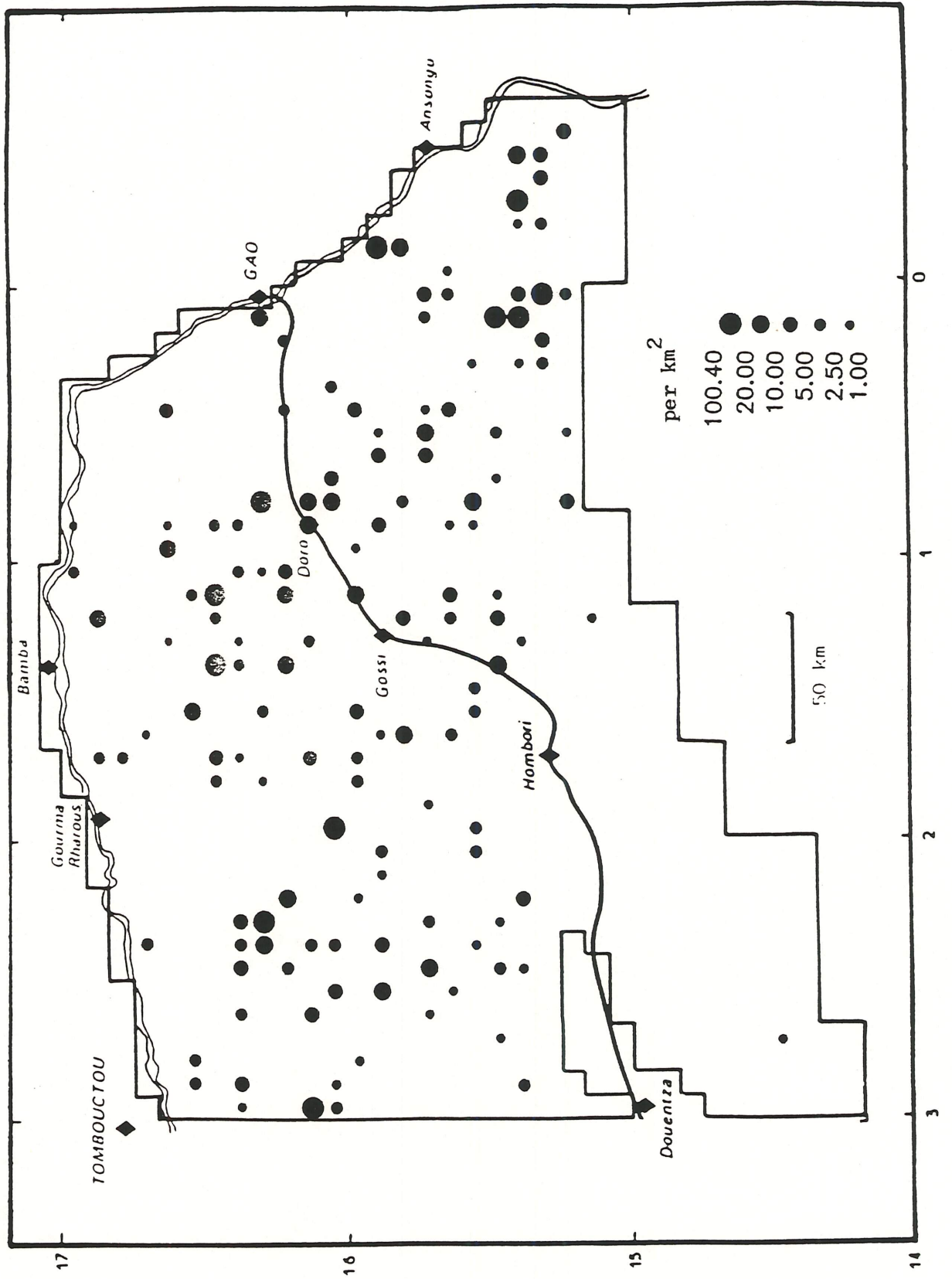


Figure 7 : Wet Season Distribution of Donkeys.

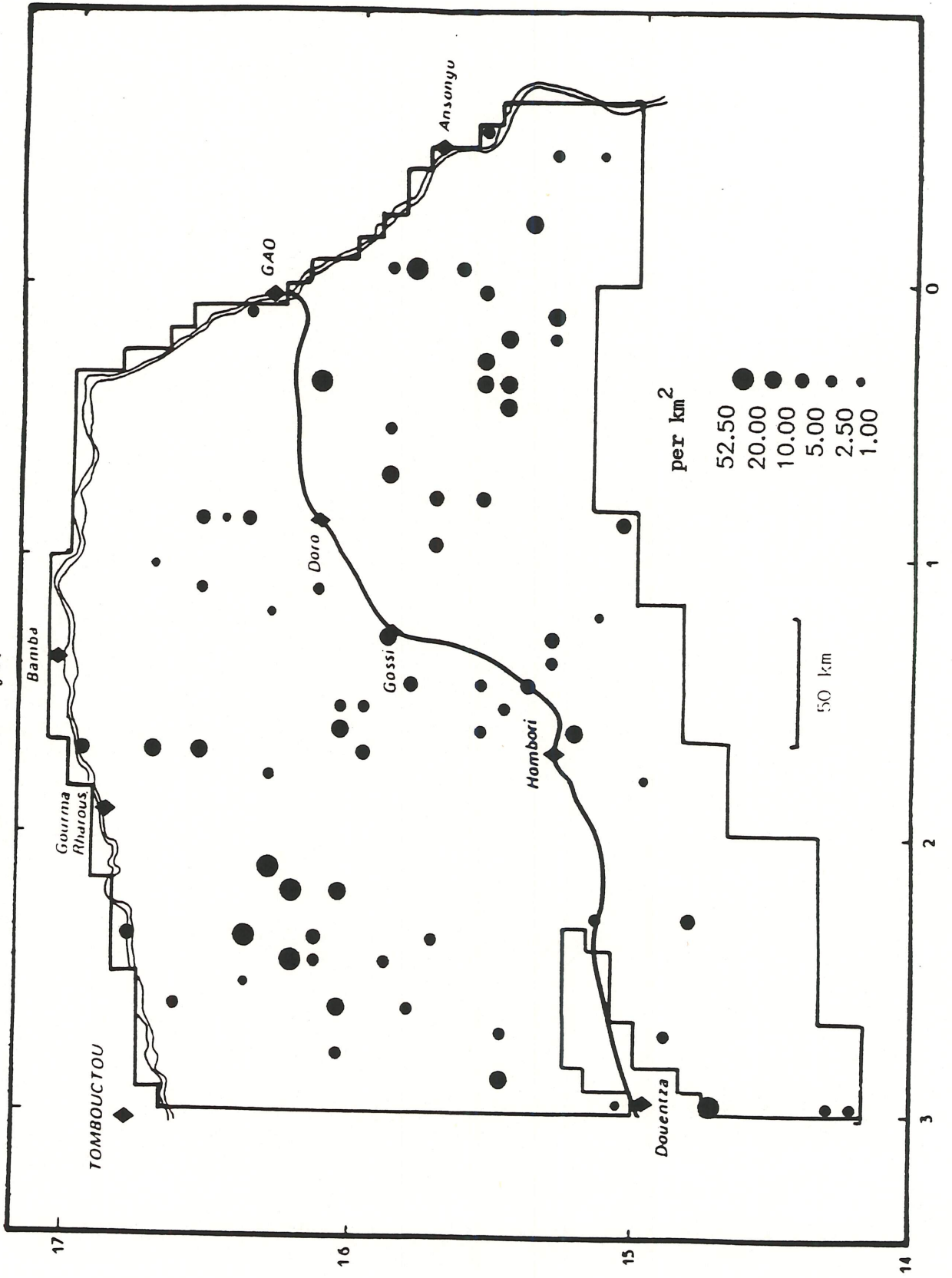


Figure 8 : Wet Season Distribution of TLU.

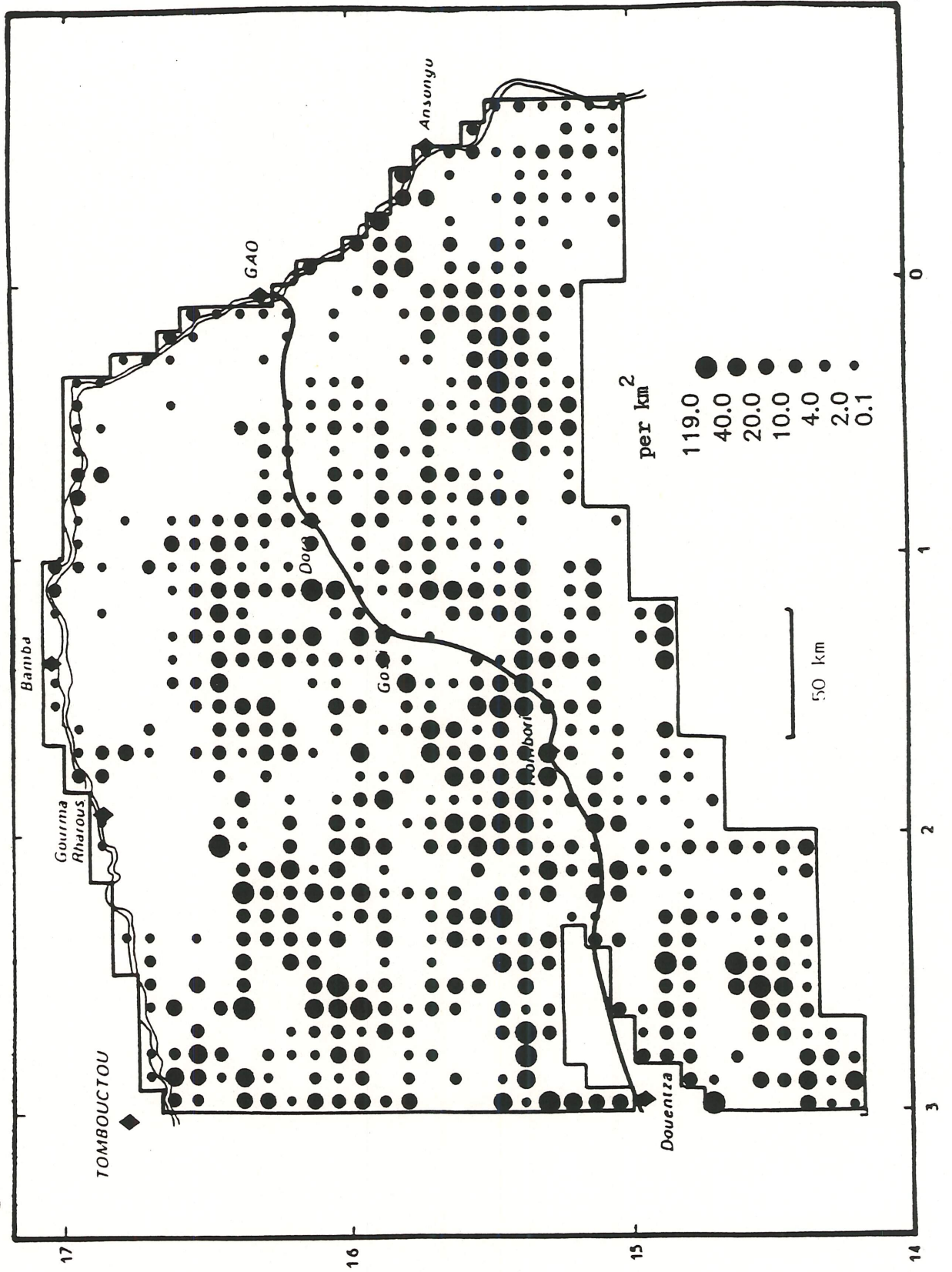


Figure 9 : Wet Season Distribution of "Bella Style" Dwellings.

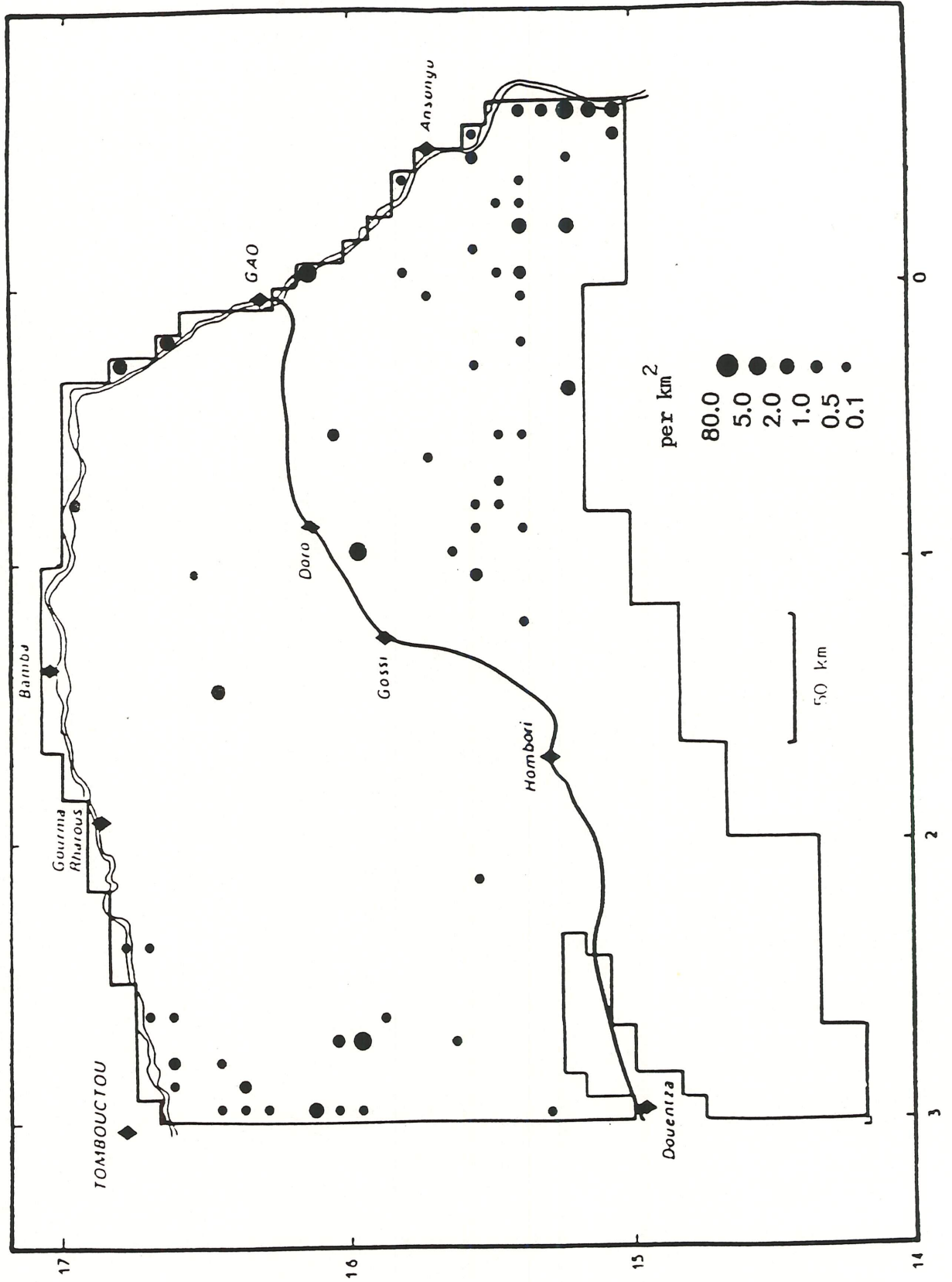


Figure 10 : Wet Season Distribution of "Dogon Style" Dwellings.

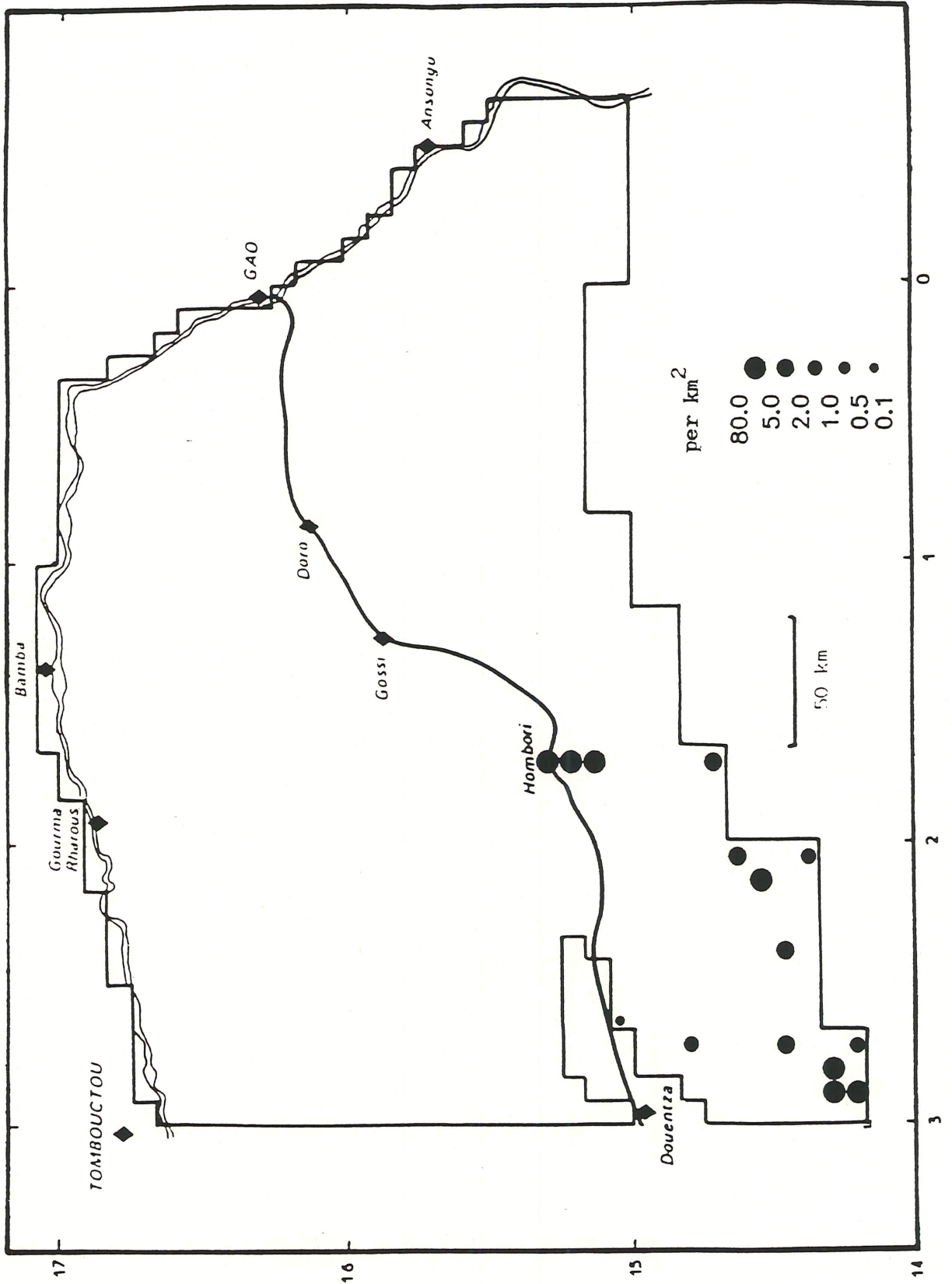


Figure 11 : Wet Season Distribution of "Maure Style" Dwellings.

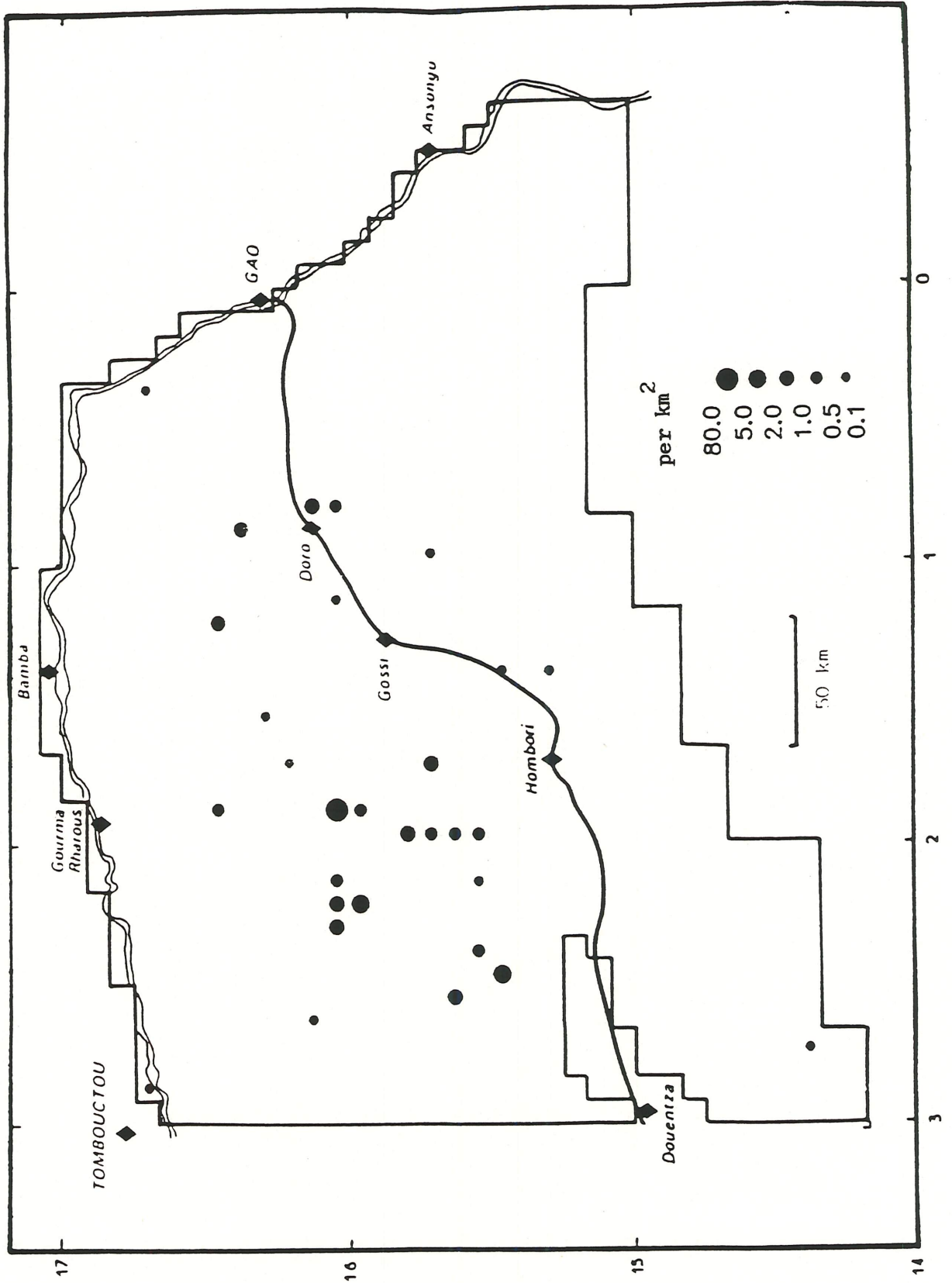


Figure 12 : Wet Season Distribution of "Peuhl Style" Dwellings.

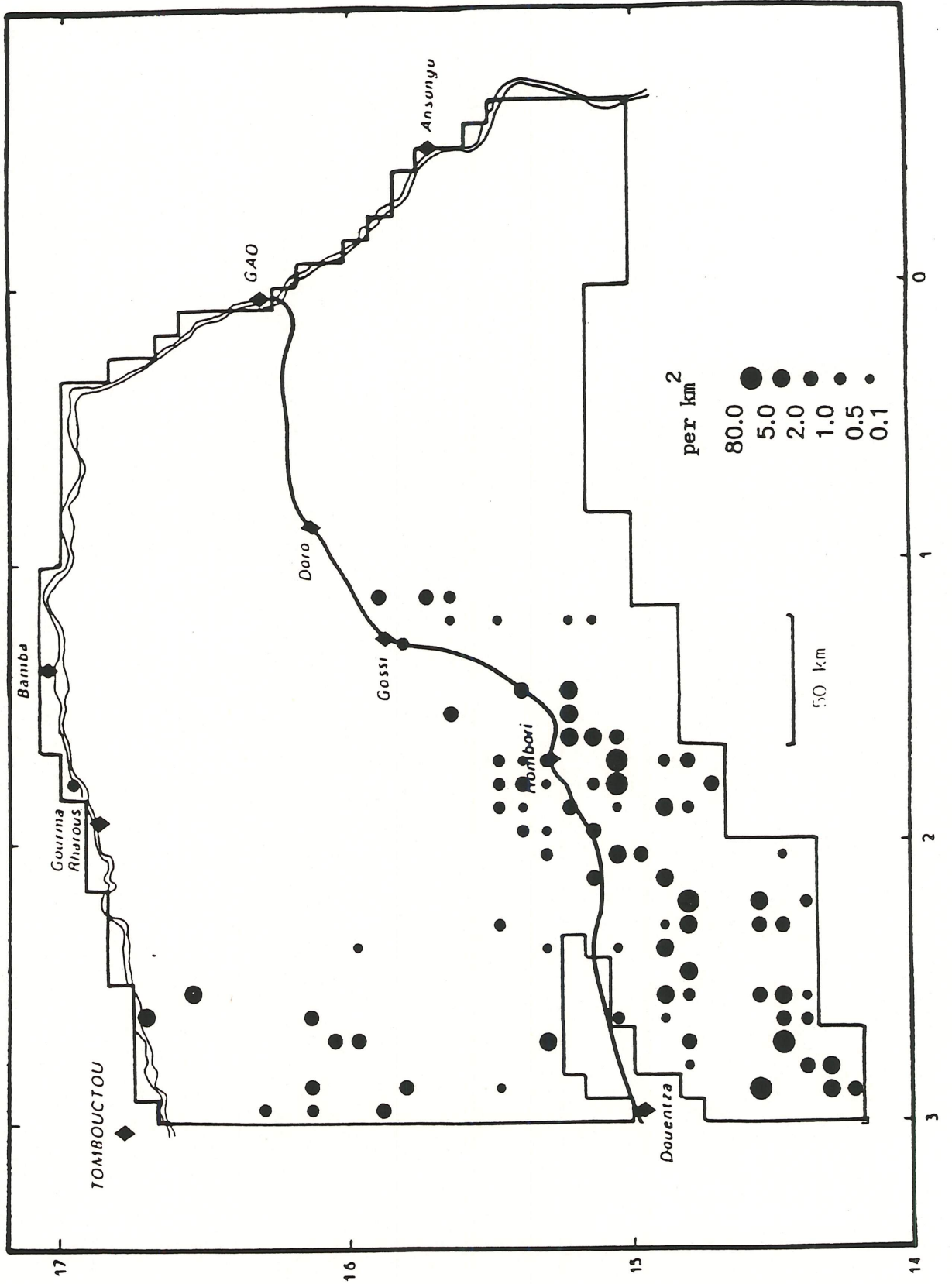


Figure 13 : Wet Season Distribution of "Sonrai Style" Dwellings.

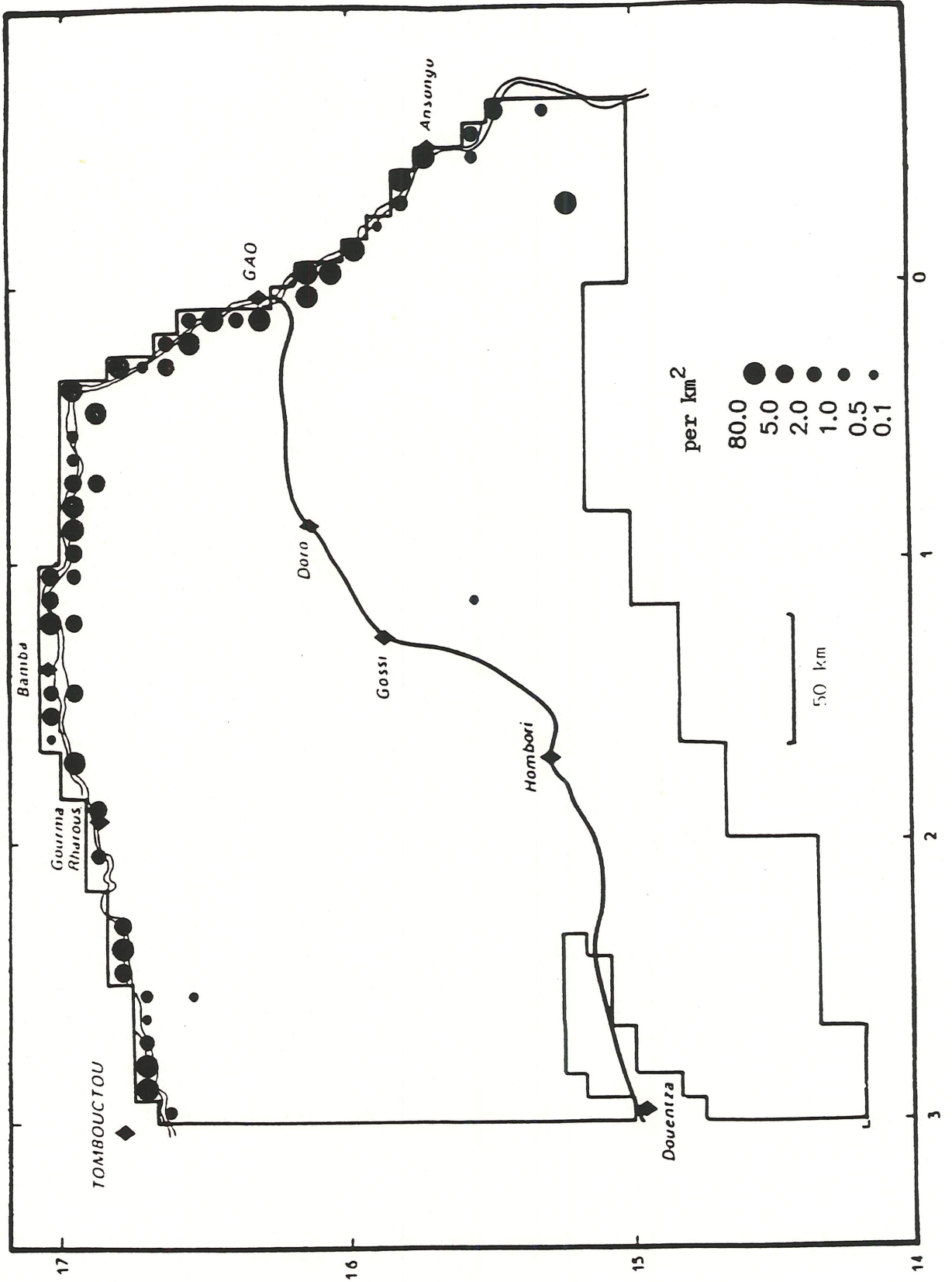


Figure 14 : Wet Season Distribution of "Tamasheq (Touareg) Style" Dwellings.

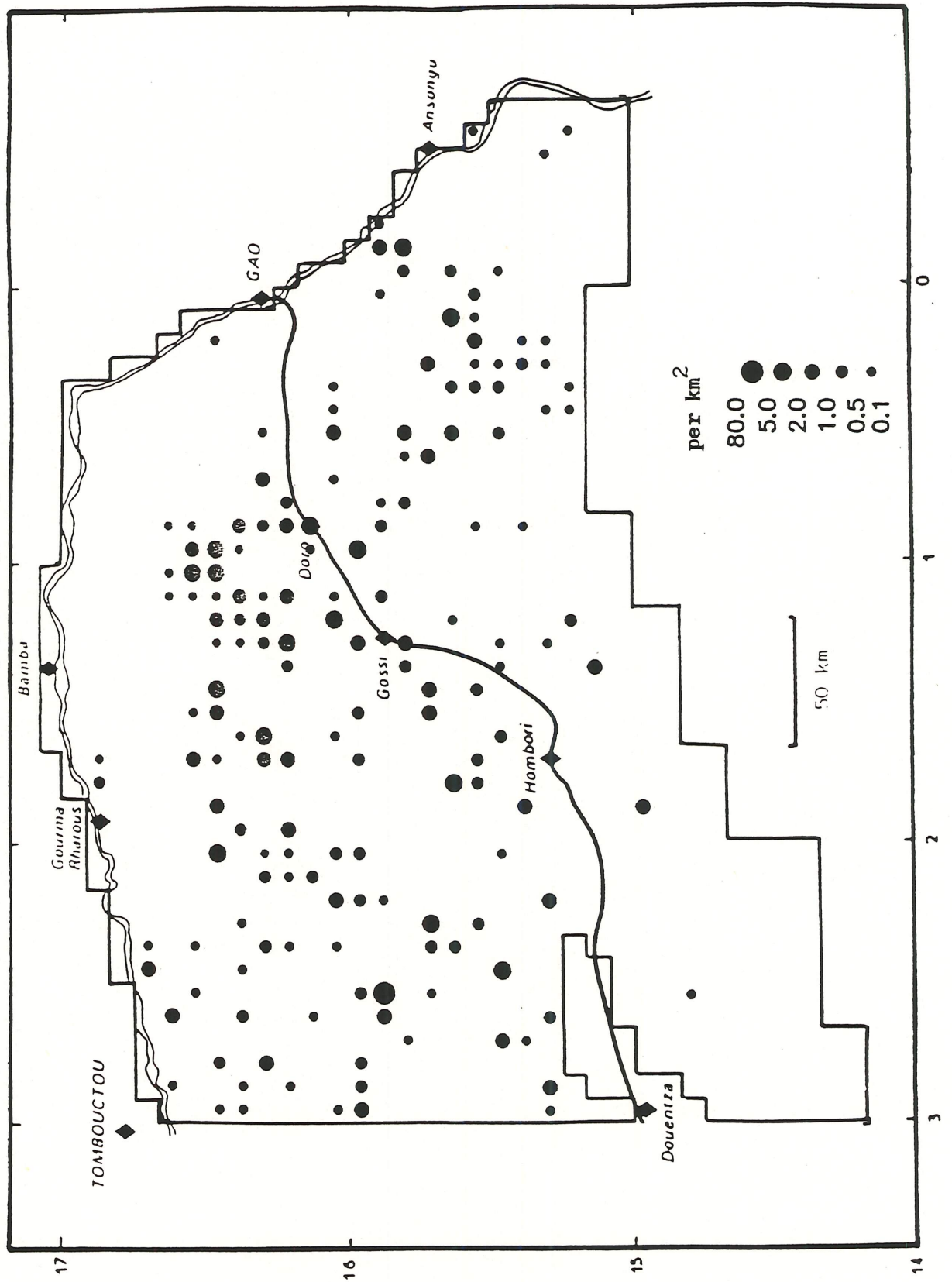


Figure 15 : Wet Season Distribution of Cultivation.

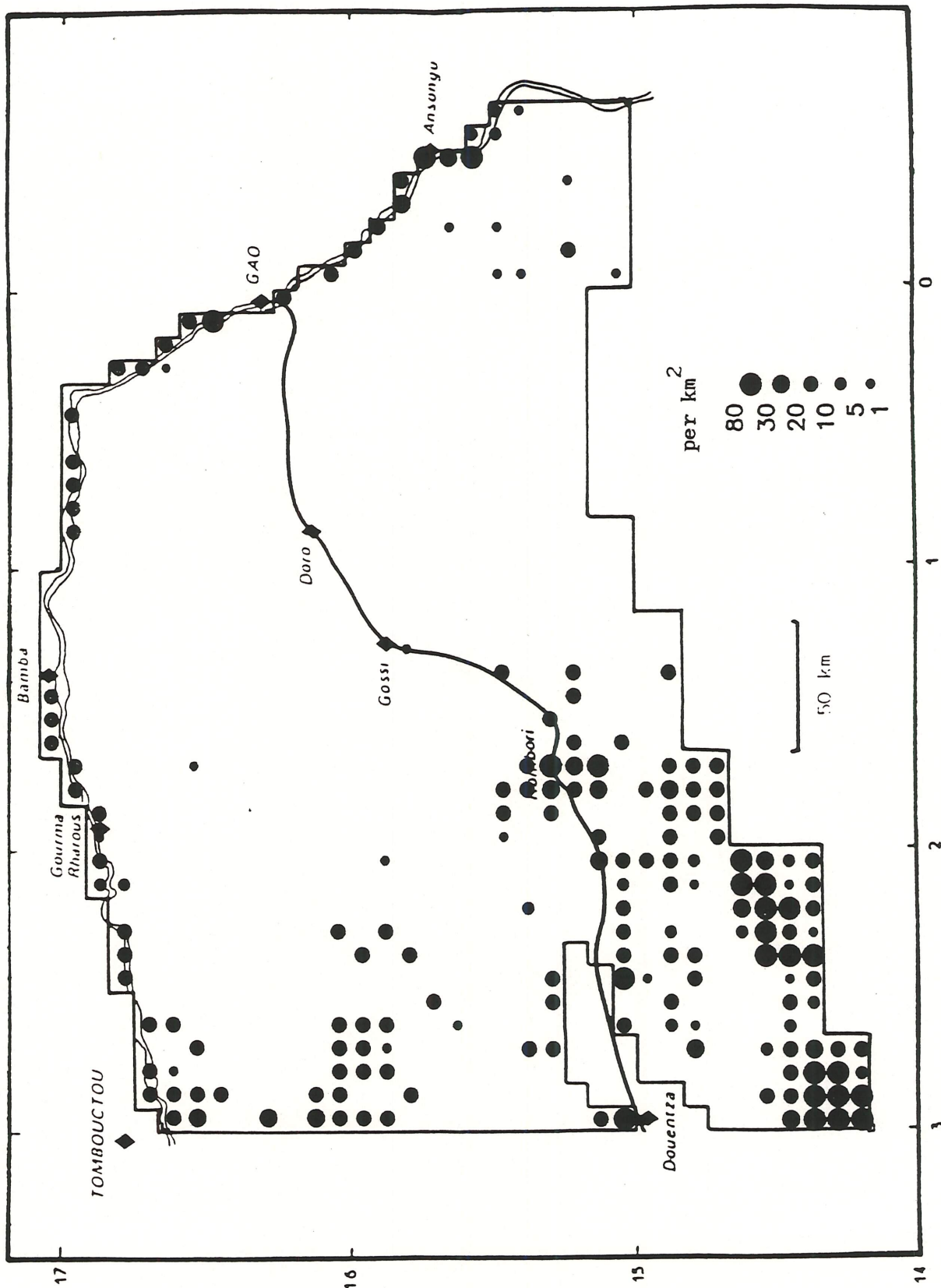


Figure 16 : Wet Season Distribution of Grass Cover.

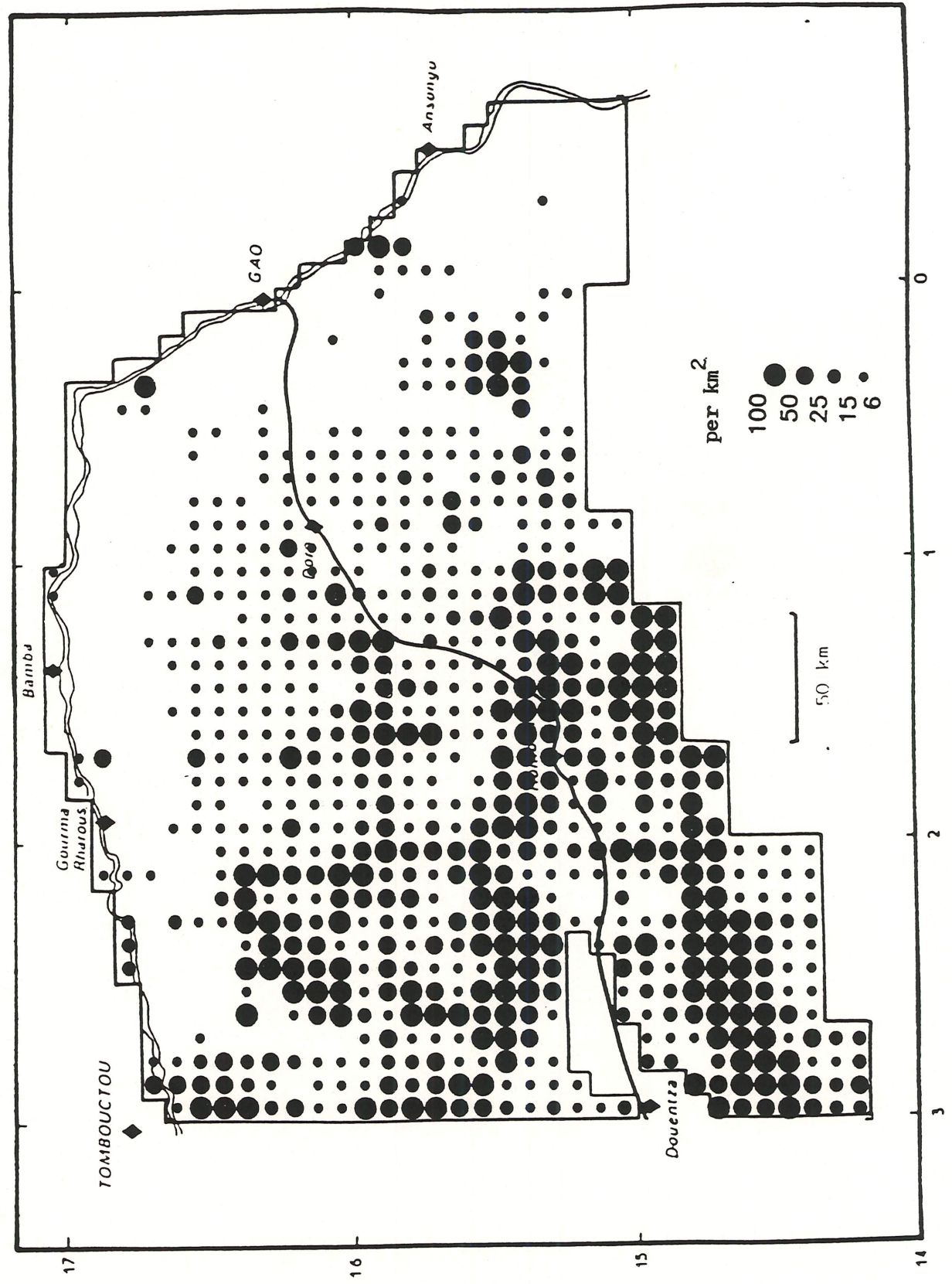


Figure 17 : Wet Season Index of Greenness.

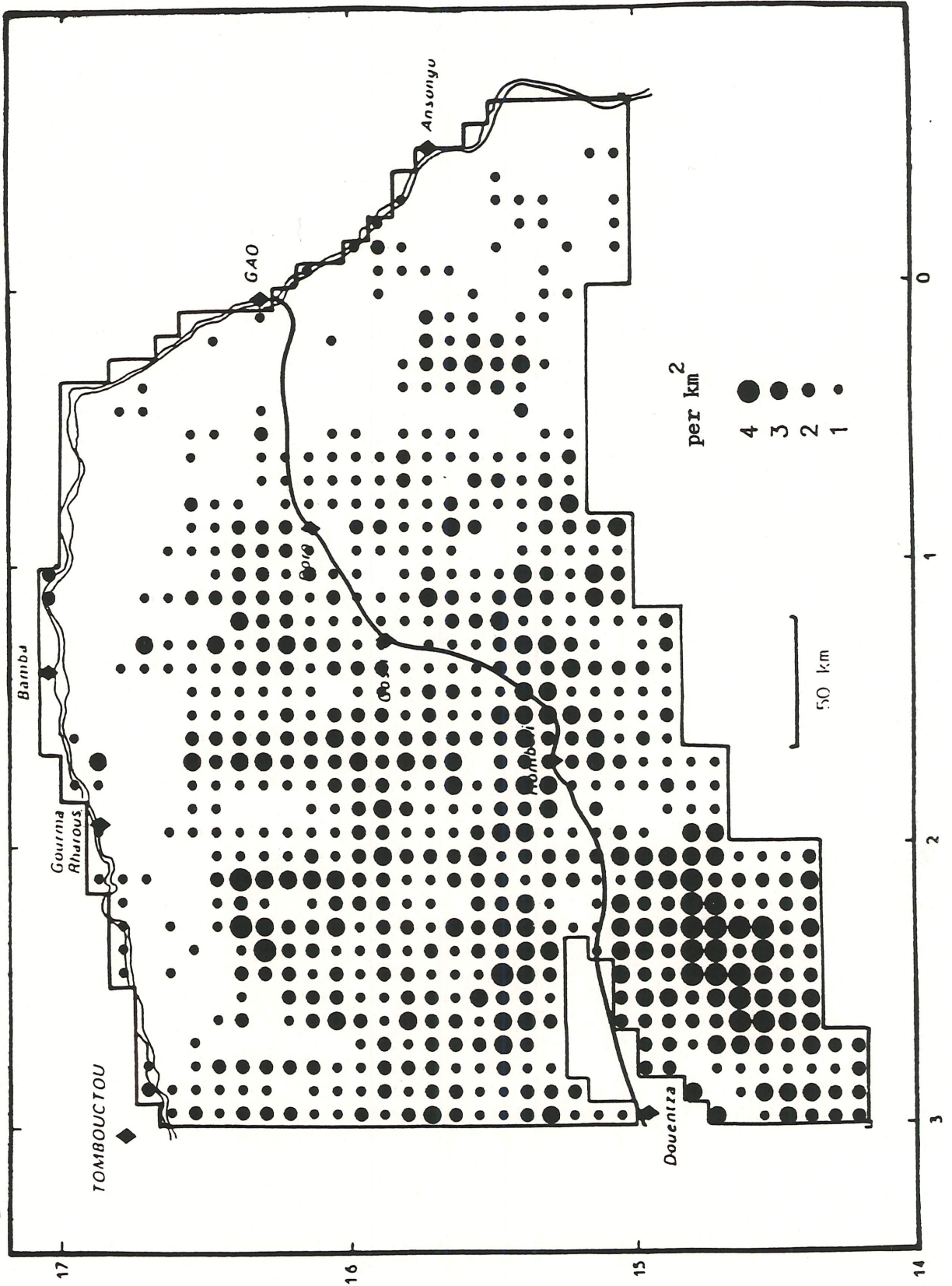


Figure 18 : Distribution of Major Vegetation Types : Dense Savanna Woodland.

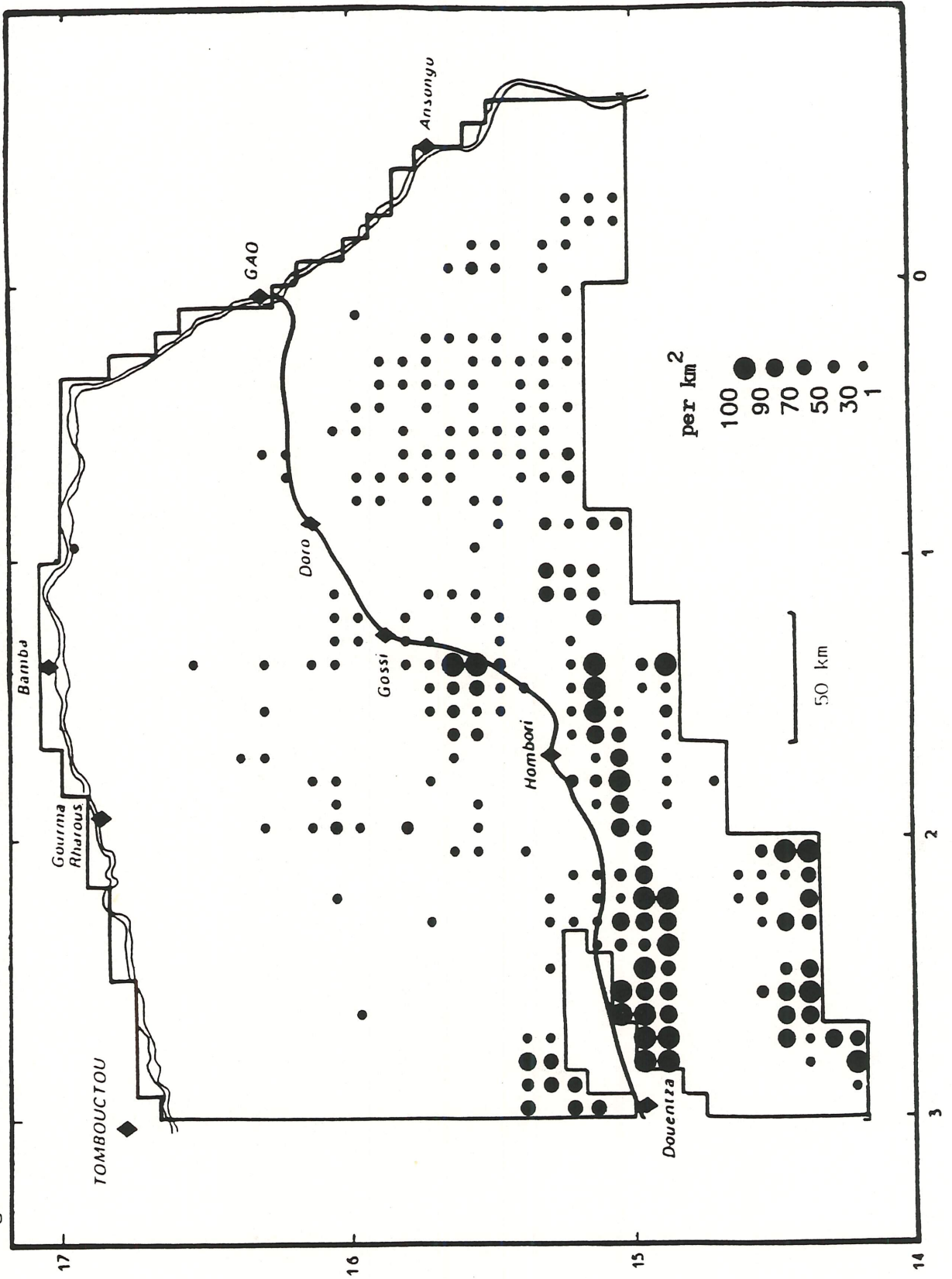


Figure 19 : Distribution of Major Vegetation Types : Light Savanna Woodland.

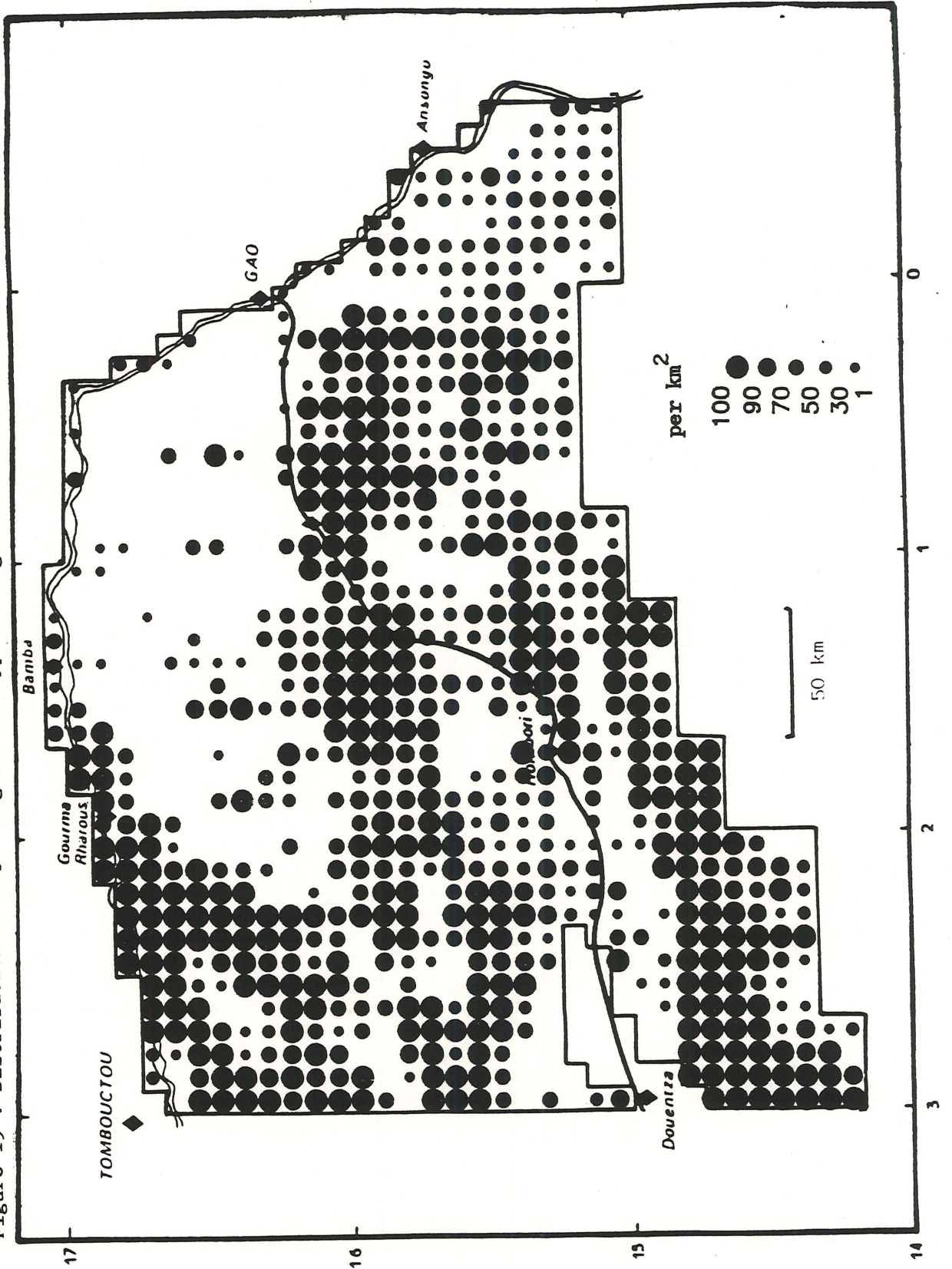


Figure 20 : Distribution of Major Vegetation Types : Shrubland/Bushland.

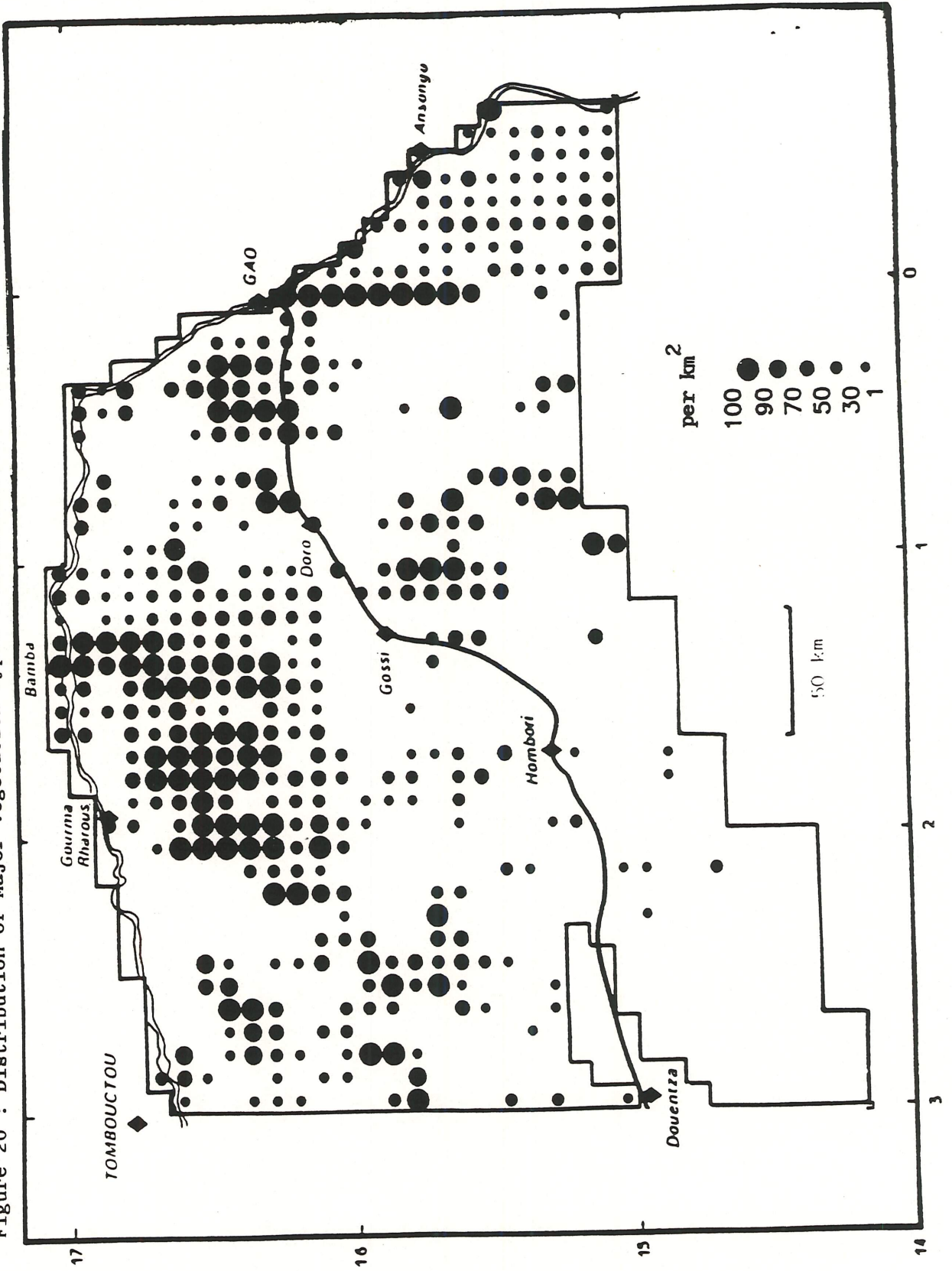


Figure 21 : Distribution of Major Vegetation Types : Grassland.

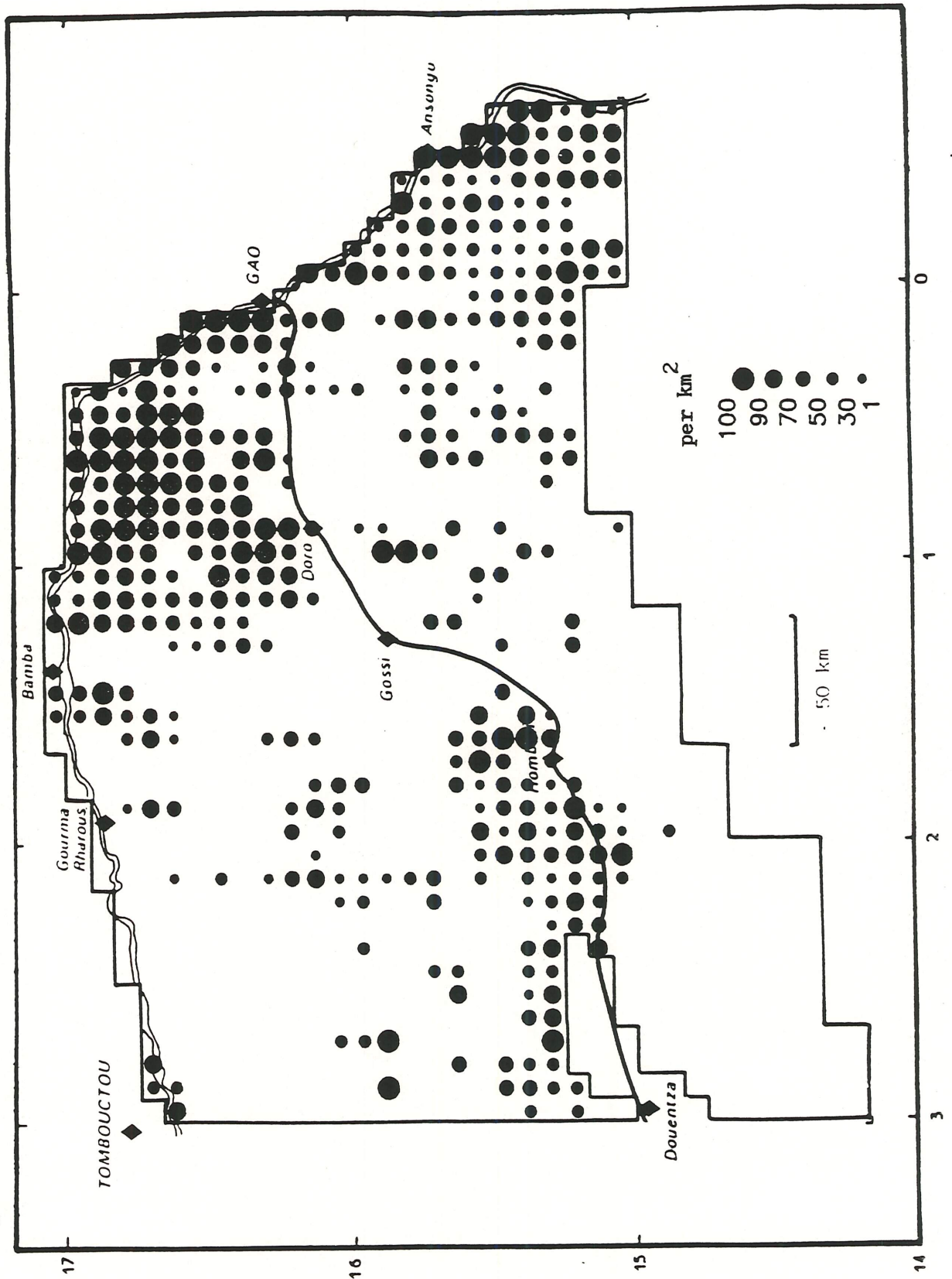


Figure 22 : Vegetation Density Index.

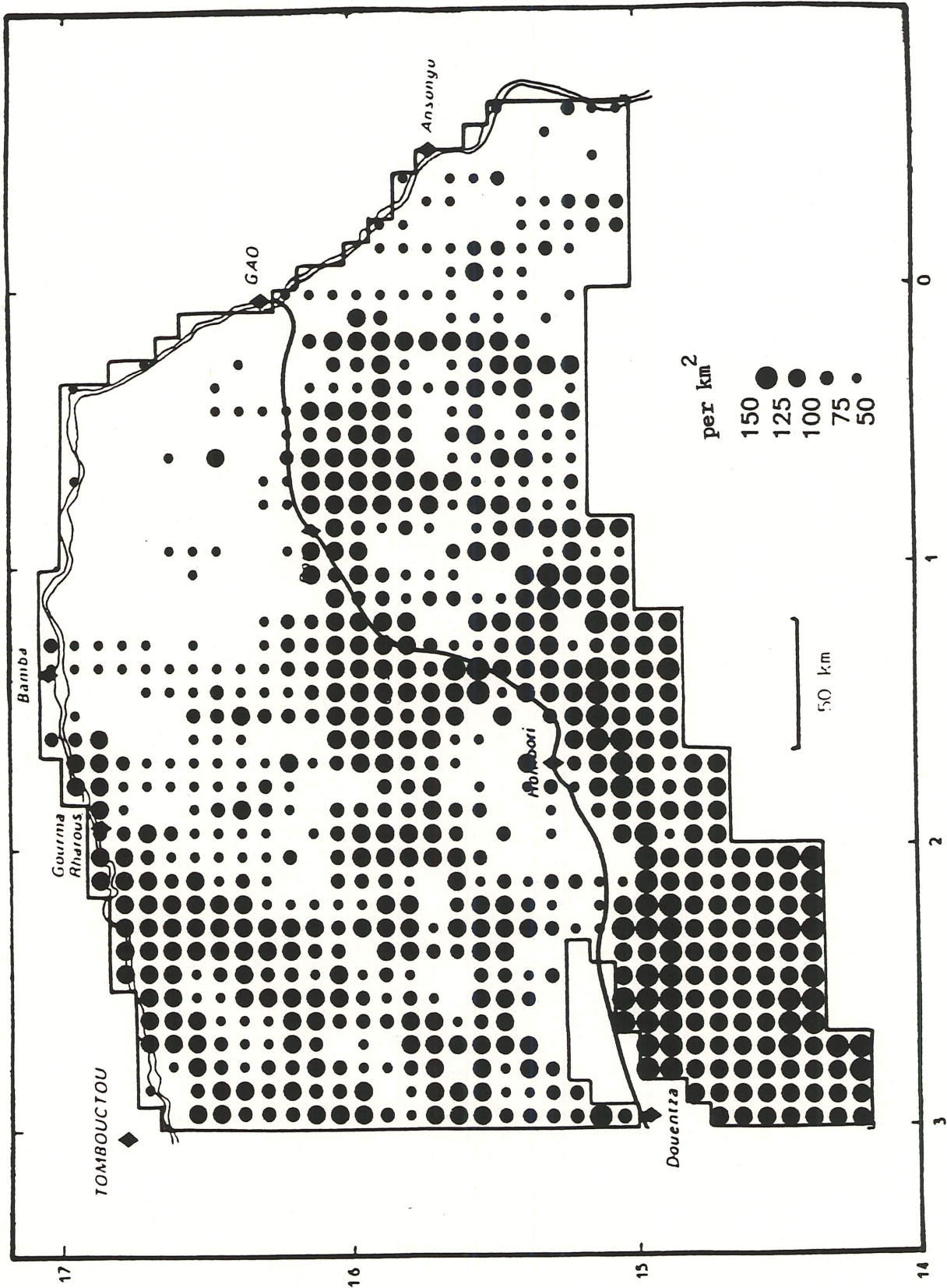


Figure 23 : Wet Season Distribution of Water.

