

Ministère de l'Elevage
Projet National d'Elevage
Laboratoire de Recherches Veterinaires et Zootechniques de Farcha
B.P. 433
N'Djamena
Tchad

**LOW LEVEL AERIAL SURVEYS OF LIVESTOCK,
HUMAN HABITATION AND PASTURELAND IN
THE BAHR EL GHAZAL REGION, TCHAD
AUGUST 1991**

FINAL REPORT

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February 1992

SUMMARY

The Programme Ecologie Pastorale, funded by the World Bank, was set up in 1990, under the auspices of the Projet National Elevage and the Ministère et de l'Hydraulique Pastorale, and operates through the Laboratoire de Farcha, N'Djamena. Part of this programme is an assessment of the numbers and distributions of livestock, human habitation, and selected environmental parameters in a study area coinciding with the wet season pastures of Tchad's Sahel zone. These assessments were made by means of integrated air and ground surveys, carried out during the wet season of 1991, over an area of 59,800 km².

The present report presents the results of these surveys, with maps showing the distribution patterns of the parameters assessed. In line with requests of project staff, the emphasis has been placed on the detailed results and methods used rather than on their evaluation or interpretation.

Method

The aerial survey was based on the well established technique of Systematic Reconnaissance Flying, whereby the study area is divided into regular 10 x 10 kilometre grids, and counts of livestock and habitation numbers, and estimates of vegetation cover, are made within each. Counts are made within a fixed sample band amounting to 10% of the area of each grid cell, whilst the extent of the vegetation parameters is estimated for the whole grid.

The ground surveys, executed by Programme staff in close cooperation with the air survey team, collected two sets of complimentary data: the ratio of sheep and goats in small ruminant herds; and the numbers of animals kept under cover within settlements. This information, when combined with the aerial survey counts, allowed the separation of aerial population estimates of otherwise indistinguishable small ruminants into their constituent species. It also enabled the calculation of the numbers of livestock concealed from aerial observation, which, when added to the air counts, provided an estimate of total livestock population numbers.

Summary of results

Of the vegetation types assessed, grass cover predominates: it accounts for 60% of the total land area and is present in all but the northern 40 - 50 kilometres of the survey area. Woody vegetation (trees and shrubs) covers approximately 12% of the survey zone, and is concentrated in the south and west. Trees are abundant in the localised clay depressions which are a characteristic of the area, and are comparatively healthy in that only 2% are dead or dying. These low lying areas also contain dum palms, which comprise 10% of the canopy. Cultivation, which covers 67,600 hectares, is sparse and restricted in its distribution. The remainder of the survey area (some 26%) is bare, and thus devoid of significant vegetation cover. Most of the bare ground is in the north-east.

Surface water was recorded in slightly under half the survey grids, mostly in the southern two thirds of the survey area, which emphasises the constraints that water availability is likely to impose on livestock management, even during the height of the wet season. Erosion is also widespread in the south.

Human habitations, with an estimated total of some 111,300, are rather sparse. Tents account for approximately a third of the total and are quite widely dispersed, whilst the permanent thatched or mud-roofed dwellings, though more abundant, are limited to the southern and western parts of the survey area.

Livestock numbers are estimated as follows: camels - 67,500; cattle - 605,500; sheep - 328,700; goats - 354,400; horses - 7,900; and donkeys - 8,300. In terms of biomass, the overall livestock population is high, when compared to other similar parts of the Sahel, and comprises a greater proportion of cattle. Nevertheless, if available estimates of carrying capacity are correct, and despite limited areas of possible overstocking, there remains considerable scope for expansion.

Camel populations are restricted to the north, with a focus, most probably of resident animals, to the north and east of Salal. The other species are largely concentrated in the southern two thirds of the survey area, especially in the Soro, and along the margins of the Eka clay plains in the south. Camel numbers are higher in areas away from habitation; cattle, sheep and goats are more numerous in the vicinity of tents and trees, whilst equines are aggregated close to the permanent dwellings.

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ACKNOWLEDGEMENTS

The successful completion of this survey would not have been possible without the help and cooperation of a number of individuals and institutions. RIM extends its particular thanks to the following:

Laboratoire de Farcha: Idriss Yosko
Paul Scholte
Dr Idriss Alfaroukh

AIEP, Kaduna, Nigeria: Klaus Gloege
Mark Snoxell
Skip Heard

Le Direction de L'Aviation Civil, N'Djamena
Le Sous-préfet, Moussoro

ACRONYMS, ABBREVIATIONS AND UNITS

AIEP	Aeronautical and Industrial Engineering Projects Limited
ANOVA	Analysis of Variance
agl	above ground level
asl	above mean sea level
CIPEA	Centre International Pour l'Elevage en Afrique
ERGO	Environmental Research Group, Oxford, Limited
ES	Erreur Standard
FAO	United Nations Food and Agriculture Organisation
FSO	Front Seat Observer
GIS	Global Information System
IEMVT	Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux
ILCA	International Livestock Centre for Africa
INTSH	Institut National Tchadien pour les Sciences Humaines
NRL	Niger Rangelands
OAR	Observateur arrière
OAV	Observateur avant
ODEM	L'Opération de Développement de l'Elevage dans la Région du Mopti
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
PEP	Programme Ecologie Pastorale
PNE	Projet National Elevage
RIM	Resource Inventory and Management Limited
RSO	Rear Seat Observer
SD	Standard Deviation
SE	Standard Error
SIG	Système Informatique Géographique
spp	Species
SPSSPC	Statistical Package for the Social Sciences, Personal Computer version
SRF	Systematic Reconnaissance Flights
TLU	Tropical Livestock Unit
UBT	Unité Bétail Tropicale
UTM	Universal Transverse Mercator
VRS	Vols de Reconnaissance Systématiques
ZOP	Zone d'Organisation Pastorale
cm	Centimètre
ft	Feet
ha	Hectare
kg	Kilogramme
km	Kilomètre
m	metre
mm	Millimètre

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Location of Survey Area Map.
→

SECTION 1. INTRODUCTION AND BACKGROUND

1.1 Country Background

Tchad covers an area of 1,284,000 km², extending south from the tropic of Cancer to 8°N, and between 14° and 24°E. It thus encompasses a broad spectrum of ecological zones, from true desert in the north, accounting for 45% of the country's total area, through the graduated types of sahelio-saharan, sahelian, soudano-sahelian and soudanian vegetation, to the forested south, of the soudano-guinean type. This variation reflects climatic differences, particularly of annual rainfall, which ranges from less than 50mm in the far north to more than 1100mm in the south.

Temperature gradients are less clearly defined: the highest temperatures are found in the centre of the country during April (maximum 41°C, minimum 28°C); the lowest in the north during January (maximum 23°C, minimum 3°C). Temperatures in the south are more moderate.

The country's natural resources are mostly concentrated in the south and are chiefly agricultural - the major export is cotton - though oil deposits are being developed. Consequently, the majority of the country's 5 million people and much of the otherwise sparse infrastructure is found in the southern third of the country. The only major route in the north runs east from N'Djamena, via Ati, to Abeche, and thence on to Sudan. Tchad is one of the world's largest land-locked countries without rail access to the coast.

Nonetheless, there are some 1.5 to 2 million people living in the region to the north of the 500 mm isohyet - i.e. beyond the soudanian zone - which coincides very approximately with the 13°N parallel. This part of the population relies to a greater or lesser extent on livestock rearing for both subsistence and income. North of the 16th parallel, where annual rainfall rarely exceeds 100 mm (a convenient definition of the Saharan zone), pastoralism is the exclusive way of life. The less extreme climate of what is best referred to as the Sahel (being the region between the 13th and 16th parallels) allows some cultivation of millet but, by the very nature of its more diverse climate, forces a transhumant lifestyle for its pastoralist and agro-pastoralist inhabitants.

Goffings' and Damsou's study (1976) put the number of cattle in the Sahel region at 3,636,000 in 1975. This was after the drought of 1973-4, when the population was drastically reduced. Although cattle represent a very important part of the nation's economy, the nomadic lifestyle of their owners is not conducive to a close monitoring of this resource. The effects of recurrent droughts over the past twenty years have demonstrated how fragile a resource base livestock can be, and this situation needs to be remedied if these Sahelian livestock and their owners are to continue to exploit their environment effectively, and to sustain the ever-growing human population.

1.2 Programme Ecologie Pastorale

The Programme Ecologie Pastorale (PEP) is funded by the World Bank, through Dutch funding, and was set up in 1990 under the auspices of the Projet National d'Elevage (PNE) of le Ministère de l'Elevage et de l'Hydraulique Pastorale, operating through the Laboratoire de Farcha. It thus benefits from the existing infrastructure and expertise of these institutions. Like the PNE, the PEP focuses on a limited study area, - 'La Zone d'Organisation Pastorale' (ZOP) - which extends from the Bahr el Ghazal in the north to Bousso in the south, and from N'Djamena in the west to Djedda in the east. Within this region, a specific study zone has been defined which coincides with the wet season pastures of Tchad's Sahel zone. This latter area is the concern of the present report (See Colour Map 1, and Text Map 1.1).

The PEP is a three year programme, begun in 1990, which aims, initially, to build up a systematic knowledge of the pastoral environment - specifically the exploitation and management of pastures - and thereby enable the maintenance of sustainable animal production. The first stage of the Programme is a study which adopts several approaches to identify the interactions between man and the environment and the factors which constrain livestock management. The second stage will involve the development of suitable interventions for implementation.

The available pasture resources are being assessed by means of remote sensing (*télédétection*), and in conjunction with other techniques such as soil analysis. The carrying capacity of the rangelands are being analysed in terms of primary productivity and sensitivity to over-grazing. Spatial variation is reflected through characteristic "pastoral ecology units" (*unités écologiques-pastorales*). The different human groups which occupy the study zone are identified, and their seasonal movements and the grazing patterns of their livestock established.

The distribution of livestock and human presence, during the wet season, is assessed by means of aerial survey. The area covered is the northern section of the ZOP, where the large majority of livestock are concentrated during the wet season. It is this last element which is the subject of the present report.

1.3 Aerial Survey

Objectives of the Aerial Survey

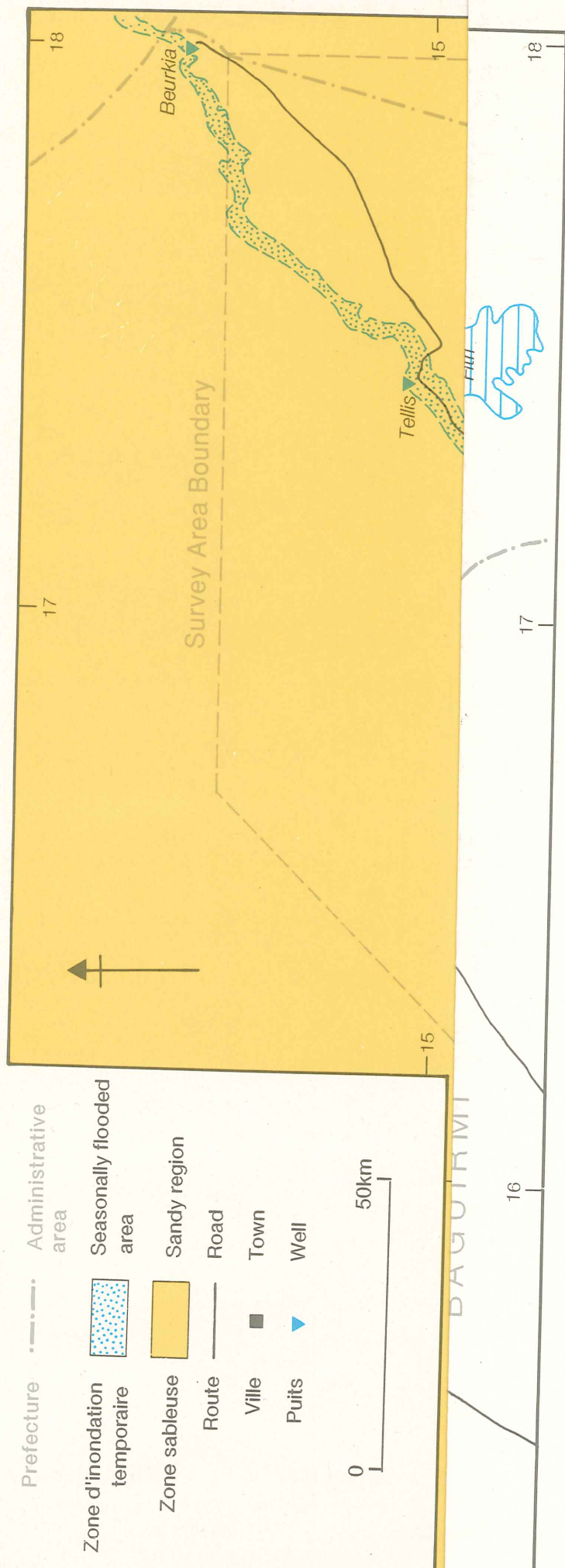
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In accordance with the requirements of the programme outlined above, Terms of Reference (see Appendix 1) were drawn up with a view to carrying out an assessment of livestock resources during the wet season of 1991, using a combination of air and ground surveys. The major objectives of these surveys were:

- to assess the density and distribution of livestock, encampments and village habitation in the survey zone;
- to assess the extent and distribution of selected vegetation types and cultivation and of surface water;
- to present the results in tabular and map form together with brief descriptions;
- to provide the data collected on diskette in a form compatible with the Project's existing data base.

The aerial surveys were conducted by Resource Inventory and Management Limited (RIM), using the established technique of Systematic Reconnaissance Flights (SRF), whereby a series of flight lines are flown over the designated region at a constant height above ground. Each flight line is divided into sectors of equal length to form a sample grid, based on the Universal Transverse Mercator (UTM) Projection, covering the entire survey area of 59,800 km². The accompanying ground surveys were carried out by Programme staff, to assess the numbers of livestock not visible from the air.

Full details of the methodology are given in Section 3 of this report. The remainder of the report provides a summary of the survey area in terms of climate, vegetation, human groups, livestock types and management, and reviews the estimates provided by previous studies (Section 2), before going on to describe the findings of the present survey (Section 4).

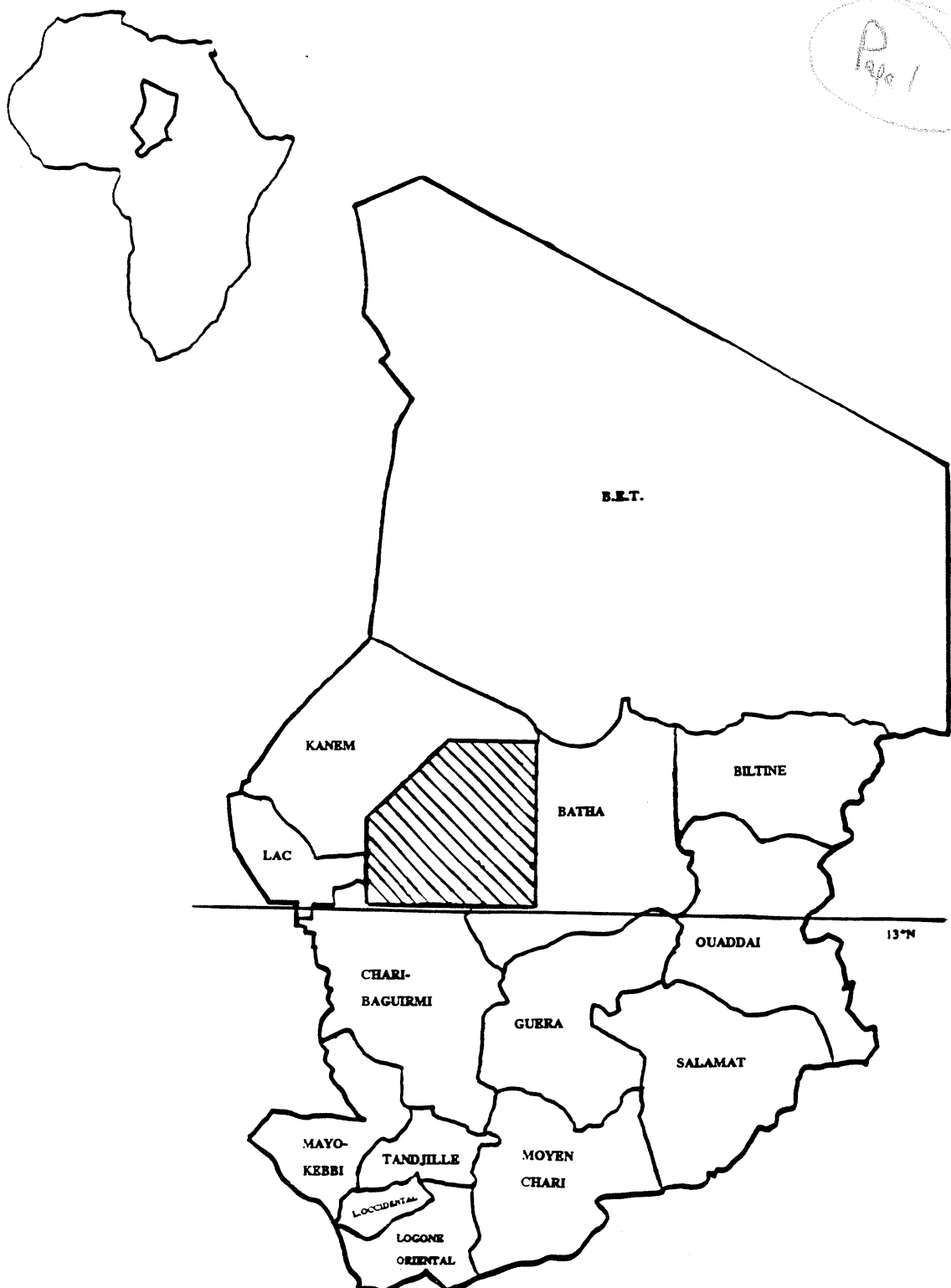


CARTE 1
MAP BASE MAP

PROJET NATIONAL D'ELEVAGE RESSOURCES PASTORALES DANS LA REGION DU BAHR EL GHAZAL (TCHAD), AOUT 1991

CARTE
TEXTE
1.1
TEXT
MAP

EMPLACEMENT DE LA ZONE D'ETUDE
LOCATION OF SURVEY AREA



SECTION 2. THE SURVEY AREA

2.1 Geography and Topography

Extending from Massakory in the south to beyond Salal in the north-east, (coinciding approximately with the area enclosed by 13° and 15.5°N and 15.5° and 18°E), the survey zone is divided into 598 10 x 10 km grids, based on a 26 x 26 grid square with the top left corner excluded (see Colour Map 2). The town of Moussoro is near the centre of the zone, in the south-west quadrat; other important settlements in the area are Salal in the north-east and Am Djéména to the south-east (see Colour Map 1).

The trough of the Bahr el Ghazal dominates the entire area, bisecting it from south-west to north-east. The only other water course to enter the zone is a small sector of the Batha river, in the south-east corner. The area's topography is characterised by plateaux, dunes and depressions, each with associated soil and vegetation types, though the range in height above sea level, from 275 to 325 m (900-1100 ft), is very narrow.

Essentially, four geophysical regions may be distinguished within the area: the Bahr el Ghazal, known locally as the Soro; the sandy plateaux, or Soulia, surrounding this depression; the Harr, an area of stabilised dunes and wooded depressions to the south of Moussoro; and the Eka clay plains in the south and east.

2.2 Climate and Water Availability

The Soro currently consists of a series of pools, often seasonal, which occupy the depressions. The trough is gradually filling with sand blown from the Sahara in the north-east. This is only part of a long term dessication of the region, once submerged by Lake Tchad, which originally extended north-east from its present day location as far as Koro-Toro, and later formed two separate lakes joined by the flowing Bahr el Ghazal. During the second millenium AD the water continued to drop to its present day level: the "Bahr el Ghazal" ceased to be a flowing river.

The climate, and consequently the vegetation and lifestyle of the people, is dominated by the contrasting wet and dry seasons. The zone falls between the 500 and 100 mm isohyets, rainfall being confined to between July and September. Though influenced by the seasons, annual temperature variation is less marked: maxima range from less than 29°C in the north during January, to over 41°C during April (end of the dry season), while minimums range from less than 18°C to over 25°C.

This clearly characterises the present climate as sahelian, though definitions differ according to sources (Le Rouvreur, 1962, pp42-43; Chapelle, 1986, p11; ORSTOM 1970, p5). However, there have been considerable long term changes which have tended to destabilise the finely balanced lifestyle of nomadic pastoralism.

Although during the course of centuries, approximately decadal cycles in rainfall patterns can be distinguished, a marked decline has occurred, particularly over the past 30 years (IEMVT, 1986, p1), with periods of drought lasting longer. In general, a shortage of rain over long periods reduces surface water and lowers the water table. For pastoralists, this means greater seasonal displacements.

A southward movement of the 200 mm isohyet culminated in severe drought conditions during the years 1973-74 and 1983-84. In 1974, many thousands of cattle were lost whilst following traditional transhumance routes (see below), or diverting from them too late. In Moussoro *sous-préfecture* (Colour Map 1), reported losses amounted to 30-35%; subsequently, the herders struck south, those in the east heading for the Lac Fitri area, those in the west for Massaguet. Mao *sous-préfecture* suffered most, with losses of up to 75%: The Dazas and Arabs of this region, being agropastoralists, were less equipped for long distance movement, and more constrained by the ties of a sedentary lifestyle. In contrast, being accustomed to covering the long distances between Salamat and the north, the losses sustained by the inhabitants of Batha

préfecture were relatively low (10-20%). As a result of these experiences, practices changed, and the drought of 1984 caused far fewer deaths (Chapelle, 1986).

Since 1984, the situation has remained somewhat erratic: rainfall in 1988 was exceptionally good, with 559.6 mm recorded in Moussoro, whilst the 1990 rains were poor throughout the area, with precipitation as low as 94.9 mm in Moussoro.

Rainfall in the area during 1991 has been fairly abundant. Figures for Moussoro show that almost as much rain fell during July and August (82.2 and 72.7 mm respectively) as throughout the entire season of the previous year. Up to September 4th, a total of 209.7 mm had been recorded (pers comm, Yosko).

Since 1946, mean annual rainfall (from 32 readings) in Moussoro has been 347.6 mm (coefficient of variation = 33%) (Yosko, 1989). Regional variations are represented by a clear gradient from south to north: Massakory has the highest average, followed by Ati, Moussoro, Ngouri and Mao.

Local water availability is determined not only by climate, but also by the substrate and soils. The geology of the Bahr el Ghazal region is of the quaternary era. Today the region is chiefly one of subarid soils over sand, with hydromorphic and halomorphic elements, whilst the southern part of the Soro is an area of vertisols. In general permeability is lower, and thus the water table higher, in the south-east of the survey area (INTSH, 1972), the Eka clay plains, and in the Soro.

As a result, seasonal flooding tends to occur in the latter two areas, and these temporary *mares* are important factors in the seasonal movements of pastoralists. Nonetheless, man has had a significant modifying influence: the sandy plateaux around the Soro (Soulia), and to the west of the survey area, have an impressive network of wells; in some parts of Kanem, distance between wells is less than 18 km (Colour Map 1).

Climate and water availability affect livestock husbandry not only directly, but also through their effects on the vegetation of the region.

2.3 Vegetation

The Sahel zone possesses a characteristic vegetation type, reflecting the low annual rainfall, long periods without rain, and high temperatures, locally modified by topographic, edaphic and other factors. However, the influence of these factors is being increasingly overshadowed by the effects of rising human and livestock populations, which, via the associated demands for fuelwood, browse, grazing, crops and water, are contributing to the destruction of the traditional *forêt sahelien*.

The woody vegetation is naturally sparse and dominated by thorny species: *Acacia* spp., *Balanites aegyptiaca*, and *Leptadenia pyrotechnica*. The non-woody vegetation typically consists both perennial and annual species, such as: *Aristida* spp., *Cenchrus biflorus*, *Panicum turgidum*, *Eragostis tremula*, and *Schoenfeldia gracilis*.

The major spatial differences are between the sandy plateaux/dunes, and the lower lying *ouaddis* and depressions, associated with a higher water table and seasonal surface water availability. In the latter, vegetation is more prolific and there is a greater incidence of certain tree species: *Acacia nilotica*, *A. senegal* and increasingly, the dum palm, *Hyphaena thebaica*.

The past twenty years have witnessed a degradation of vegetation in the region: woody species have become less diverse and trees less abundant, the trend being towards smaller tree species and shrubs. Though this change in woody vegetation, caused in part by over-exploitation, may not be immediately detrimental to pastoralists, of some direct concern, perhaps, are the increasing areas of bare ground appearing and the changes in species composition of the non-woody flora. The PEP studies allied to the present survey are investigating the vegetation patterns at the species level.

2.4 Ethnic Groups

A number of ethnic groups are represented in the survey zone. The principal sedentary groups are the Kanembou which inhabit the south-west of the survey area, spreading as far as Moussoro, and the Bilala and Kouka populations of Chari-Baguirmi which are represented in small numbers on the southern edge.

The majority of the population is either nomadic or transhumant. The Toubou Kreda, of which there are approximately 80,000, inhabit the Soro and surrounding plateaux, whilst the closely related Kecherda (5,000) occupy the more northerly latitudes. Other Toubou groups, chiefly the Dogorda in the north-west, and Arab minorities, including the Hassaoun, Dagana, Djaatne and Ouled Himet, live at the periphery of the survey area. Nomadic Peul enter the zone on a seasonal basis.

The Kreda and Kecherda of the Bahr el Ghazal are part of the large group of Toubou, spread throughout northern Tchad. Records of their existence in this region go back as far as the 4th century BC. The Teda herd camels in the Saharan zone (some entering the north of the survey area during the wet season), whilst the Daza, of which the Kreda and Kecherda are a part, live further south, herding both cattle and camels in the *préfectures* of Kanem and Batha.

Genealogically, the Toubou are divided into clans, each sharing a common ancestor going back a fixed number of generations. Geographic and historic associations have brought about tribal divisions; there are 10 Kreda tribes, the principal ones being the Yria and Yorda, and 3 Kecherda tribes, the Sanakora, Sakerda and Medema. On a day to day level, their communities are not fixed: as befits a transhumant lifestyle, they readily form temporary associations and equally readily divide.

Whilst the Kanembou speak their own language, and various Toubou dialects are spoken throughout the survey zone, Arabic is the language of trade and, more formally, of religion; indeed, some prestige is attached to its knowledge.

Arabs first arrived in the region during the 8th century; they were of the Judam tribe in Upper Egypt which later divided into the Al Adjam and Hasan groups. Over the centuries they have merged with both nomadic and sedentary populations, influencing culture to a great extent, but nonetheless maintaining their own identity, principally in their original role as traders. Today they exist as many separate groups; of those in the survey area, the Djaatne and Ouled Himet to the south-east are Al Adjam, the Hassaoun and Dagana to the west are Hasan.

Whilst nomadism and sedentarism represent extremes in the degree of mobility of a population, intermediate forms exist. "Agropastoralists" both herd livestock and raise crops, each to a greater or lesser extent. The Dogorda and other Daza, for example, grow millet, and cultivate vegetables and palm trees in the *ouaddis* of Kanem; the Kreda grow some millet on the Soulia; the Kecherda, and most of the Arab groups within the survey area, are pure pastoralists.

Cultural convergence between ethnic groups of the region, trade relations and, more recently, a shared administrative structure, (with groups '*dépendant de*' local authorities), may have brought about a large degree of inter-group homogeneity. Even so, as Le Rouvreur (1962) points out, the fundamental differences between the nomadic and sedentary way of life will always serve to reinforce inter-group distinctions.

2.5 Livestock Types

The present survey is concerned with all the major livestock species in the region: camels, cattle, sheep, goats, horses and donkeys.

Cattle, as they need frequent watering, are confined to the wetter rangelands south of 15°N. The principal race in Tchad is the zebu, the most common breed of which is locally known referred to as the *zebu arabe*. Short horned and of various colours, this animal is perceived as comparatively hardy, and able to move long distances. Its meat and milk production, however, are relatively poor (RIM 1991).

The less common *zebu M'bororo* is distinctive in its very long lyre-shaped horns. It tends to be less tolerant of environmental stress and more susceptible to disease than the *zebu arabe* but is often more productive in ecologically favourable conditions, and some prestige is attached to its ownership.

Camels are rarely found south of 15°N, other than for short periods on transhumance. They are highly resistant and well adapted to a harsh environment and, although a fairly slow *marcheur*, provide an excellent means of transport and load carrying - camel trains bring dates, soda and salt from Bourkou to the south. This animal is also a source of milk, and a base of capital for its owners. The main breed in the survey zone is the *dromadaire arabe*.

The principal breeds of both goats and sheep in the zone are called *arabe*. The *chèvre arabe*, or *caprin du sahel*, is large (up to 80 cm at withers height) and long eared. It is found throughout the survey area, though tends to be restricted to areas close to water. Much less abundant is the *Kirdi caprin*, which is generally restricted to towns such as Moussoro

The *mouton arabe* is of medium size, with a long black coat; whilst providing very good meat, the milk production is poor. The *mouton Oudah*, herded exclusively by Peuls, is very distinctive in its coat, half black/half white, and large size, (around 85 cm); its owners benefit from its good meat and average milk production.

Sheep are particularly selective in their dietary requirements, a characteristic which, together with their need for frequent watering, tends to restrict their distribution. They are nonetheless prized for their role as a sacrificial animal (Chapelle, 1986, p90) in religious festivals such as *Sallah*.

Horses and donkeys are both used for transport and as pack animals. The principal breeds are the *cheval du Bahr el Ghazal* and the *ane du Kanem*. Horses, like sheep are generally limited to the less harsh ecological conditions, and are rare in the north. Donkeys, in contrast, are ubiquitous.

2.6 Livestock Management

For cattle, the optimum herd size, in terms of water/pasture availability and protection from theft, is around 60 animals (Chapelle, 1986). In addition to a few goats, sheep, donkeys and possibly a horse, the herd is usually associated with 7-8 people (not necessarily the owners), occupying 2-3 tents. The age and sex structure of the herd will ideally fit the needs of the herders: provision of milk and butter for consumption and sale; ability to increase the herd by breeding; surplus animals for insurance, marriages and to sell for capital.

Encampments may number tens of tents, particularly during the wet season when groups converge, but have no fixed structure; members of different clans mix and hierarchy is absent: the social structure is one of temporary fission and fusion. According to the occupations and structure of the family at any given time, either all its members, or perhaps only the young couples or adolescents, will move with the herd.

The lifestyle of Sahelian livestock herders is dictated by the needs of their animals, especially for grazing and water. Annual movements generally follow those of the rains but, since climate and vegetation are unpredictable, they vary from year to year. As pasture has been

degraded, particularly during periods of drought, the displacements have become greater. In turn this has increased conflict between pastoralists and farmers, as pastoralist herds invade farmers' crops during the growing season; and previously informal arrangements have given way to limitations imposed on routes and formal financial transactions for trade goods.

Pastoralism is limited by the presence of tsetse fly, which inhabit the more humid areas beyond the Sahel; in the wet season, their presence in areas just to the south of the survey zone can prohibit the presence of livestock. The wetter conditions further south are unsuitable for camels in the long term and, likewise, the general shortage of watering points to the north make the area ill-suited to the needs of cattle and sheep. Since transhumance distances have increased over the past two decades, these "species-specific" zones have created a problem for mixed herd owners, necessitating increased specialisation.

Although movements may vary from year to year, a general pattern persists. From February to April (late dry season) the Kreda are dispersed, in small tents, around the pastures and wells of the dunes outside of the Soro. During May, when the very first rains begin in the south of the survey area, those dwelling south of 14°N "*font l'Eka*"; the herders move their animals south to the clay plains, whilst other members of the family sow millet on the Soulia. This is a brief sejour. By July, the flooding and tsetse populations drive the pastoralists back north towards the Soro, wither all 13 tribes converge to pass the wet season from August to October. The following three months are the time of greatest plenty: living in large tents, forming encampments with 20 - 30 herds around wells, the Kreda profit from the pastures of the Soulia, and themselves enjoy weddings and other gatherings.

The Arab groups and the Peuls to the south of the area follow a similar route to the Kreda, though slightly later, during the wet season. The Al-Adjam Arabs to the south-east move up from Chari-Baguirmi and Salamat in time to cross the Batha river during June, and head north before the floods in July. They pass the next few months on the pastures of the sandy plains and pools in the *ouaddis* of this area, before returning south during December.

In contrast, the movements of the Daza are more influenced by the annual cultivation cycle: prior to and during the rains, the herders leave the fields and villages, dispersing to salt licks. After the rains, the whole family moves to pastures within 30 km of the village.

2.7 Previous Surveys

A number of estimates of Tchadien livestock populations have been made over the past two decades, although none of them coincide precisely with the present survey area. Table 2.1 shows the dates, areas and estimates of various species for which data are available. In addition, several relevant estimates for ecologically similar areas in other countries in the Sahel Belt are available. These regions include parts of Mali, Niger, Senegal, Sudan and Nigeria, and are detailed in Appendix 2.

Table 2.1: Previous Estimates of Livestock Numbers in Tchad.
(Numbers given in thousands)

Region	Area (km ²)	Year	Cattle	Small Ruminants	Source
Kanem	122,500	1966-70	1,100 (9.0)	800 (6.5)	Cabot and Bouquet (1973)
Batha	105,000	" "	900 (8.6)	800 (7.6)	
Kanem	122,500	1970-74	850 (6.9)	800 (6.5)	Anon (1973)
Batha	105,000	" "	900 (8.6)	900 (8.6)	
Kanem	122,500	1983	604 (4.9)	855 (7.0)	Tchad (Rep) (1083)
Batha	105,000	"	790 (7.5)	910 (8.7)	

Figures in brackets are densities (No/km²)

Other livestock surveys, both quantitative and qualitative, have been done (Louis Berger International, 1988; IEMVT, 1986). Studies carried out by IEMVT suggested that carrying capacities ("*potentialités pastorales*") decreased, in the middle third of the survey area, from up to 15 hectares per Tropical Livestock Unit (TLU, equivalent to 1 animal of 250 kg live weight) during the dry season in 1974, to less than 2 ha per TLU in the wet season during 1983. In the lower third of the survey area, they declined from 6 ha per TLU during the 1974 dry season to 2 ha per TLU during the wet season of 1983 (IEMVT, 1986). However, a projection made by *le Ministère du Plan et de la Reconstruction* (Tchad Rép., 1983) estimated that livestock populations would have increased by 2.5% (for cattle) and 3% (for sheep) between 1980 and 1986.

SECTION 3. METHODOLOGY

3.1 Background

In accordance with the objectives of the Programme, there are three possible means of conducting an assessment of livestock populations:

- a). direct enumeration of animals on the ground;
- b). indirect derivation from other sources such as vaccination figures, tax returns, slaughter figures and records of animal movement;
- c). integrated air-ground surveys.

Direct enumeration poses severe logistical problems, including the large numbers of trained enumerators and four-wheel drive vehicles needed to collect the data within the time allowed, (thus introducing problems of quality control); the lack of accurate maps; and the difficulties of over-land travel during the wet season. Furthermore, substantial numbers of cattle reside in remote or inaccessible areas and are therefore likely to escape the attention of ground based enumerators. Conversely, since by their very nature pastoral livestock populations are highly mobile, there is no obvious way of guarding against double counting.

Indirect derivations are inevitably selective; for example, only a proportion of the total number of animals can be vaccinated in a given period of time. In addition, records are often restricted to cattle, and perhaps sheep, thus precluding population figures for other types of livestock. Deriving population estimates from such information is thus fraught with uncertainty; not only is the actual sample proportion rarely known with any degree of confidence, but it is also likely to vary from locality to locality. Finally, existing records are rarely up-to-date, or complete.

3.2 Integrated Air-Ground Surveys

Due to deficiencies in available livestock statistics and in their methods of collection in many African countries, the use of low level aerial survey and selective ground validation has been advocated and continues to be promoted by various international agencies, including the World Bank.

The technique is now well established: such surveys have been used in Sudan, Botswana, Kenya, Somalia, Mali, Niger, Nigeria and Senegal. Its primary advantages are:

- rapid coverage of extensive land areas; uniform sample intensity, irrespective of accessibility on the ground;
- problems associated with the logistic support, supervision and coordination of ground based livestock surveys are greatly reduced;
- the unreliability inherent in information collected by large teams of inexperienced enumerators is eliminated;
- representative village sampling greatly reduces the difficulties of reaching remote communities;
- objective population estimates for most, if not all, livestock species can be obtained;
- a rapid turnaround of information is obtained, with preliminary results available within a few weeks of field work completion, and final results a few months thereafter;

- apart from livestock population figures, a wide range of related agricultural and environmental and human settlement information can be obtained at the same time;
- seasonal changes in livestock distribution and abundance can be assessed relatively easily;
- the precise methodology, particularly of SRF surveys, can be repeated at will, so that comparisons with later figures can easily and reliably be made;
- the data collected are compatible with a wide range of additional information, particularly cartographic, and can be analysed or evaluated in relation to such variables after the surveys have been completed.

Integrated air-ground surveys are based on a system of sampling; as such the figures produced are estimates rather than absolute counts. However, as the proportion of an area sampled is known, a fact which is not true of either direct enumeration or indirect derivation methods, an associated standard error can be calculated objectively.

3.3 Air Survey Methodology

The aerial surveys were carried out using the standard Low Level Systematic Reconnaissance Flights employed for the estimation of livestock, habitation and land use, as derived from wildlife surveys described by Norton Griffiths (1978) and then adapted and developed by RIM and ILCA (eg RIM, 1986).

Essentially a series of regularly spaced parallel flight lines were flown over the designated region, and at a constant height above the ground level (agl). Each flight line was divided into sectors of equal length, to form a sampling grid based on the UTM Projection. The sampling strategy employed was thus an unstratified and systematic one, which best suits areas where the foci of animal concentration are not previously known. It means that the study area was covered evenly and uniformly, so that the data collected were immediately mappable and thus easy to interpret. It also allowed for the incorporation into the dataset of additional information which could be derived from complementary ground surveys, published maps, or other sources, after the survey itself was finished.

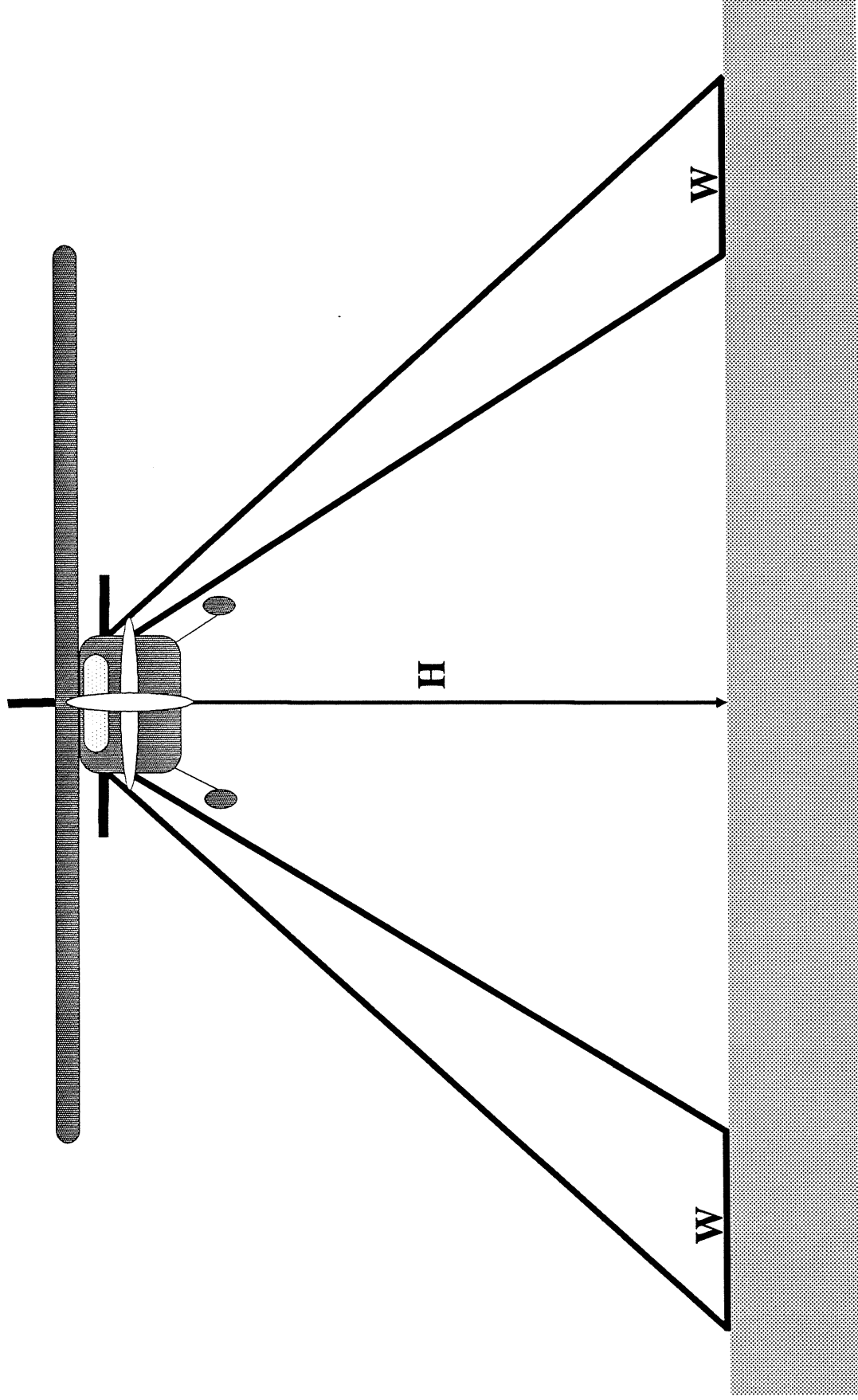
The size of sample cells was chosen with a view to the sample intensity required and the budget available. The survey area was flown with 10 x 10 km grid cells, at a nominal flying height of 800 ft agl, giving a sample intensity of approximately 10%. Survey work was carried out between 8am and midday, a time when pastoral animals are out grazing and therefore more clearly seen.

The aircraft, a Cessna 172, was crewed by a pilot and three observers. The front seat observer was responsible for flight planning and navigation and for recording flying altitude and selected environmental and vegetation parameters in each grid cell.

The two rear seat observers each examined a strip of ground on their own side of the aircraft, and recorded the type and size of each group of animals and dwellings that passed through it for each sample cell. The sample strips were delineated by an externally mounted viewing frame which was adjusted and fixed, prior to the survey, to give the desired strip width at the nominal flying height (Figure 1). The frames were fixed to give a combined strip width, at 800 ft, of 1012 m. This resulted in a nominal sample intensity of 10.1%.

As well as manually recording their observations, the back seat observers were each equipped with an automatic 35 mm camera, fitted with a 200 mm telephoto lens, and were required, whenever possible, to photograph all animal groups and settlements numbering more than ten which passed through the sample band. Comparison of subsequent accurate photocounts with the observers' visual estimates then allowed an individual counting bias to be determined for each animal and habitation category observed. These were then used to correct visual records for which clear photographs were not available.

FIGURE 1: AERIAL SURVEY SAMPLING



Only those herds and settlements which pass through the observation strips are counted and photographed. The strip width (**W**) is directly proportional to the flying height above ground (**H**) and is defined by externally mounted viewing frames which are typically set to delineate a band 500m wide at 800 ft above ground or 250m wide at 400ft above ground.

3.4 Ground Survey Methodology

A feature of aerial surveys is that, in the absence of integrated ground surveys, they are liable to miss those animals obscured by thick vegetation or by buildings, walls and similar artificial structures. In the Bahr el Ghazal region, the prevailing vegetation cover is light and so unlikely to hide significant numbers of livestock. However, the region contains a number of human habitations, and consequently is likely to contain significant numbers of these 'hidden animals'.

Aerial survey is also unable to distinguish reliably between sheep and goats. As separate population estimates of each small ruminant species are required, it was also necessary to establish the proportion of each species within the herds counted by the air team's observers.

Amongst the ground survey's major objectives were thus to assess the number of 'hidden animals' in relation to the number of habitations; and to establish the proportions of sheep and goats in small ruminant herds.

The ground survey comprised two teams, each responsible for the collection of livestock production and socio-economic data, hidden animal counts and the ratios of sheep to goats in pastoral herds. It is these last two which are the concern of the present report.

In the course of the survey, both teams travelled throughout the survey area collecting data, often in widely scattered villages and camps. From a given point in the survey area, a constant direction was maintained until a settlement was reached; in this way sites were selected at random. Absolute numbers of sheep and goats were recorded by conducting counts of observed herds en route. These data were used to calculate the sheep/goat ratios applied to the numbers of small ruminants observed from the air (see Section 4.3).

To assess any local variations in the numbers of hidden animals, it is necessary to visit sites spread throughout the survey zone. In practice, however, the distribution of settlements within the area is very uneven, being most dense in the south-west and south-east of the zone and more sparse in the north. Site visits were thus concentrated in the former two areas (see Text Map 3.1), and are listed in Appendix 3.

The enumerators recorded the number of different species of livestock associated with various habitation types. Three habitation types were distinguished, each corresponding to the categories counted from the air: tents, mud roofed dwellings and thatched dwellings.

The animals counted were those inside dwellings at the time of the visit, as opposed to those which were either in the open or had been taken out to graze, and would therefore be visible to the aerial survey team's observers. For this reason, visits were not conducted after 5 pm, the time when animals are brought into the village, thus eliminating the possibility of double counting.

3.5 Parameters Assessed

The quantitative parameters assessed by the air and ground teams are given in Table 3.1, below.

Table 3.1: Quantitative Parameters Assessed.

Aerial Survey

Number of:	Cattle Camels Uda Sheep Other Small Ruminants Horses Donkeys	Tents Mud Roofed Dwellings Thatched Dwellings
Percent Cover of:	Cultivation Trees Shrubs Depressions Trees within Depressions Grass within Depressions Shrubs within Depressions	Bare Ground Dead Trees Grass Dead Trees within Depressions Green Vegetation within Depressions Dum Palms within Depressions
Occurrence of:	Gully and Sheet Erosion Livestock Tracks	Rivers, Pools, Inundated Plains

Flying Height above Ground Level

Ground Survey

Proportion of Sheep and Goats in Small Ruminant Herds
Numbers of Hidden Animals in Tents, Mud Roofed and Thatched Dwellings:
Cattle
Camels
Sheep
Goats
Horses
Donkeys
Number of Rooftops in Settlements Visited *
Information concerning seasonal movements *

* results will be included in the analysis report, April 1992

3.6 Analysis And Mapping

3.6.1 Aerial Survey Data

Data collected by the rear and front seat observers were entered into a lap-top microcomputer during the course of the field work. The rear seat observer (RSO) records were entered into a custom-written menu-driven programme, written in DBase II and designed specifically to handle aerial counts of livestock and habitation (RIM 1986). The programme has a built-in validation system which checks for outlying values and codes. Front seat observer (FSO) records were entered into a simple word processing file using Word for Dos and were saved in an ASCII text format for subsequent loading into the analysis programme.

Once the photographs taken by the rear seat observers had been processed and examined, accurate photocounts were entered into the computer; both front and rear seat observer databases were checked exhaustively against the original data sheets, and any errors in data entry were corrected.

FSO data, consisting of a single row of parameters for each of the 598 grids, were loaded into the PC (personal computer) version of SPSS (Statistical Package for the Social Sciences). This analysis package is particularly adept at processing data from a number of different sources (in this case, air and ground counts), combining them into single amalgamated files and then performing sophisticated statistical analyses.

Various simple calculations were performed to ensure that the values in each row added up to the appropriate totals, and several new columns, containing data derived from addition and/or subtraction of the values in existing columns, were created. A column of data codes indicating the administrative district (*sous-préfecture*) in which each grid lies was also added.

RSO biases were calculated using the bias calculation programme included in the RIM data entry package. This compares every photocount with the accompanying original estimate of herd or settlement size and thus calculates individual biases for each livestock and habitation category, for each observer. The programme considers only those estimates of more than 10 animals or dwellings.

The RSO data were loaded into SPSSPC and estimates for which no photographs were taken were adjusted by multiplying them by the appropriate bias figure. Those estimates for which photographs were taken were replaced by the photocounts.

At this stage, livestock and habitation data were processed in separate files. It was decided that although the RSOs had scored small ruminants as being herded alone, with cattle, with camels, or with both cattle and camels, these categories were not meaningful and so, for the purposes of analysis, were combined. Hence the aerial livestock files contain data concerning: camels, cattle, small ruminants, Uda sheep, horses and donkeys. Additional data columns containing values for 'all small ruminants' (small ruminants plus Uda sheep) and for 'all equines' (horses plus donkeys) were created.

The aerial habitation files contain values for numbers of thatched roofs, mud roofs and tents. Additional columns containing data on 'permanent dwellings' (thatched plus mud roofed dwellings) and on 'all dwelling types' were created.

The livestock and habitation files were then sorted into numerical grid order (since as a result of the flying itinerary, data were not necessarily collected from grids in numerical order) and total numbers of animals, herds, rooftops and settlements in the sample strip of each grid were calculated. These values were then corrected for variations in flying altitude (and hence in strip width on the ground) which were recorded as part of the FSO records.

3.6.2 Ground Survey Data

Ground data, concerning both numbers of animals hidden in settlements and numbers of sheep and goats in mixed herds of small ruminants, were entered into word processing text files, checked thoroughly and any mistakes corrected.

The sheep and goat data were loaded into SPSSPC and the proportion of goats in each recorded herd was calculated. An analysis of variance (ANOVA, one of several appropriate methods) was performed, in order to isolate the parameters which varied significantly in concert with the proportion of goats recorded. Any significant variations found could then be used to define spatial strata which contained differing species ratios. The variables tested were drawn from: the % vegetation cover assessed from the air, each divided into 5 codes (0 = 0%; 1=0.1 - 25%; 2=25.1 - 50%; 3=50.1 - 75%; and 4=75.1 - 100%); water and erosion scores, and grid coordinates. Because the results are to be used for extrapolation to the whole survey area, variables were included in the ANOVAs only if the frequency distribution of the percentage intervals in the grids sampled for sheep and goat ratios matched that of the entire survey area. The results of this analysis are given in Section 4.4.

The hidden animal data were loaded into SPSSPC and columns containing numbers of 'permanent dwellings' (thatched plus mud roofed) and of 'total dwellings' were calculated. Numbers of animals (camels, cattle, sheep, goats, horses and donkeys) per rooftop (thatch, mud, tent, permanent and total) were calculated for each 'household'. These values were then summed to give the mean number of animals (of each type) per rooftop (of each type) per grid and per site (settlement). These figures are known as 'rooftop ratios' and are the means by which, in combination with aerial counts of rooftop numbers, hidden animal populations can be estimated.

3.6.3 Combination of the Air and Ground Data

Inevitably there were some grids in which rooftops were recorded by the aerial survey but which were not visited by the ground survey, and hence it was necessary to obtain rooftop ratios for these grids. Ground sites did not cover enough grids to allow extrapolation of rooftop ratios to neighbouring grids, and so, as for sheep and goat ratios (see above) an ANOVA was performed to ascertain whether the rooftop ratios varied according to any identifiable spatial stratum. The results are given in Section 4.3.

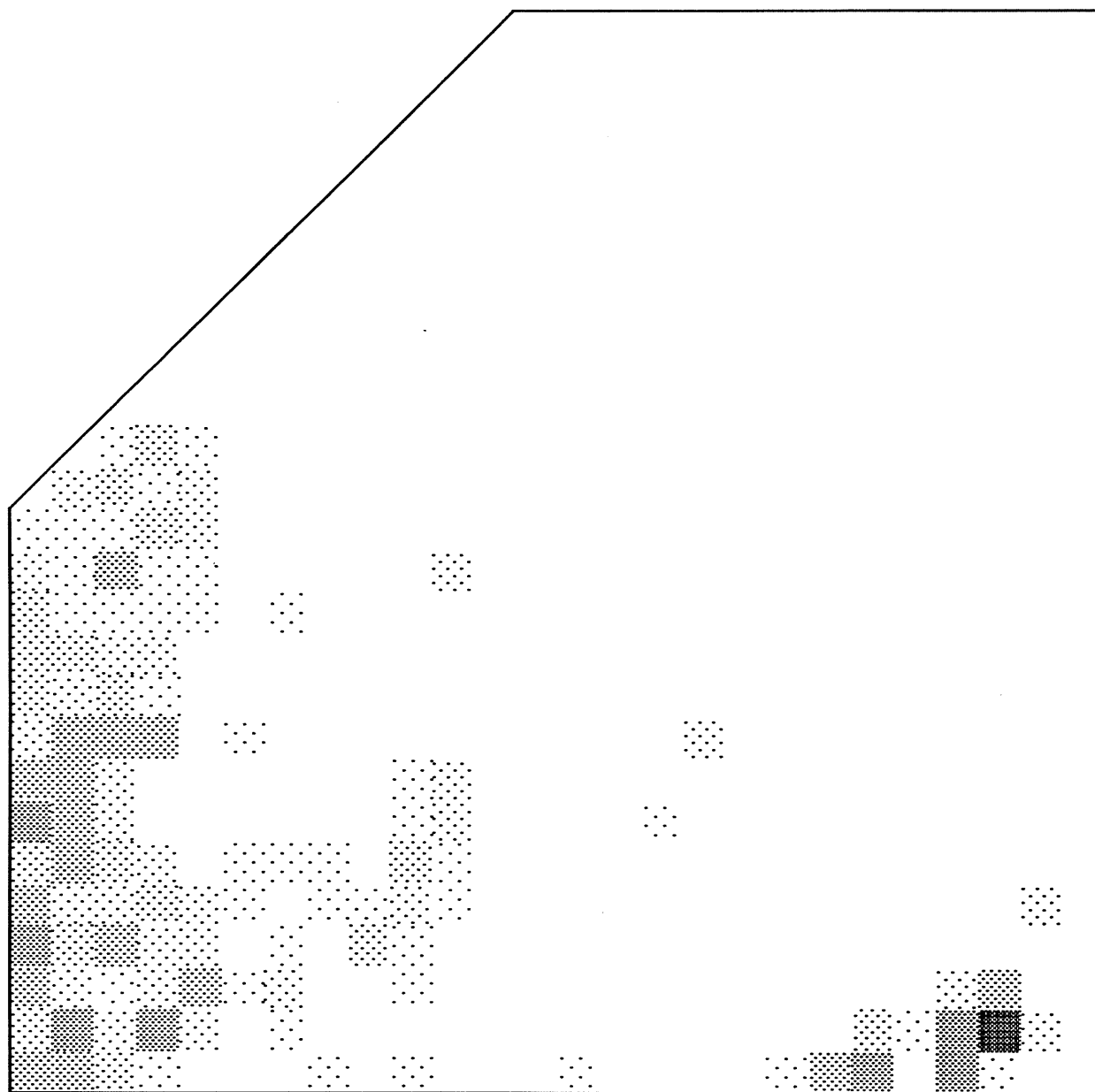
The remaining analysis, and subsequent mapping, were carried out using another custom written package, MAPICS, which is a simplified Geographical Information System (GIS) designed to perform basic manipulation and fairly sophisticated point and choropleth mapping of grid co-ordinated (raster) data. All data entered into this database were in the form of single values (e.g. total numbers, percentages or codes) per variable per grid.

Files containing the numbers of animals and herds in the sampled area of each grid were loaded into MAPICS and appropriate sheep and goat ratios were applied according to the variations identified within the significant stratum. Thus aerial counts of 'all small ruminants' were converted into values for 'goats' and for 'sheep', the latter of which were added to those for 'Uda sheep' to give values for the total number of sheep observed.

The SPSSPC file containing numbers of rooftops within the nominal sample strip in each grid was loaded into MAPICS, and rooftop ratios applied according to the distribution of various strata, as ascertained by the analysis of variance described above. The resulting values, the numbers of hidden animals in the sampled area of each grid, were then added to the numbers of animals observed from the air to give total livestock numbers in the nominal strip width of each grid.

From these data, population estimates and related standard errors (SEs) were calculated using either the Jolly Ratio Method, which uses the flight line as the sample unit, or the Marriott 4-cell Method, for which the grid cell is the sample unit. The relative advantages of each are discussed at length in Marriott and Wint (1985), and depend on the spatial integrity of the stratum selected, as well as on the distribution pattern of the population within it.

It should be emphasised that both methods are statistically conservative, and give rise to SEs which are well above the actual errors of the sampling strategies used, and which tend to increase in concert with the patchiness of the population. Moreover, although the calculated standard errors may differ depending upon the method adopted and upon the underlying statistical assumptions, the size of the estimated population is not affected.



CARTE	DENSITE D'HABITATION:
TEXTE	MAISONS PERMANENTES
3.1	
TEXT	HABITATION DENSITY:
MAP	PERMANENT DWELLINGS

No./km²

- 100 +
- 50-100
- 20-50
- 10-20
- 5-10
- 2.5-5
- 0.1-2.5

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BAHR EL GHAZAL (TCHAD), AOUT 1991

The formulae which give the population total and the variance for the Jolly SE are as follows:

Population Total: $Y = Z.R$

Population Variance:
$$\text{Var}(Y) = \frac{N(N-n)}{n} \cdot (s^2_y - 2.R.s_{yz} + R.s^2_z)$$

Where:

Y = total population estimate
 N = the potential number of sample units in the survey region
 n = the actual number of sample units surveyed
 Z = the area of the survey region
 z = the area of any one sample unit
 y = the number of animals counted in that unit
 R = the ratio of the animals counted to the size of the area searched

and:

s^2_y = the variance of animals counted between sample units
 s^2_z = the variance of sampled area between sample units
 s_{yz} = the covariance between counts and areas of each unit

The relevant formula for the calculation of the Marriott SE is:

$$\text{Var}(Y) = \frac{\sum (4y(i,j) - y(i-1,j) - y(i+1,j) - y(i,j-1) - y(i,j+1))^2}{20n^*}$$

Where:

i,j = co-ordinates of a grid point
 y = number of items recorded for a given grid cell
 n^* = number of grid points with four surrounding neighbours

The standard error is $\sqrt{(\text{Var}(Y)/N)}$, based on the difference between sample value (y) at point (i,j) and the average of its four neighbours, provided they all fall within the overall survey sample.

Finally, MAPICS was used to generate distribution maps and bar charts representing the distribution of various parameters.

SECTION 4. SURVEY RESULTS

4.1 Vegetation and Environmental Parameters

4.1.1 Vegetation and Land Use

A number of vegetation types were assessed from the air, each recorded in terms of the percentage of each grid they occupied. Whilst much of the survey area consists of sandy plateaux or dunes, one of its particular characteristics is the presence of depressions, where the water table is closer to the surface than elsewhere, and where surface water tends to persist well into the dry season. Though these amount to only about a tenth of the total area (11.55%), they are a widespread (Colour Map 3) and relatively reliable agro-ecological resource, and so are of special significance to the livestock and human populations.

In recognition of this, the various types of vegetation cover inside and outside these depressions were recorded separately, and subsequently added together to provide estimates of the total cover within the survey area attributable to each category. In addition to this information, the levels of the vegetation cover categories within the depressions was assessed, expressed as a percentage of the total vegetation cover (or 'green patch', see Colour Map 4) contained therein.

The levels of five basic types of vegetation cover were thus recorded, both inside and outside depressions, which are shown in Table 4.1, below. Tree and shrub cover refers to the proportion of the grid (or green patch in depressions) covered by tree and shrub canopy. Grass cover is the proportion of the grid (or green patch in depressions) with actual grass cover: - this is distinct from the ecological category 'grassland' which may include shrubs and trees. Cultivation is the proportion of the grid within the current cultivation cycle, and bare ground is the proportion of the grid devoid of vegetation observable from the air. These various categories are illustrated in Figure 2.

The survey team was also requested to assess the percentage of all trees, inside and outside depressions, that were either dead or were dum palms (see Table 4.1, below), a species of some considerable economic importance because the fruits are eaten, and the leaves serve as the raw material for ropes, matting, and a variety of other products. However, their value in pastoral terms is negligible.

Slightly over a quarter of the survey area (25.9%) supports no vegetation at all. Most of the bare areas are in the north and east, though there are some less extensive ones in the centre of the region (Text Map 4.1), which are mainly composed of the parts of the depressions devoid of green tree, shrub or grass cover (Text Map 4.2). In absolute terms, the majority of the bare land is found on the sandy plateaux or dunes, though, in relative terms, the low lying clay depressions contain the greater proportion (55%). This apparent imbalance may be a seasonal phenomenon: similar areas in Borno State, Nigeria, locally known as *firki*, and in Tchad as *naga*, often consist of bare soil during the wet season, when periodic flooding prevents the growth of either natural vegetation or crops. It is only after the onset of the dry period that plants can germinate successfully, and it is this delay in growth that makes the *naga* a valuable source of dry season grazing.

Whether inside or outside depressions, grass cover is the dominant vegetation type, accounting for approximately 60% of the total land area. Outside the most northerly 40 to 50 kilometres, only four survey grids contain less than 50%, and a substantial part of the north-western, eastern and southern sectors support in excess of 75% grass cover (Colour Map 5).

The woody vegetation of the survey zone is somewhat sparse, covering, as it does, little over 6% of the total area. Though trees were recorded in every grid cell, most were concentrated either to the north and west of Moussoro, or on the Eka clay plains to the south of the 'sand region' (Colour Map 6). In relative terms, trees (as opposed to shrubs) are three times as abundant inside the depressions as outside them (15.2% as opposed to 5.1% of the total area). Furthermore, the depressions contain a substantially lower proportion of dead trees than does the higher ground (2.2% and 7.0%, respectively).

FIGURE 2: VEGETATION PARAMETERS ASSESSED FROM THE AIR
PARAMETERS SHOWN IN TABLE 4.1 UNDERLINED

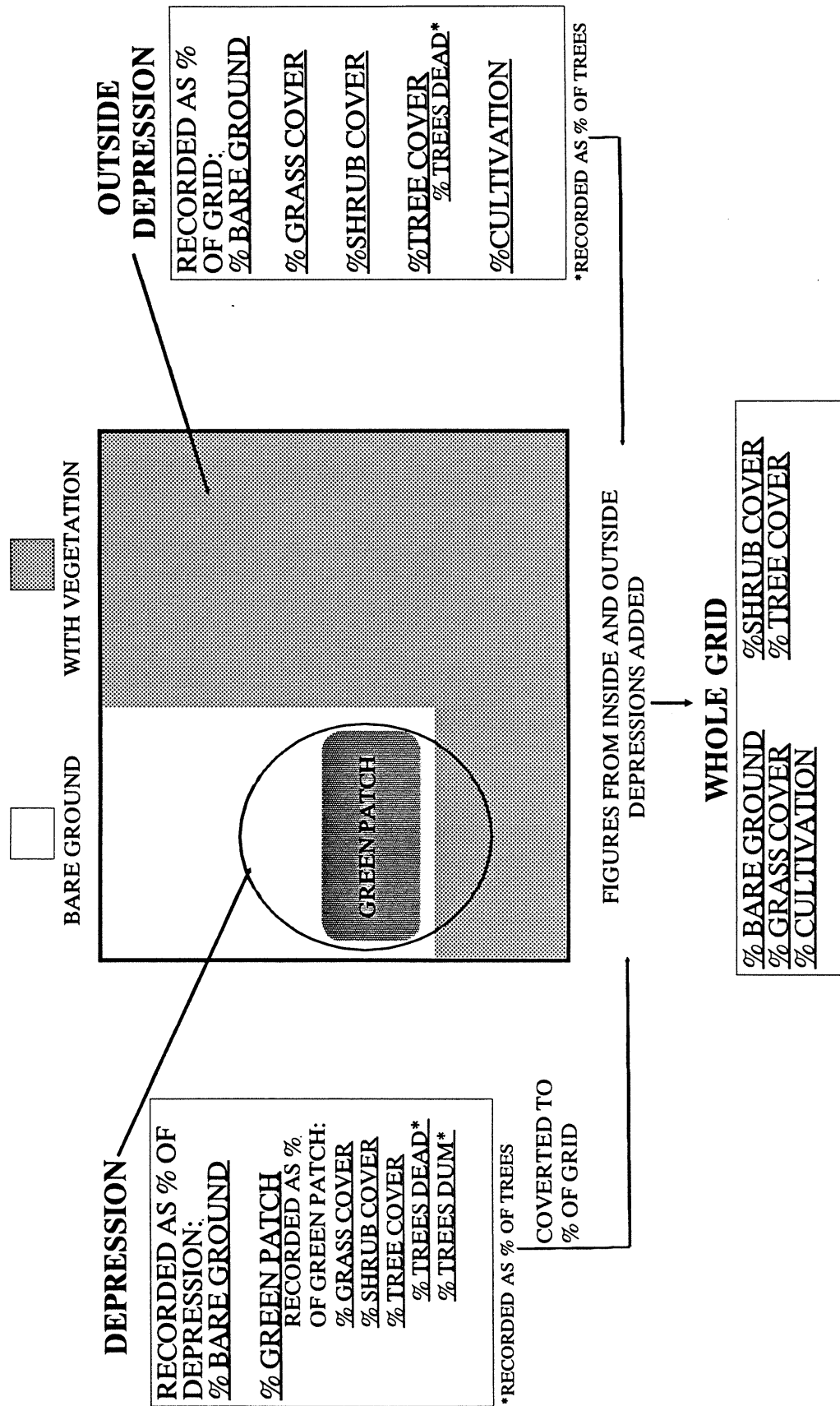


Table 4.1: Estimated Vegetation Cover.

Vegetation Category	Maximum % Recorded	Mean %	Area Covered (km ²)	%SE
a). All Vegetation Cover (% of Grid)				
Tree Cover	43.00	6.31	3773	2.1
Shrub Cover	60.35	8.00	4784	3.2
Grass Cover	97.00	58.66	35079	0.9
Bare Ground	99.00	25.90	15488	2.1
Cultivation	30.00	1.13	676	1.7
b). Vegetation outside Depressions (% of Grid)				
Tree Cover	43.00	4.55	2721	0.2
Shrub Cover	60.00	7.66	4581	3.3
Grass Cover	97.00	55.59	33243	1.0
Bare Ground	99.00	19.52	11673	2.1
Cultivation	30.00	1.13	676	3.8
Total	100.00	88.45	52894	0.3
% Trees which are Dead	95.00	7.02	191	5.8
c). Vegetation inside Depressions (% of Grid)				
Tree Cover	23.40	1.75	1045	4.2
Shrub Cover	9.80	0.35	209	8.2
Grass Cover	33.84	3.07	1836	4.1
Bare Ground	42.50	6.38	3816	3.6
Total (Green Patch)	60.00	11.55	6906	2.4
% Trees which are Dead	50.00	2.17	23	10.3
% Trees which are Dum Palms	92.00	7.40	77	5.8
d). Vegetation inside Depressions (as % of Green Patch)				
Tree Cover	90.00	35.80	1045	2.5
Shrub Cover	50.00	6.17	209	4.9
Grass Cover	98.00	58.03	1836	2.4

The comparative abundance of the tree cover in the lower lying basins (Text Map 4.3) is most probably due to the qualities of the clay soils, and to the superior and more predictable water supply from which these sites benefit. These factors are also almost certainly associated, to some extent, with the restriction of the dum palm to the depressions, where this species accounts for 10% of the observed tree cover. However, its exclusively southern distribution (Text Map 4.4) argues the influence of additional climatic or edaphic constraints.

The lower proportion of dead trees in the depressions (Text Maps 4.5 and 4.6) may also be caused by variations in water availability between the two land types, though it is possible that dead wood on the higher ground is more durable, or less frequently collected for firewood and construction. Either of these possibilities is consistent with the relatively high proportion of dead trees observed outside the depressions in the north and east of the survey area, though the occurrence of isolated records as high as 95% is likely to have a more localised cause.

Shrub cover is more abundant than that of trees and, though present in all but ten grids, it is still sporadic in the majority of the survey area (Colour Map 7). The highest levels of shrub cover are concentrated along the survey's western boundary, and in the region to the north of Moussoro, where they tend to be associated with ground outside depressions. Within the clay basins, shrubs are disproportionately rare, their cover representing only 0.35% of the total land area, and 6.2% of the total vegetation cover (Text Map 4.2).

With an estimated 67,600 hectares under crops, cultivation is both the least abundant and least widely distributed of all the vegetation categories assessed (Colour Map 8). Only 16 (2.7%) of the grids contained more than 10% farmed land, mostly in the extreme south-west of the region, close to Massakory, whilst in the entire sector to the north of parallel 14 and east of 16°E, no cultivation was recorded at all. Unless dum palms are considered to be a crop, all farmed land was observed outside depressions. However, cultivated areas within depressions may often be hidden.

4.1.2 Environmental Parameters

In addition to assessing vegetation cover of various types, the occurrence of three environmental parameters was recorded from the air: the presence of gully and sheet erosion; the presence of three sorts of surface water (pools, rivers and flood plains); and the presence of livestock tracks, scored on a scale of 0 (= none) to 3 (= many). The results are summarised in Table 4.2, below.

Table 4.2: Proportion of Grids with Erosion, Tracks, and Water.

	Number of Grids	% Survey Grids
Erosion:		
Sheet	42	7.0
Gully	112	18.7
Water:		
Pools	245	41.0
Rivers	9	1.5
Flood Plain	17	2.8
Tracks:		
Few	127	21.2
Some	150	25.1
Many	70	11.7

Erosion of one sort or another was recorded in over a quarter of the survey grids. Gully erosion, potentially the most damaging of the two, at least in undulating land, is the most widespread: not only is it nearly three times as common as is sheet erosion, but it was consistently recorded throughout an area measuring 80 by 130 km to the north and west of Moussoro (Text Map 4.8). Sheet erosion was rarely recorded in the region where gullies predominate, and was restricted to the region to the south-east of Moussoro. Its distribution is matched, to some extent, by that of bare ground outside depressions (Text Map 4.9).

Even though the survey was carried out at the height of the wet season, surface water was recorded in only slightly under half of the grids (45.3%), over 90% of the observations being of pools (Colour Map 9). This serves to emphasise the limitations that water availability is likely to impose on livestock distributions in the survey area, even during the wettest period of a wet year, as well as to highlight the key role played by wells and boreholes. The precise location of these is well documented elsewhere (e.g. IGN, 1969), but are generally more frequent where surface water is scarce.

Surface water is concentrated in the south and along the main drainage lines. The trough of the Bahr el Ghazal is locally dominated by surface water, particularly in the section immediately north of Moussoro, though its more northerly reaches, near Salal, are considerably drier.

Outside the Soro, surface water is very sparsely distributed north 14°N. A small concentration of pools, recorded on the eastern edge of the survey area, marks the western extremities of the Ouaddi Rimé, (stretching from the Ouaddai *préfecture* in the east of the country). Further south, at the northern limits of the Eka clay plains, a comparatively dry belt is evident in the Harr, south of Moussoro, which extends eastwards to the edge of the survey area.

The clay plains themselves are a comparatively wet region with not only many pools, but also an extensive area of flooded plains in the vicinity of lac Fitri. The western reaches of the Batha River also occur in this south-east corner.

Livestock tracks were recorded in over half the grids flown, and though their overall distribution coincides with that of livestock, no discernible pattern in their frequency is apparent (Appendix 7, Map A7.1).

4.2 Human Habitation Numbers

In total, the survey area contains 111,300 rural human habitations, which is equivalent to less than two per square kilometre (Table 4.3, below). This figure excludes the dwellings in the major settlements of Moussoro, Chèddra, Am Djéména, Salal, Méchiméré, Am Selep, and Mougaira. A preliminary estimate of the number of habitations in Moussoro, the largest town in the survey area, and in Chèddra, indicates a total of some 3,000 and 500 respectively. This suggests an overall total of approximately 117,000 habitations including the larger settlements.

Some forty percent of the rural dwellings are tents associated with transhumant or nomadic livestock owners. These structures were thinly, but widely dispersed throughout the survey area (Colour Map 10). Ten grids contained more than 10 tents per square kilometre, most notably in the Soro, to the north-west of Moussoro, where densities as high as 11.53 per km² were observed.

Of an estimated total of 80,000 permanent houses, three quarters were thatched, whilst the remaining 19,400 were roofed with mud. Though permanent rural habitations were more than twice as abundant as were tents, their distribution was much more restricted. The thatched dwellings were found only in the south west of the survey area, primarily along its western margins, or in the extreme south east, around the *ouaddis* near the Batha river (Colour Maps 11 and 12). The rural mud roofed dwellings are effectively limited to a fifty kilometre band along the western edge of the region, though some were observed near Ambassatna, and along the eastern border of the Soro.

Table 4.3: Human Habitation Numbers

Habitation Type	Number	Density (per km ²)	% SE
Tents	31,309	0.52	7.7
Permanent Dwellings	80,010	1.34	18.9
Thatched	60,372	1.01	19.6
Mud Roofed	19,368	0.33	17.9

The numbers of habitations in each survey grid are statistically correlated with several of the vegetation parameters assessed from the air. Regression analyses, discussed more fully in Appendix 6, confirm the expected links between permanent habitations and the presence of cultivation and water, as well as suggesting that these dwellings are not found in areas supporting extensive tree cover, or a high proportion of dum palms. High tent densities, in contrast, are primarily associated with trees and shrubs, particularly in depressions, but tend not to be concentrated on farmed land.

4.3 Hidden Animals

A total of 54 sites in 35 grids were visited on the ground to assess the numbers of livestock that could not be observed from the air. The site locations are shown on Text Map 4.10, which details the types of habitation scored in each.

The mean numbers of each livestock species counted per rooftop category (i.e. tent, mud or thatched) are given in Table 4.4, below. The figures range from a minimum of 0 to approximately 1 per 2.75 dwellings, but are mostly in the region of 1 animal per 20 to 100 rooftops. Many of the animals encountered, especially small ruminants, were young stock. This reflects the fact that the survey coincided with the birthing season (August/September), when the number of animals kept under shelter is at its highest.

Table 4.4: Numbers of Hidden Livestock per Rooftop. (Mean for the Whole Survey Area)

Animal Species	Habitation Category		
	Tents 43 Encampments	Mud 511 Households	Thatch 822 Households
Camels	0.000	0.002	0.001
Cattle	0.000	0.052	0.056
Sheep	0.363	0.022	0.018
Goats	0.152	0.057	0.034
Horses	0.000	0.024	0.019
Donkeys	0.000	0.066	0.054

Despite this, the recorded ratios are quite low compared to similar data from other Sub-Saharan regions, such as north east Sudan, and western Mali (see Table 4.5, below). This disparity is partly due to the fact that the present survey recorded only those animals that were actually under shelter, as the aerial team were able to count the animals inside settlements that were out in the open. In the other surveys, all animals in settlements were assined as hidden, and were ignored by the aerial surveys. However, as the habitation densities in the survey area are also relatively low, the overall contribution of hidden animals to the total livestock populations is substantially lower in the Bahr el Ghazal region than in many other pastoral areas.

Table 4.5: Numbers of Hidden Livestock per Rooftop in Selected Sub-Saharan Areas

Animal Species	Tents		Mud Roofed	
	Sudan ¹ No. Households: 33	Mali ² 197	Sudan ¹ 42	Mali ² 380
Camels	0.233	0.00	0.036	0.00
Cattle	0.000	0.08	0.000	0.03
Sheep	0.388	0.18	0.357	0.42
Goats	1.136	1.46	1.542	0.52
Donkeys	0.264	0.08	0.202	0.06

¹ Red Sea Province, Sudan (ERGO, 1990): ² Mali Delta (RIM, 1987)

Though mean figures are useful for comparative purposes, they are likely to conceal geographical variations. Such variations are evident from Appendix Maps A7.2 to A7.7 which show the distribution of measured livestock to rooftop ratios amalgamated for all habitation categories. These variations must be accounted for when applying the ratios to habitation numbers in order to calculate hidden animal populations.

These maps suggest some consistent geographical variations in animal numbers per rooftop: for example hidden cattle are restricted to the south of the survey area, and are most abundant in the south-eastern corner, around lac Fitri, where the relatively high humidity leads to the presence of numerous biting flies. As a result, more animals are kept under shelter in this part of the survey area than elsewhere, and fires are often built inside the huts to ward off the flies.

Table 4.6: Significance levels of ANOVA of Hidden Animal Numbers per Dwelling in relation to Vegetation Cover as assessed by Aerial Survey.

Vegetation Category	Camels	Cattle	Animals/Dwelling		Horses	Donkeys
			Sheep	Goats		
Animals/Tent						
<u>Outside Depression</u>						
Tree Cover	n/a	n/a	ns	ns	n/a	n/a
Cultivation	n/a	n/a	0.037	ns	n/a	n/a
Total	n/a	n/a	ns	ns	n/a	n/a
<u>Depression</u>						
Tree Cover	n/a	n/a	ns	ns	n/a	n/a
% Dead	n/a	n/a	ns	ns	n/a	n/a
Animals/Thatched Dwelling						
<u>Outside Depression</u>						
Shrub Cover	ns	ns	ns	ns	ns	ns
Grass Cover	ns	0.018	ns	ns	ns	ns
Cultivation	ns	0.040	ns	ns	ns	ns
<u>Depression</u>						
Tree Cover	ns	0.003	ns	ns	0.003	ns
% Dum	ns	0.027	ns	ns	ns	ns
% Dead	ns	0.046	ns	ns	ns	ns
Shrub Cover	ns	ns	ns	ns	0.000	ns
Grass Cover	ns	0.006	ns	ns	0.006	ns
Total	ns	0.041	ns	ns	0.005	ns
Animals/Mud Roofed Dwelling						
<u>Outside Depression</u>						
Shrub Cover	ns	ns	ns	ns	ns	ns
Grass Cover	ns	0.025	ns	ns	ns	ns
Cultivation	ns	ns	ns	ns	ns	ns
Total	ns	ns	ns	0.011	ns	ns
<u>Depression</u>						
% Dum	0.000	ns	ns	ns	ns	ns
% Dead	ns	ns	ns	ns	ns	ns
Shrub Cover	ns	0.000	ns	ns	0.002	ns
Grass Cover	ns	0.001	ns	ns	0.028	ns
Total	ns	0.000	ns	0.021	0.023	ns

Notes: Significance levels are given for all categories for which frequency distributions of grids per vegetation subcategory match the frequency distributions of sampled dwellings in each vegetation subcategory.

ns: Variation not significant. n/a: There is no variation between groups, or the sample distribution does not match that of vegetation category.

However, when considered by separate habitation category, it can be seen that some of this apparent pattern of variation results from the distribution of samples: for example, there are no goats shown in tents in the south-west (Text Map 4.11) because no tents were sampled there. There were, however, tents recorded from the air in that part of the survey area and, in order to extrapolate a rooftop ratio that can be applied to these dwellings, some statistically relevant variations in relation to some stratum must be identified.

In order to identify strata which are associated with variations in rooftop ratios, it is necessary to examine hidden animal numbers in relation to variables other than geographic location. The results of an ANOVA of rooftop ratios for each animal species for every habitation category in relation to the vegetation cover parameters assessed by aerial survey (see Section 3) are shown in Table 4.6. This reveals a number of statistically significant variations which could be used to generate hidden animal estimates. From these, the most significant have been selected and are indicated in the Table in **bold type**. Where no significant variations have been identified, the mean values, shown in Table 4.4 above, are applied to the habitation estimates.

The selected rooftop ratios are given in Table 4.7, below. It is indicated at the top of each column whether the survey mean ratios or values for different levels of the selected vegetation category are used.

Table 4.7: Hidden Animal Rooftop Ratios applied in the Calculation of Hidden Animal Populations.

Vegetation Cover %	Camels	Cattle	Animals/Dwelling Sheep	Goats	Horses	Donkeys
Animals/Tent						
	Mean	Mean	% Cult (of Grid)	Mean	Mean	Mean
0	0.0000	0.0000	0.5036	0.1520	0.0000	0.0000
0.1-25	0.0000	0.0000	0.0000	0.1520	0.0000	0.0000
25.1-50	0.0000	0.0000	0.0000	0.1520	0.0000	0.0000
50.1-75	0.0000	0.0000	0.0000	0.1520	0.0000	0.0000
75.1+	0.0000	0.0000	0.0000	0.1520	0.0000	0.0000
Animals/Thatched Dwelling						
	Mean	% Tree (of Depr)	Mean	Mean	% Shrub (of Depr)	Mean
0	0.0010	0.1894	0.1800	0.0340	0.0432	0.0540
0.1-25	0.0010	0.0033	0.1800	0.0340	0.0076	0.0540
25.1-50	0.0010	0.0000	0.1800	0.0340	0.1667	0.0540
50.1-75	0.0010	0.0000	0.1800	0.0340	0.0000	0.0540
75.1+	0.0010	0.0000	0.1800	0.0340	0.0000	0.0540
Animals/Mud Roofed Dwelling						
	% Dum (of Depr)	% Shrub (of Depr)	Mean	% 'Dune' (of Grid)	% Shrub (of Depr)	Mean
0	0.0000	0.1055	0.0220	0.0000	0.0509	0.0660
0.1-25	0.0000	0.1107	0.0220	0.0000	0.0121	0.0660
25.1-50	0.0047	0.0223	0.0220	0.0000	0.1111	0.0660
50.1-75	0.3333	0.0145	0.0220	0.1212	0.0000	0.0660
75.1+	0.0000	0.0000	0.0220	0.0157	0.0000	0.0660

Depr: Depression. Cult: Cultivation. Dune: Land outside Depression

Application of these values to the habitation numbers per grid assessed from the air results in the hidden animal population estimates given in Table 4.8, below. As might be expected from the relatively low rooftop ratios and habitation densities, these animals represent comparatively low population densities, but fairly substantial proportions of the total populations, especially of horses and donkeys. Equivalent figures for areas with similar rainfall are, however, somewhat higher (Table 4.8).

Appendix Maps A7.7 to A7.13 emphasise the scarcity of hidden animals. Camels, cattle, horses and donkeys under cover are restricted to the western and southern margins of the survey area. Hidden sheep and goats, in contrast, are spread throughout, in parallel with the distribution of tents. However, even these small ruminant species are rarely present in densities exceeding 5 per km².

Table 4.8: Calculated Hidden Animal Numbers for the Whole Survey Area, and for Selected Other Regions.

Animal Species	Number	Bahr el Ghazal		% Total Population	Nigeria ¹	Mali ²	Sudan ³
		Density per km ²	% SE		% Total Popn.	% Total Popn.	% Total Popn.
Camels	222	0.004	55.0	0.33	87.7	0.0	7.5
Cattle	5,079	0.08	35.5	0.83	11.1	3.5	13.4
Small Ruminants	30,561	0.51	10.0	4.47	n/a	n/a	n/a
Sheep	23,281	0.39	10.7	7.08	61.9	22.7	25.5
Goats	7,279	0.12	8.1	2.05	71.6	18.4	26.4
Equines	6,485	0.11	23.5	40.14	n/a	n/a	n/a
Horses	1,929	0.03	35.3	24.41	98.9	n/a	n/a
Donkeys	4,556	0.08	18.8	55.22	99.4	92.9	89.5

n/a: Not available

¹ Borno State, Nigeria, abutting west of Lake Chad (RIM, 1991).

² Mali Delta (RIM, 1987).

³ Red Sea Province, Sudan (ERGO, 1990).

It should be remembered, however, that animals kept under cover in a number of large settlements were not assessed, and so the figures given here are likely to be underestimates to some degree. Mean rooftop ratios for a number of specific settlements are given in Appendix 4, so that the numbers of hidden animals each contains may be calculated should information on the number of dwellings in each settlement become available in due course.

4.4 Sheep and Goat Ratios in Pastoral Herds

The ground teams assessed the numbers of sheep and goats in 127 small ruminant herds, sampled in 69 grids. The mean proportion of goats in these herds was 0.5781, and there is no evidence of any direct geographical stratification, as is evident from Text Map 4.12.

Herds consisting of Uda or Arab animals were distinguished, though a sample of only nine herds of Uda was recorded. The two herd types were significantly different in their species composition ($F=28.036$; $df\ 1,125$; $p < 0.000$), with Uda containing a mean of 4.09% goats, and Arab herds a mean of 61.91%. This suggests that the Uda herds closely corresponded to the category 'Uda Sheep' counted from the air. As a result, the figure for Arab herds alone was assumed to equate with the air category 'Small Ruminants'.

When tested against the various categories of vegetation cover assessed from the air, the proportion of goats in Arab herds varies significantly with three variables: % of Shrub Cover on 'Dunes'; the % of 'Dunes'; and most significantly with the % Cultivation. Where there is no cultivation the proportion is 0.5606, and where there is 0.1 - 25% cultivation it is 0.7522 ($p = 0.0029$). The appropriate values were therefore applied to the aerial counts of small ruminants in those grids where the recorded cultivation was less than or equal to 25%. As only a single grid was estimated to contain more than 25% cultivation, this was included within the 0.1 - 25% category.

4.5 Livestock Populations

Total estimated livestock populations for the survey area are given in Table 4.9, below, and their distributions shown on Colour Maps 13 to 17, and Text Maps 4.13 to 4.15. The sizes of livestock herds seen from the air are shown in Table 4.10, below, and, in histogram form, in Figures 3 to 9. The distributions are shown in Appendix Maps A7.14 to A7.17.

Table 4.9: Estimated Livestock Populations.

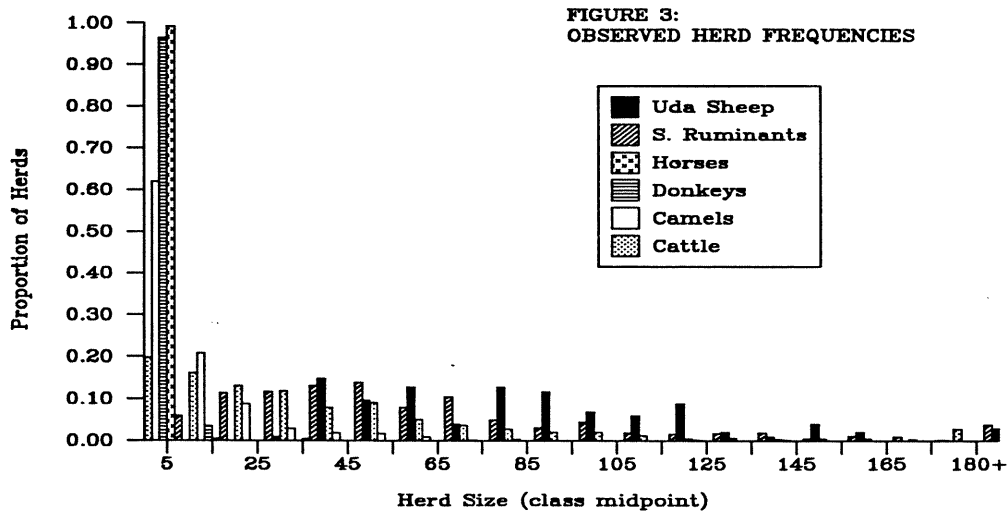
Animal Species	Number	Density (per km ²)	Stocking Rate (ha/hd)	% SE
Camels	67,525	1.13	88.56	9.9
Cattle	605,494	10.13	9.88	7.9
All Small Ruminants	683,026	11.42	8.76	7.6
Sheep	328,675	5.50	18.19	10.8
Goats	354,351	5.93	16.88	6.6
All Equines	16,155	0.27	370.16	11.0
Horses	7,904	0.13	756.58	13.7
Donkeys	8,251	0.14	724.76	11.6
TLU*	566,775	9.49	10.54 ⁺	6.3

*TLU: (Tropical Livestock Unit); Calculated as (Camels x 1) + (Cattle x 0.7) + (Small Ruminants x 0.1) + (Equines x 0.5); ⁺ Units are hectares/TLU

Table 4.10: Observed Livestock Herd Sizes.(see also Figures 3 to 9)

Herd Size Class	% Herds in Class						Arab Herds**	Uda Herds**
	Cattle ⁺	Camels ⁺	Donkeys ⁺	Horses ⁺	Small Rum'ts ⁺ *	Uda Sheep ⁺		
1-10	19.7	61.9	96.4	99.2	5.9	0.0	1.7	0.0
10-20	16.1	20.8	3.6	0.4	11.3	0.0	6.8	0.0
20-30	13.1	8.8	0.0	0.0	11.8	1.0	9.3	0.0
30-40	11.8	2.9	0.0	0.4	13.0	14.7	9.3	0.0
40-50	7.9	1.9	0.0	0.0	13.8	9.8	7.6	11.1
50-60	9.1	1.7	0.0	0.0	7.9	12.7	8.5	11.1
60-70	5.0	1.0	0.0	0.0	10.4	3.9	11.0	22.3
70-80	3.6	0.2	0.0	0.0	4.8	12.7	3.4	11.1
80-90	2.7	0.4	0.0	0.0	3.1	11.8	7.6	11.1
90-100	1.9	0.0	0.0	0.0	4.4	6.9	5.1	0.0
100-110	2.0	0.0	0.0	0.0	1.9	5.9	2.5	11.1
110-120	1.3	0.0	0.0	0.0	1.6	8.8	7.6	0.0
120-130	0.5	0.2	0.0	0.0	1.7	2.0	0.8	0.0
130-140	0.7	0.0	0.0	0.0	1.8	1.0	3.4	0.0
140-150	0.3	0.2	0.0	0.0	0.4	3.9	1.7	0.0
150-160	0.5	0.0	0.0	0.0	1.1	2.0	0.0	11.1
160-170	0.5	0.0	0.0	0.0	1.0	0.0	0.3	0.0
170-180	0.3	0.0	0.0	0.0	0.1	0.0	2.5	11.1
180+	3.0	0.0	0.0	0.0	4.0	2.9	10.1	0.0
Mean	45.77	12.16	3.02	2.30	59.23	82.22	84.23	90.00
N	1183	524	111	238	891	102	118	9

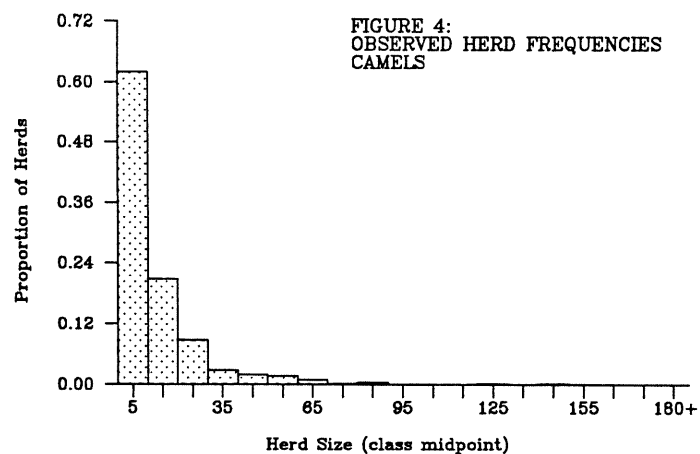
⁺ Observed by Air Team: * Includes all Small Ruminants except Uda Sheep: ** Small Ruminant Herds observed by Ground Teams



Camels are effectively restricted to the north and west of the survey area, and are thinly spread throughout that region (Colour Map 13). A limited population focus was found just inside the survey zone to the east of Mao, though the only area in which they are present in significant numbers is near Salal, where they are found to the east of the Bahr El Ghazal. It is there that camel densities are highest, reaching between 20 and 50 per km². This concentration is likely to represent the southern extremity of the migrant camel population centered to the north of the survey area, whilst the remainder of the population is most probably resident.

The average density is, at first glance, quite low, especially in relation to cattle and small ruminants. However, when compared to other Sahel regions, it is, in fact, fairly high: at 1.13 per km², it is roughly twice the mean density for Africa as a whole (FAO, 1978), and is comparable to the populations surveyed in Niger in 1981, 1982, and 1983, and the estimated pre-drought (1978) levels in Arid Sudan (Appendix 2).

The average herd size of 12.2 animals is on a par, or somewhat higher than those observed in other areas during or close to the rainy season. Most camel groups observed comprised 20 or fewer animals with less than one in five herds (17.3%) containing more than 20. No obvious pattern in the distribution of herd sizes is evident (Appendix Map A7.14).



Cattle are the most abundant livestock species in the survey area with a total estimated population of some 605,000 - i.e. almost an order of magnitude greater than that of camels. In concert with their predilection for better watered environments, they are absent from the northern sectors of the survey area, where surface water is scarce (Colour Map 9) and are concentrated in the south-western quadrant, and near the *ouaddis* to the north of lac Fitri.

Some 5% of the grids support more than 50 cattle per km², and several (9) support densities in excess of 100 per km² (Colour Map 14). Most of these are located either along the edge of the clay plains, where it may be assumed that surface water is most readily accessible, or near the southern edge of the Soro to the north and east of Moussoro.

The mean cattle density of 10.13 per km² is substantially higher (between 50 and 100%, see Section 2.7) than those estimated for Kanem and Batha *préfectures* in 1970-74 and 1983, and approximately 15% greater than the densities estimated by Cabot and Bouquet in the late sixties (Section 2.7). It is, however, similar to that recorded in the Mali Delta (11.4/km²) during the late wet season of 1987, but twice that found during the wet season in the Gourma at the time of the droughts in 1984, and more than 20 times the equivalent figure estimated for rangelands in Niger the following year and for north-eastern Sudan in 1989 (Appendix 2).

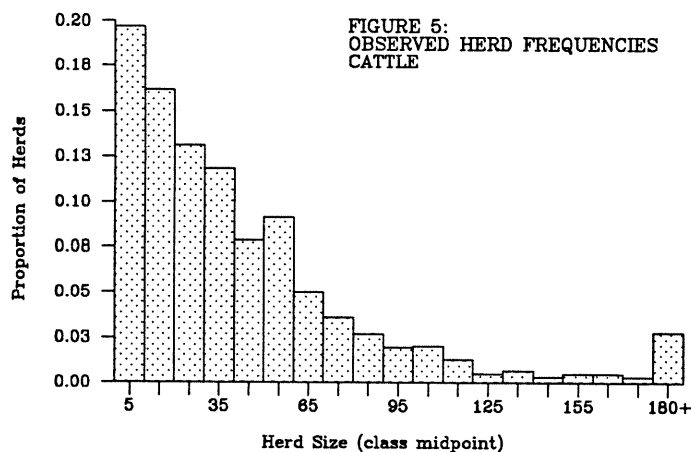
The present cattle population is thus relatively high, given that 1991, like 1984, also followed a year of very poor rains (Section 2.2), and infer that stock losses in 1990 were low. This is in accordance with the situation recorded in 1990, to the west of Lake Chad, in Borno State, Nigeria, where the rainfall deficit led to temporary changes in transhumance patterns rather than to drought induced mortality (RIM, 1991).

A number of herds containing M'Bororo cattle were identified from the air (Table 4.11, below), most of which were recorded on the southern edge of the survey zone. However, it was agreed that it was not possible to make a wholly reliable distinction between these and Arab cattle, particularly when herds contained young animals which had not yet developed the distinctive lyre-shaped horns. Hence, the figures given below should be used solely to give an indication of the presence of M'Bororo cattle, and not to identify their absolute numbers.

Table 4.11: M'Bororo Cattle Herds Observed from the Air

Grid EWNS	No. of M'Bororo Herds	M'Bororo Herd Sizes	No of Arab Herds
1502	2	75, 80	20
1402	3	300, 150, 170	3
1302	1	120	1
1203	1	90	9

For the purposes of analysis, therefore, cattle of both types were treated as a single category. Approximately 1200 herds were observed from the air, containing an average of 45.77 animals. This mean conceals a range of 1 to 1075, with nearly a third (31.4%) of the observed groups consisting of more than 50 animals, a pattern common to cattle herds in many regions. Most of the larger herds were seen in the south and east of the survey area (Appendix Map A7.15).



The mean herd size is somewhat smaller than the optimum of around 60 head suggested by Chapelle (Section 2.6), but is similar to herd sizes recorded during the wet season from the Gourma in Mali (46) and the rangelands of Niger (40-42) in the years following the 1983/84 droughts (Appendix 2). Earlier estimates of herd size from these two countries ranged between 60 and 70 head - i.e. comparable to Chapelle's optimum. This might be taken to suggest that the Tchadien cattle herds represent stock which are recovering from earlier heavy losses, though the relatively high densities estimated for the survey area (see above) do not support this assertion, which, in turn implies that cattle herds observed in the present study are somewhat smaller than those commonly found in the Sahel.

It should be emphasized, however, that observed herds may not equate to the stock owned by a single household, which may apportion its animals amongst several herds. Though such herd splitting is generally more characteristic of the dry season than of the rains, the present data could be taken to infer that some sub-division of a single owner's cattle into several grazing herds is maintained throughout the year.

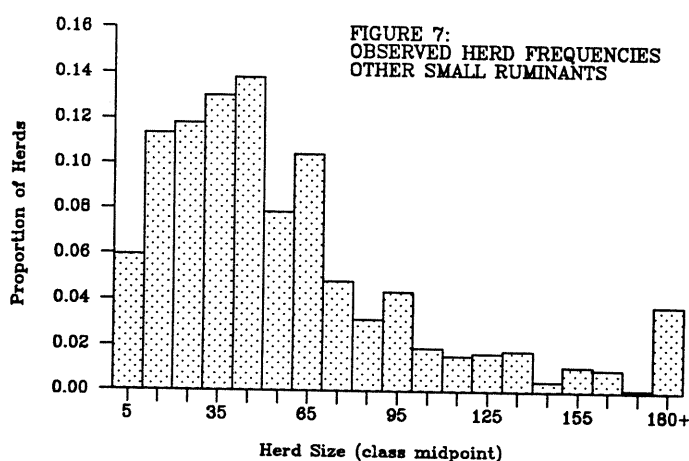
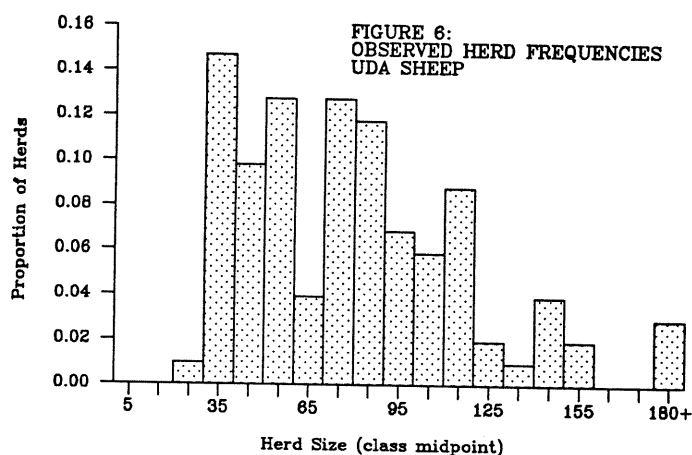
The region's small ruminant population is more or less equally divided between sheep and goats. Of a total of 683,000, 51.9% are goats, and 48.1% sheep, of which 31.8% (104,600) were recorded as Uda. The distributions of both species are fairly similar, in that each are concentrated in the southern two thirds of the survey area, and are found in low densities to the north of Salal (Colour Maps 15 and 16). However, some differences are evident: goats extend further west and south than do sheep, and a number of isolated pockets of high sheep densities were recorded along the eastern edge of the survey area. These concentrations were largely composed of Uda sheep (see Text Map 4.16).

The combined density of 11.42 small ruminants per km² is considerably higher than those of earlier estimates for Kanem and Batha *préfectures* (Section 2.7) which range from 6.5 to 8.7 per km², depending on the year. It is, in contrast, rather lower than the figures recorded in Mali, Niger or nearby parts of Nigeria, where wet season small ruminant densities ranged from 14 to a high of 28.3 per km² (Appendix 2).

As only two categories of small ruminant were distinguished from the air - Uda sheep and others - information on the herd sizes of each discrete species is not available. From the data that is available, it can be seen that Uda sheep were recorded in larger groups than were the other small ruminants (means = 82 and 59 respectively), a contrast likely to be associated with the more purely nomadic pastoralism of the Peuls which herd the Uda.

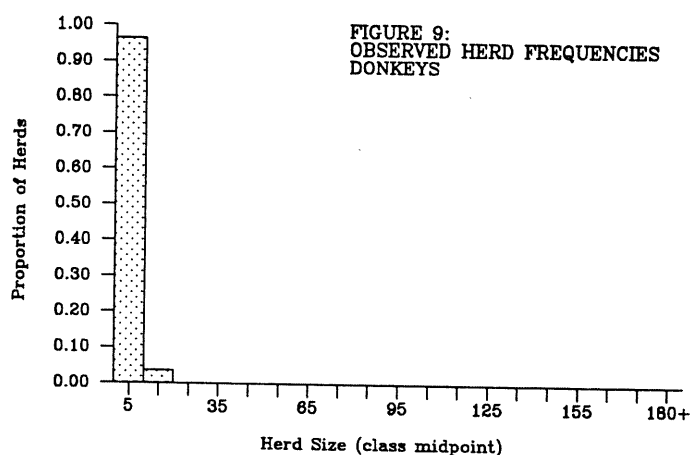
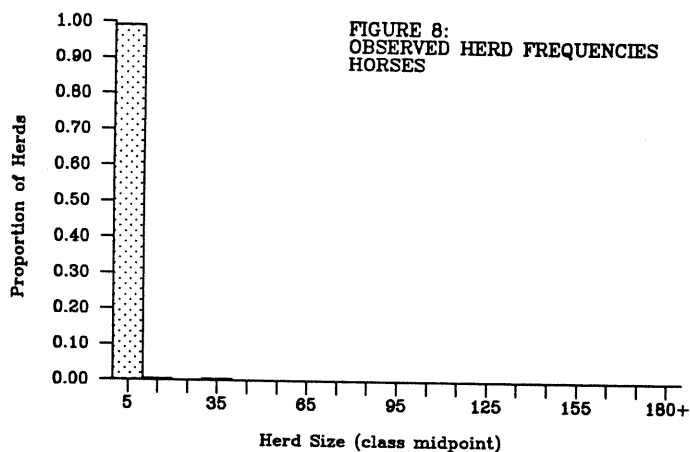
As might be expected from the comparatively high mean herd sizes, the frequency distributions for small ruminant herd sizes present a more bell-shaped curve than do those for cattle and camels: a smaller proportion of small ruminant groups contain less than 20 stock, especially of the Uda sheep, of which no herds smaller than 20 were observed from the air (Appendix Map A7.16).

Given that sheep and goat herds were assessed by both air and ground survey teams, a comparison of the two sets of results is possible. The means for Uda sheep are quite closely comparable, given the disparity in sample size, but the herds of other small ruminants observed on the ground were, on average, substantially larger than those recorded from the air. Part of this disparity is likely to arise from the fact that many of the sheep and goats seen from the air were associated with groups of cattle and tended to consist of relatively few animals. In addition, as shown by Appendix Map A7.17, many of the



smaller herds (less than 50 animals) seen by the air teams were found in the more remote areas not visited on the ground (see Text Map 4.10).

Nearly all equines observed from the air were recorded in groups of 10 or less. This is to be expected, as these animals are not managed in herds like the other livestock species. With a combined population of 16,155, horses and donkeys are the least abundant livestock species assessed, and are present in nearly equal numbers. Both are widely, though thinly dispersed throughout the survey area, and tend to be more consistently present in the western and central sectors (Colour Map 17 and Text Maps 4.14 and 4.15). Perhaps surprisingly, given their greater susceptibility to adverse environmental conditions, horses are more extensively distributed than are donkeys.



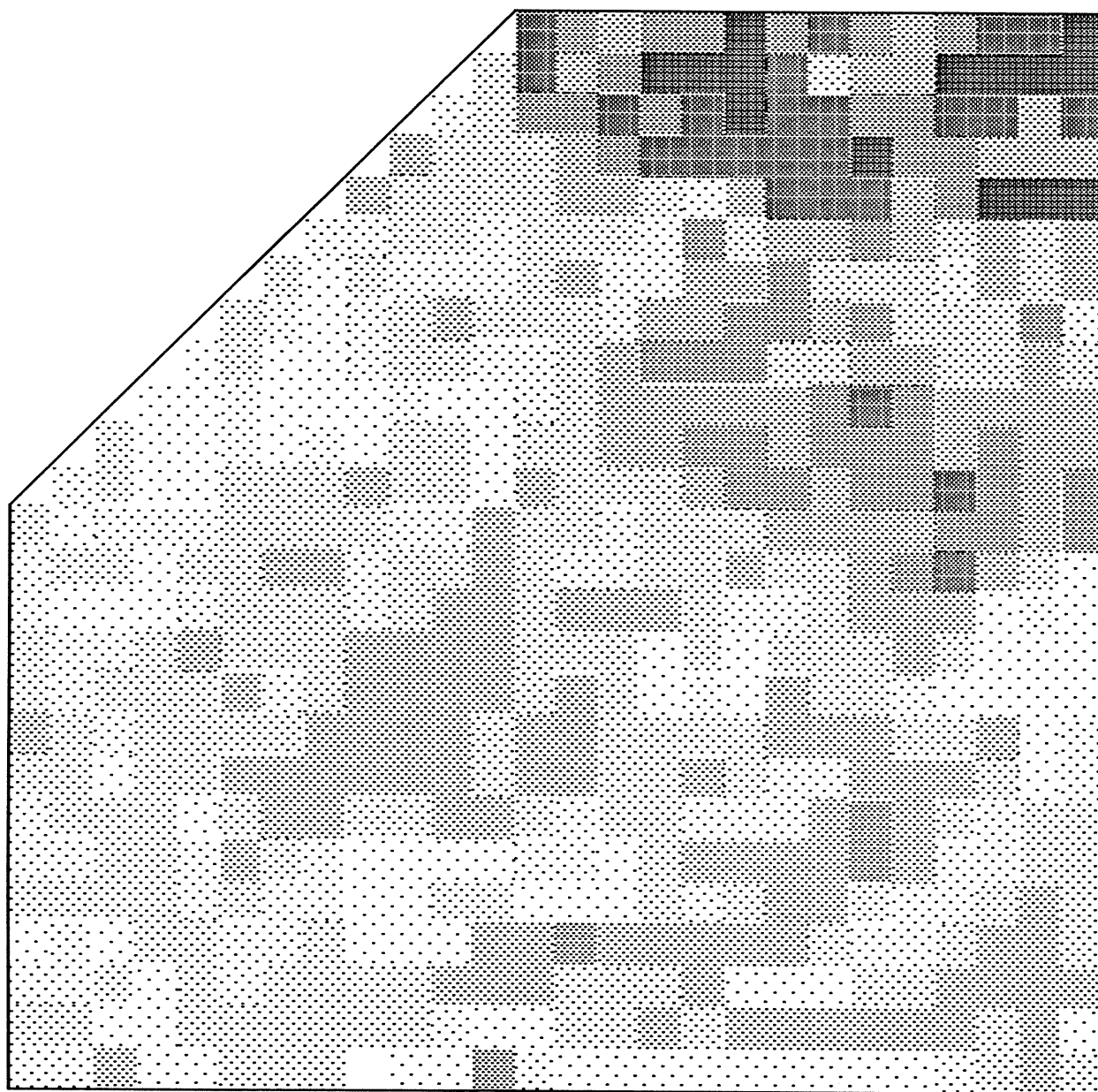
The estimated density of donkeys, at 0.13 per km², falls in the middle of the spread that has been recorded in other regions for which comparable data are available: these figures range from 0.05/km² in the Gourma region of Mali, through 0.3/km² in central Niger, to 1.6/km² in Borno State, Nigeria (Appendix 2). This variation is largely a reflection of the habitation densities in each area.

Perhaps of more importance in environmental terms than the population levels or distributions of each individual livestock species, is the abundance of livestock as a whole. There are many measures which may be used to represent this information, some based on live weights and others on dressed weights. In the absence of precise information on average weights of animals in a study area, a commonly used unit is the Tropical Livestock Unit, which is based on a biomass of 250 kg live weight, such that a camel is 1 TLU, a cow 0.7, a small ruminant 0.1, and an equine 0.5 TLU.

In these terms, the survey area supports a wet season livestock population of 566,775 TLUs, at a mean density of 9.49/km². The Arid Zone, as defined by CIPEA, with less than 600mm annual rainfall, commonly holds livestock populations of 4-6 TLU/km², which suggests that the current population in the survey area is comparatively high.

The estimated mean TLU density is equivalent to a stocking rate of 10.54 hectares per livestock unit. This is about three quarters of the potential sustainable carrying capacity suggested for arid areas by Putt et al (1980), and only a fifth of that estimated by IEMVT as applicable to the southern two thirds of the survey area during the wet season of 1983 (Section 2.7). These figures imply considerable room for expansion of the current livestock populations.

However, it should be remembered that many carrying capacity estimates assume that all the land is suitable for livestock, an hypothesis which may not be tenable in the present case, as much of the area has very little vegetation cover (Section 4.1), and so is incapable of supporting



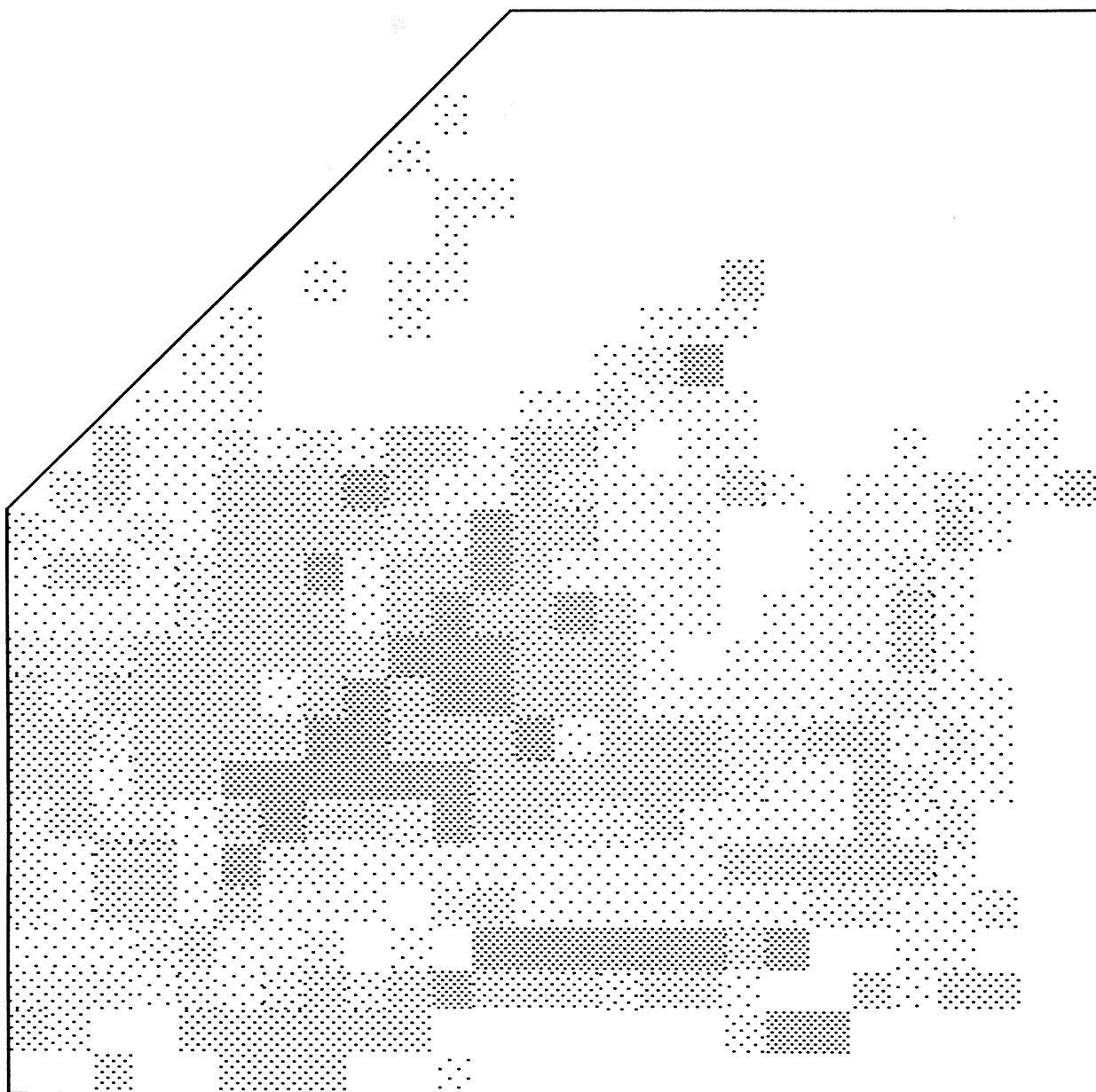
CARTE
TEXTE
4.1
TEXT
MAP

COUVERT VEGETAL:
SOL DENUDE
EN POURCENTAGE DU QUADRILLAGE

VEGETATION COVER:
BARE GROUND
AS PERCENTAGE OF GRID

%
■ 90+
■ 75-90
■ 50-75
■ 25-50
■ 10-25
■ 5-10
■ 0.1-5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

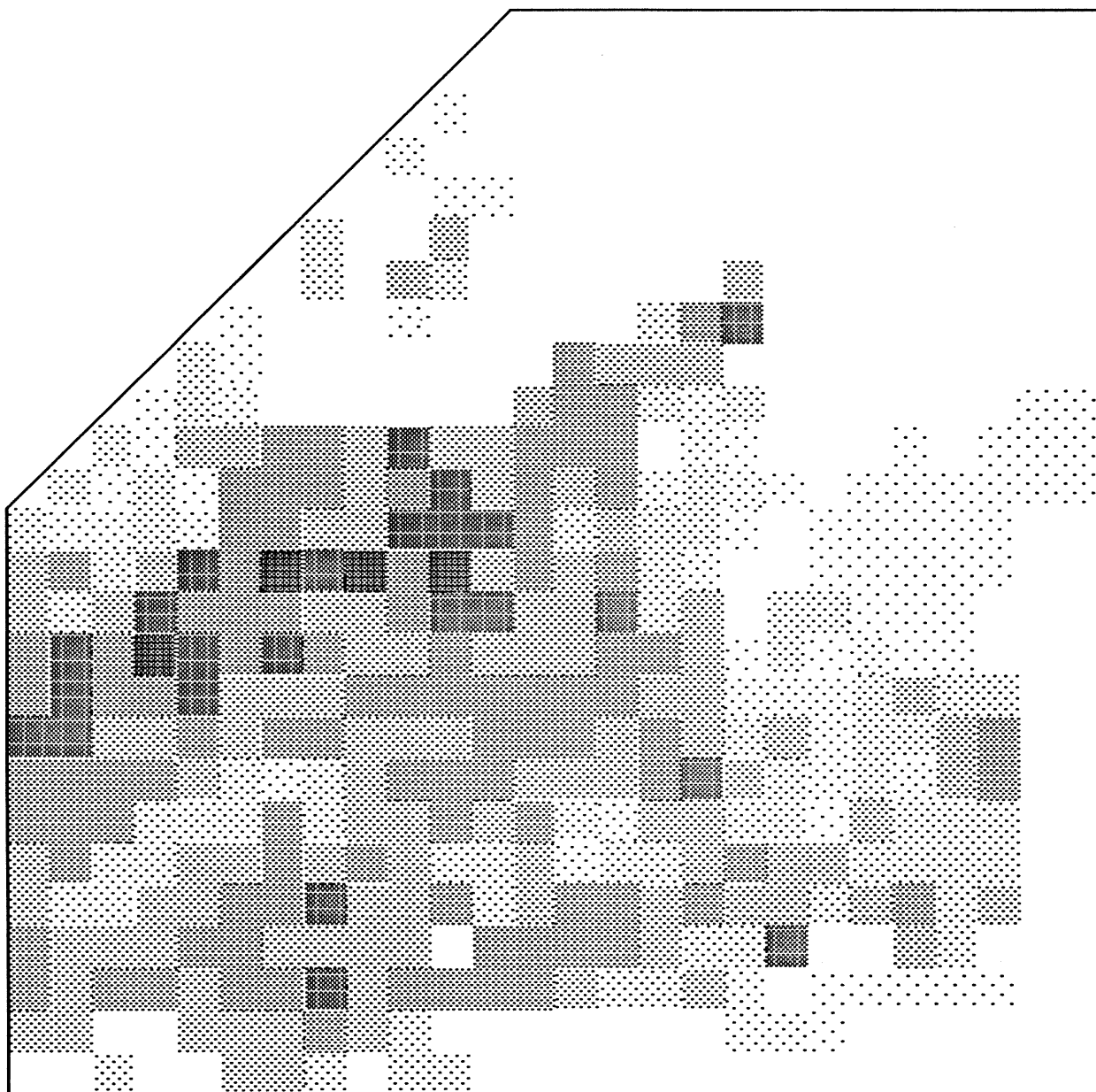


CARTE	COUVERT VEGETAL:
TEXTE	DEPRESSION DENUDE
4.2	EN POURCENTAGE DU QUADRILLAGE
TEXT	VEGETATION COVER:
MAP	BARE DEPRESSION
	AS PERCENTAGE OF GRID

%

■	90+
▣	75-90
▤	50-75
▥	25-50
▦	10-25
▧	5-10
▨	0.1-5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



CARTE	COUVERT VEGETAL:
TEXTE	POURCENTAGE D'ARBRES
4.3	DANS LA DEPRERSSION VERTE
TEXT	VEGETATION COVER:
MAP	PERCENT TREES
	WITHIN GREEN DEPRESSION

%
■ 90+
■ 75-90
■ 50-75
■ 25-50
■ 10-25
■ 5-10
■ 0.1-5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



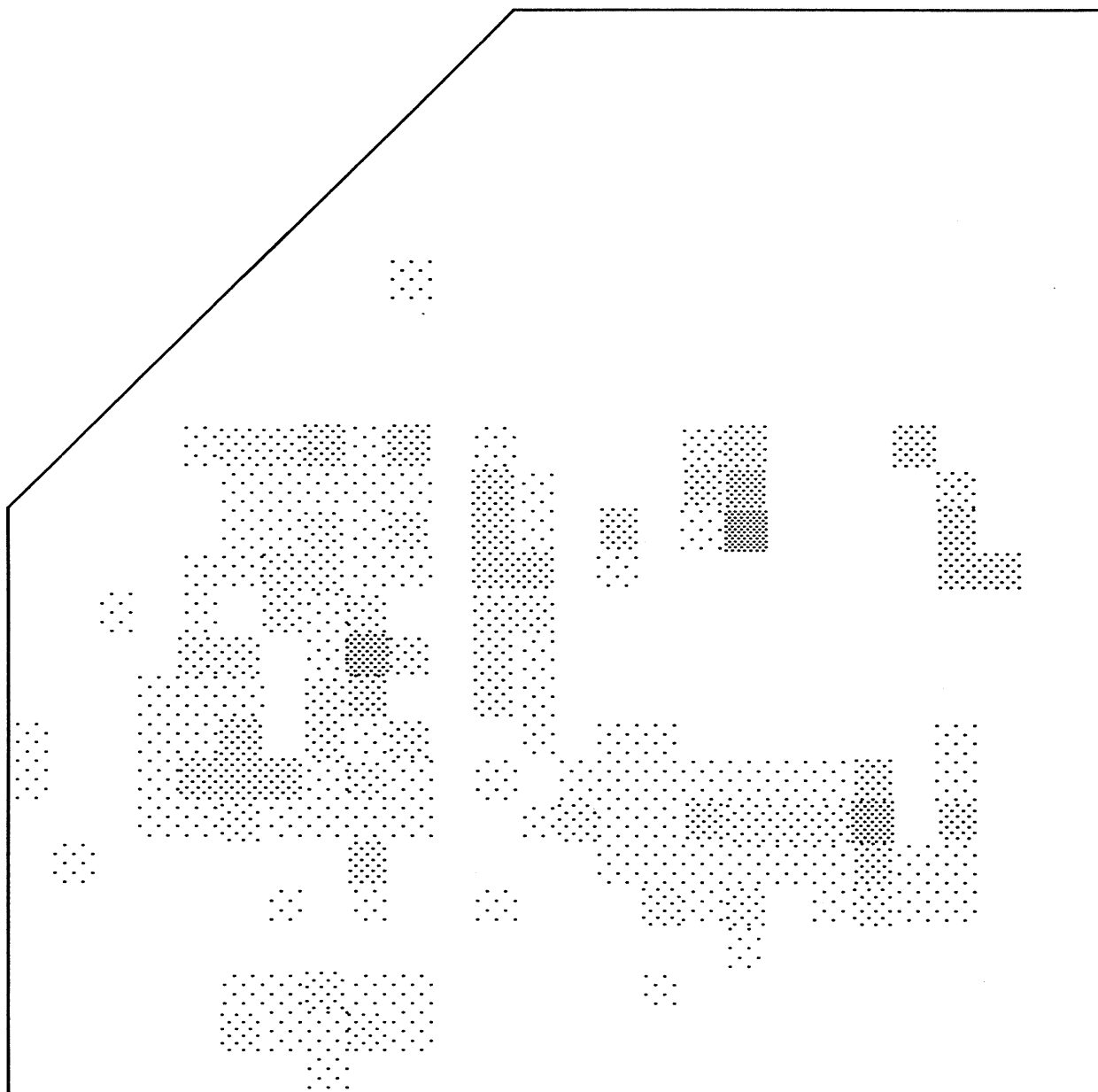
CARTE
TEXTE
4.4
TEXT
MAP

COUVERT VEGETAL:
POURCENTAGE DE PAILMIERS DOUM PARMI
LES ARBRES DANS LA DEPRESSION VERTE

VEGETATION COVER:
PERCENT TREES WHICH ARE DUM PALMS
WITHIN GREEN DEPRESSION

%
■ 90+
● 75-90
▤ 50-75
▥ 25-50
▦ 10-25
▧ 5-10
□ 0.1-5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



**CARTE
TEXTE**

4.5

**TEXT
MAP**

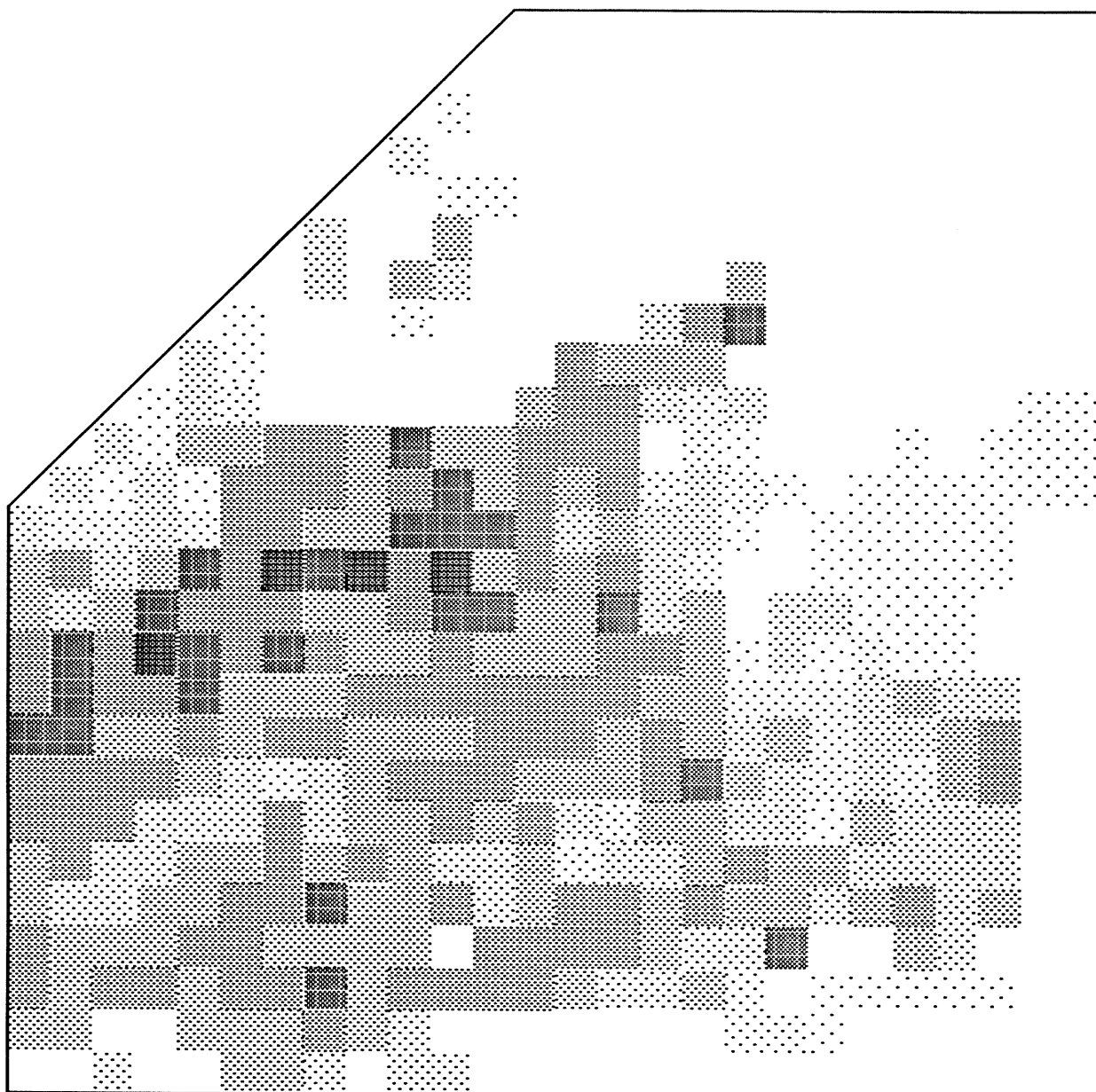
**COUVERT VEGETAL:
POURCENTAGE D'ARBRES MORTS
HORS DES DEPRESSIONS**

**VEGETATION COVER:
PERCENT TREES WHICH ARE DEAD
OUTSIDE DEPRESSIONS**

%

- 90+**
- 75-90**
- 50-75**
- 25-50**
- 10-25**
- 5-10**
- 0.1-5**

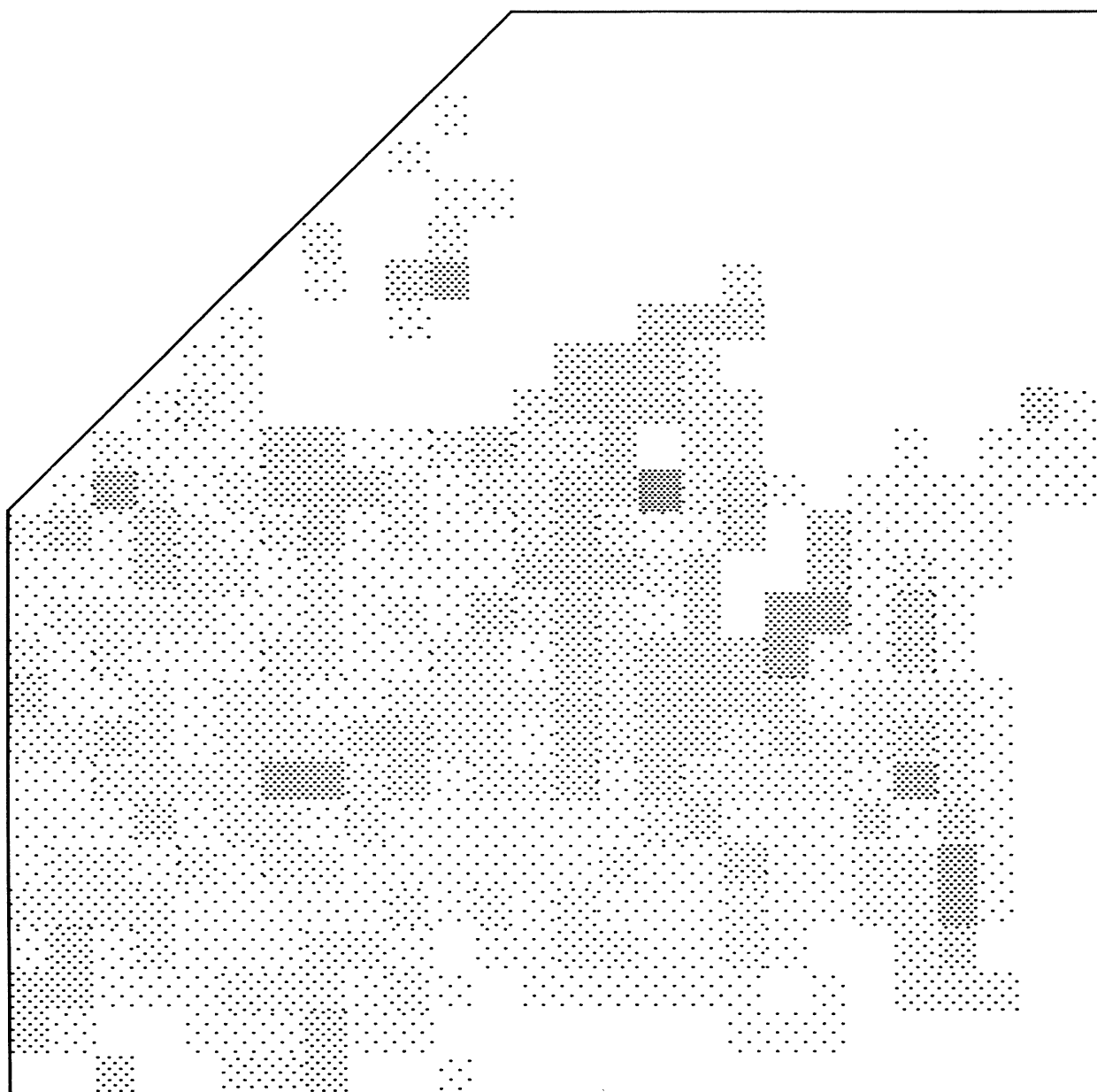
**PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991**



CARTE	COUVERT VEGETAL:
TEXTE	POURCENTAGE D'ARBRES MORTS
	DANS LA DEPRESSION VERTE
4.6	
TEXT	VEGETATION COVER:
MAP	PERCENT TREES WHICH ARE DEAD
	IN GREEN DEPRESSION

%
■ 90+
■ 75-90
■ 50-75
■ 25-50
■ 10-25
■ 5-10
■ 0.1-5

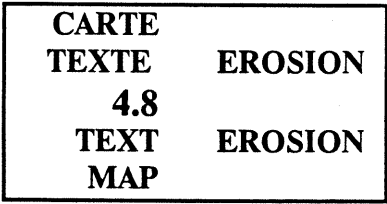
PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



CARTE	COUVERT VEGETAL:
TEXTE	POURCENTAGE D'ARBUSTES DANS
4.7	LA DEPRESSION VERTE
TEXT	VEGETATION COVER:
MAP	PERCENT SHRUBS
	WITHIN GREEN DEPRESSION

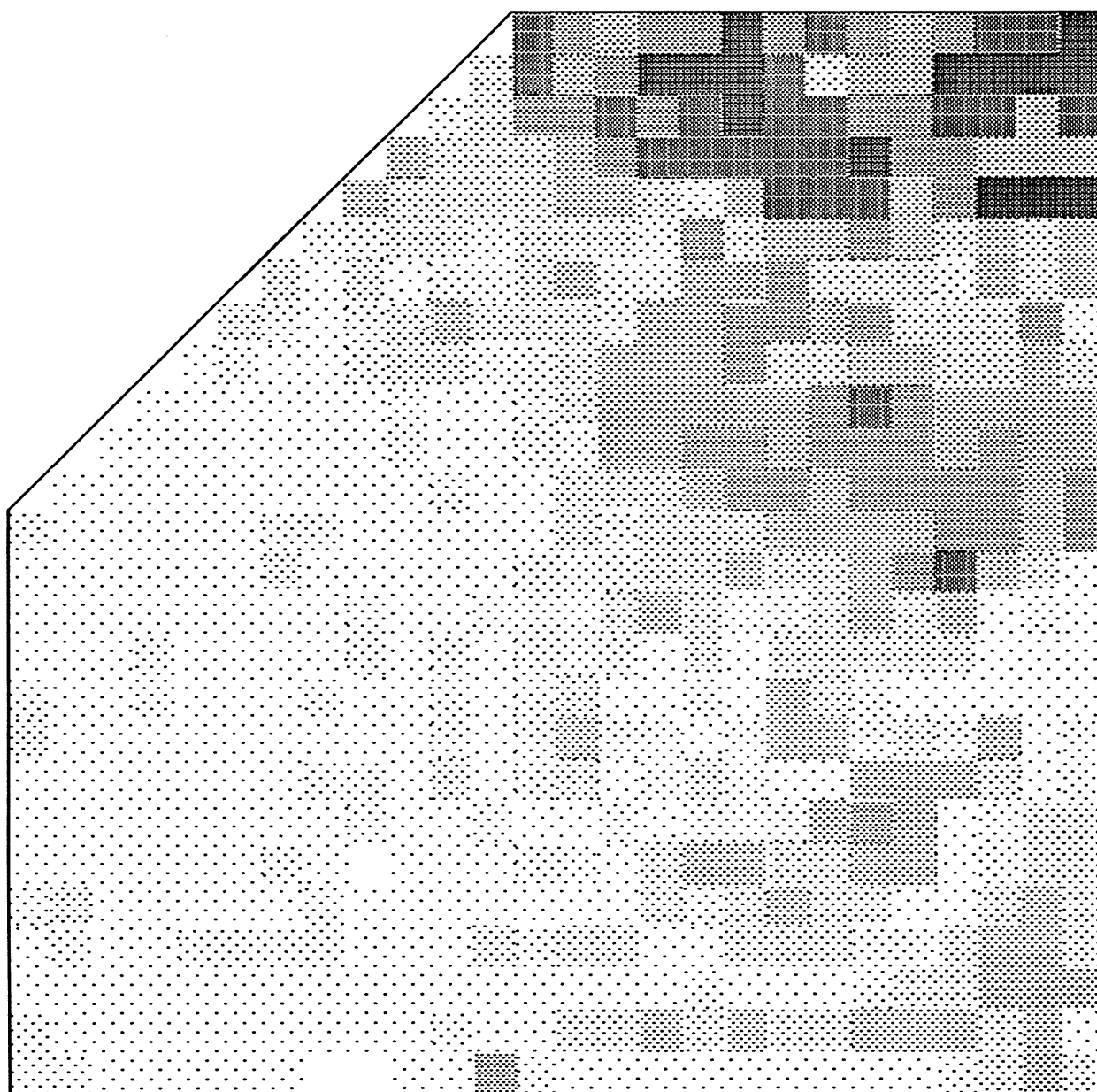
%
■ 90+
■ 75-90
■ 50-75
■ 25-50
■ 10-25
■ 5-10
■ 0.1-5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



Superficielle = 2 = Sheet

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



CARTE
TEXTE
4.9

TEXT
MAP

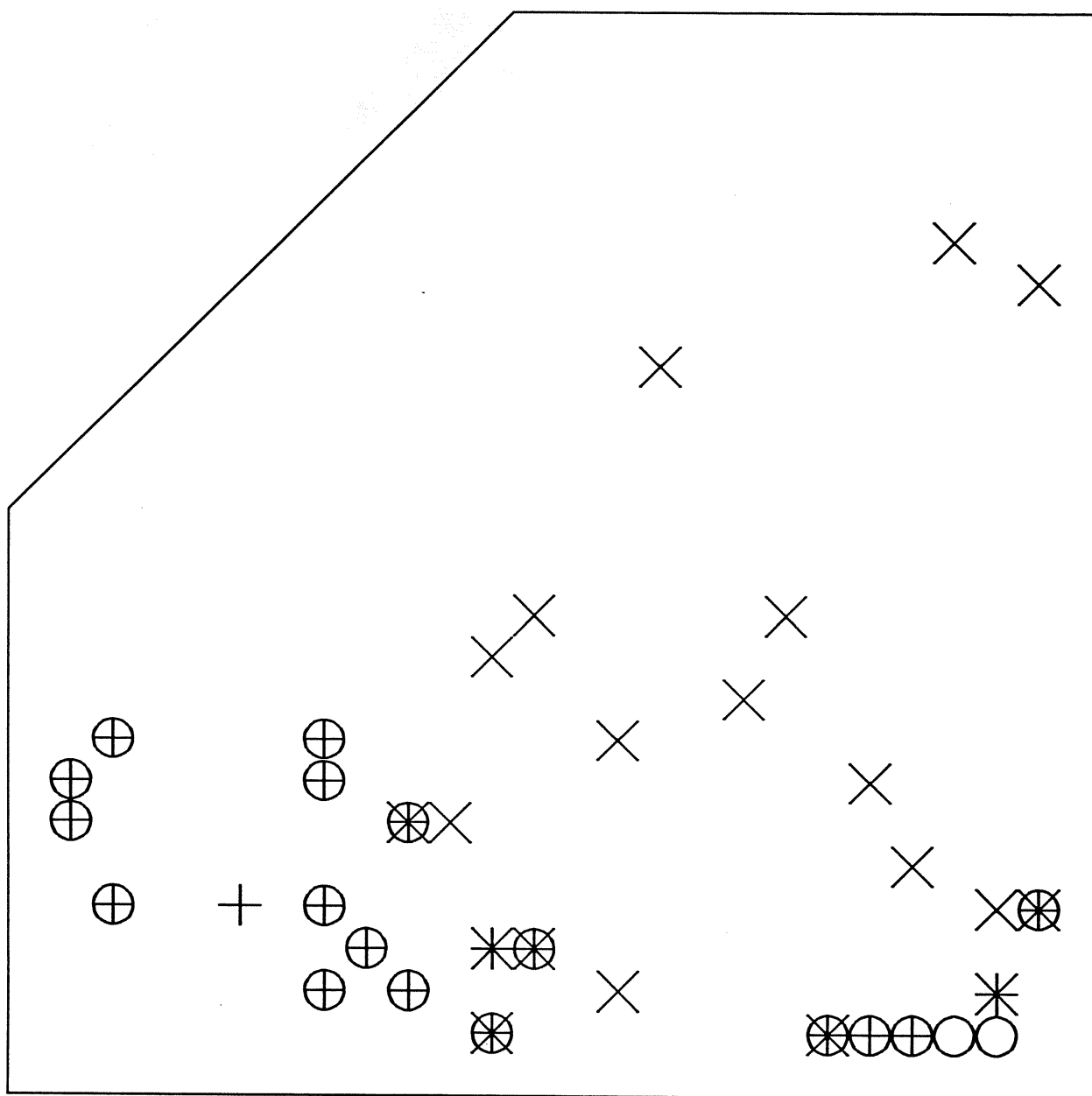
COUVERT VEGETAL:
SOL DENUDE HORS DES DEPRESSIONS
EN POURCENTAGE DU QUADRILLAGE

VEGETATION COVER:
BARE GROUND OUTSIDE DEPRESSIONS
AS A PERCENTAGE OF GRID

%

- 90+**
- 75-90**
- 50-75**
- 25-50**
- 10-25**
- 5-10**
- 0.1-5**

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



CARTE

TEXTE

4.10

TEXT

MAP

TYPES D'HABITATION MARQUEES

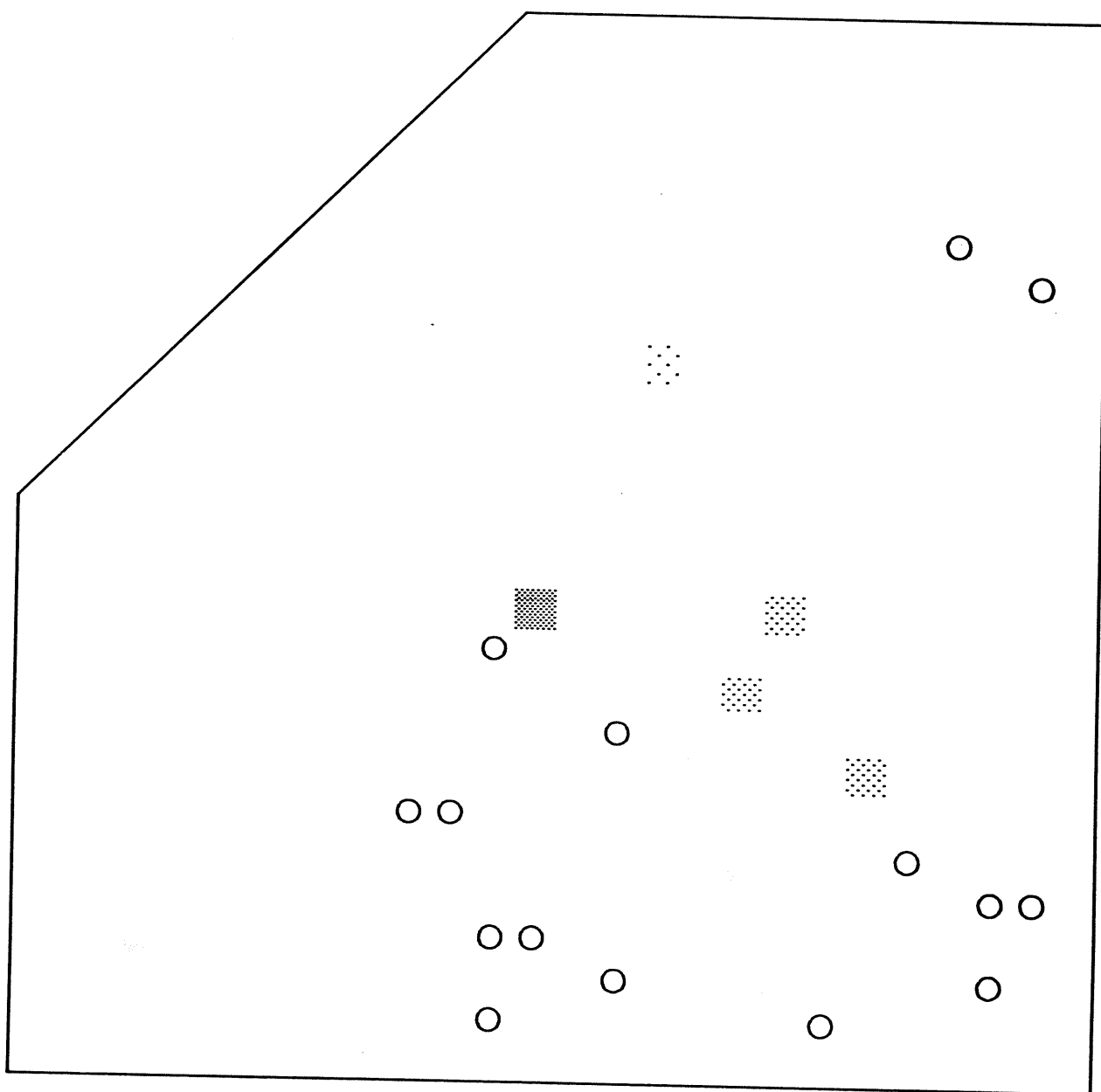
HABITATION TYPES SCORED

Tente = X = Tent

Chaume = + = Thatch

Argile = O = Mud

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

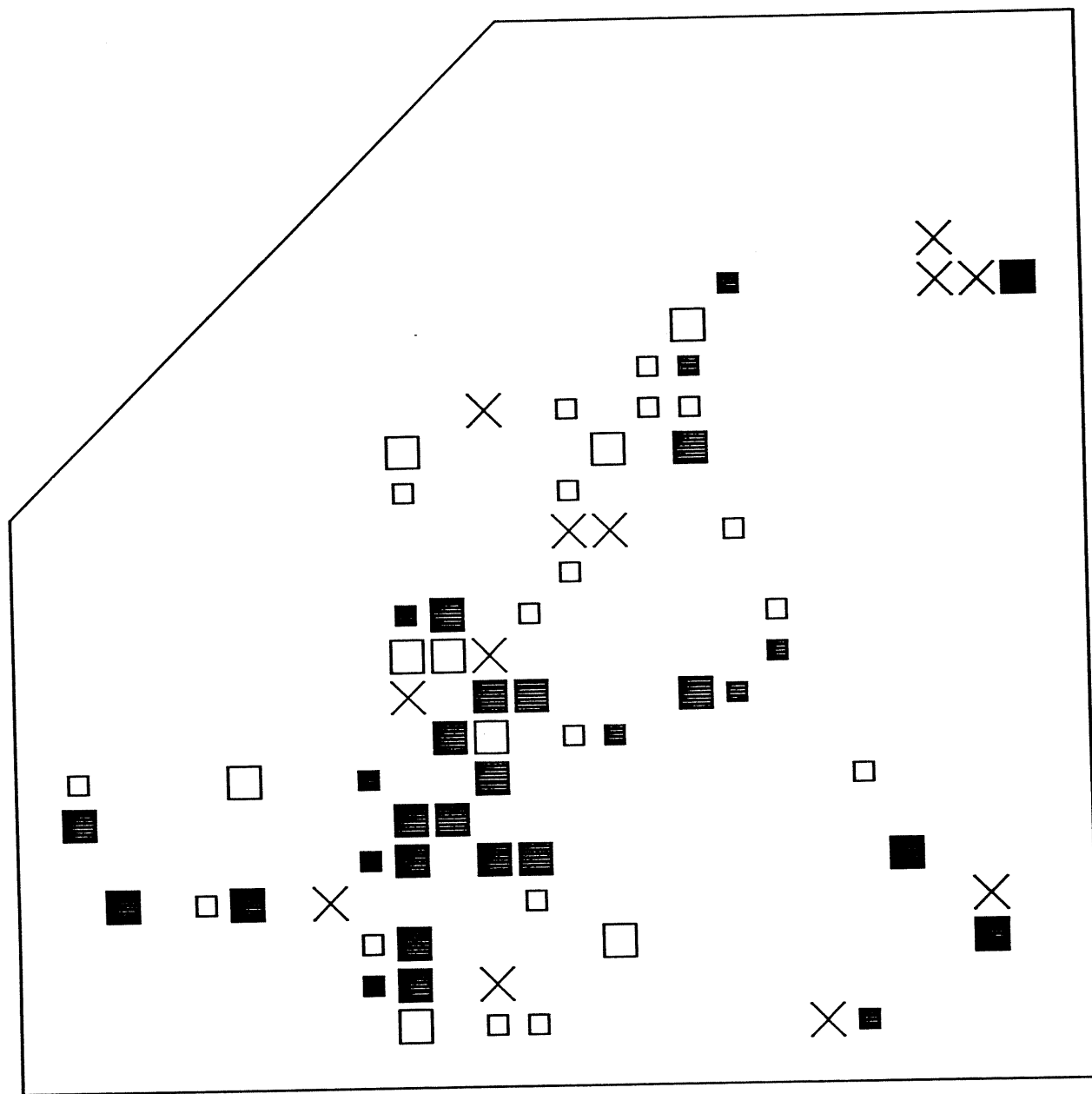


CARTE	ANIMAUX PAR HABITATION:
TEXTE	CAPRINS PAR TENTE
4.11	
TEXT	ANIMALS PER DWELLING:
MAP	GOATS PER TENT

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

No/Habitation

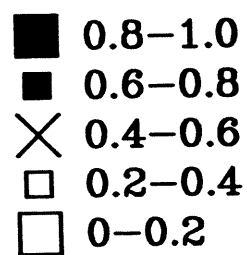
- 1 +
- ▨ 0.8-1
- ▩ 0.6-0.8
- ▧ 0.4-0.6
- ▦ 0.2-0.4
- ▤ 0.001-0.2
- 0



CARTE	PROPORTION DE CAPRINS
TEXTE	PROPORTION OF GOATS
4.12	
TEXT	
MAP	

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

Proportion



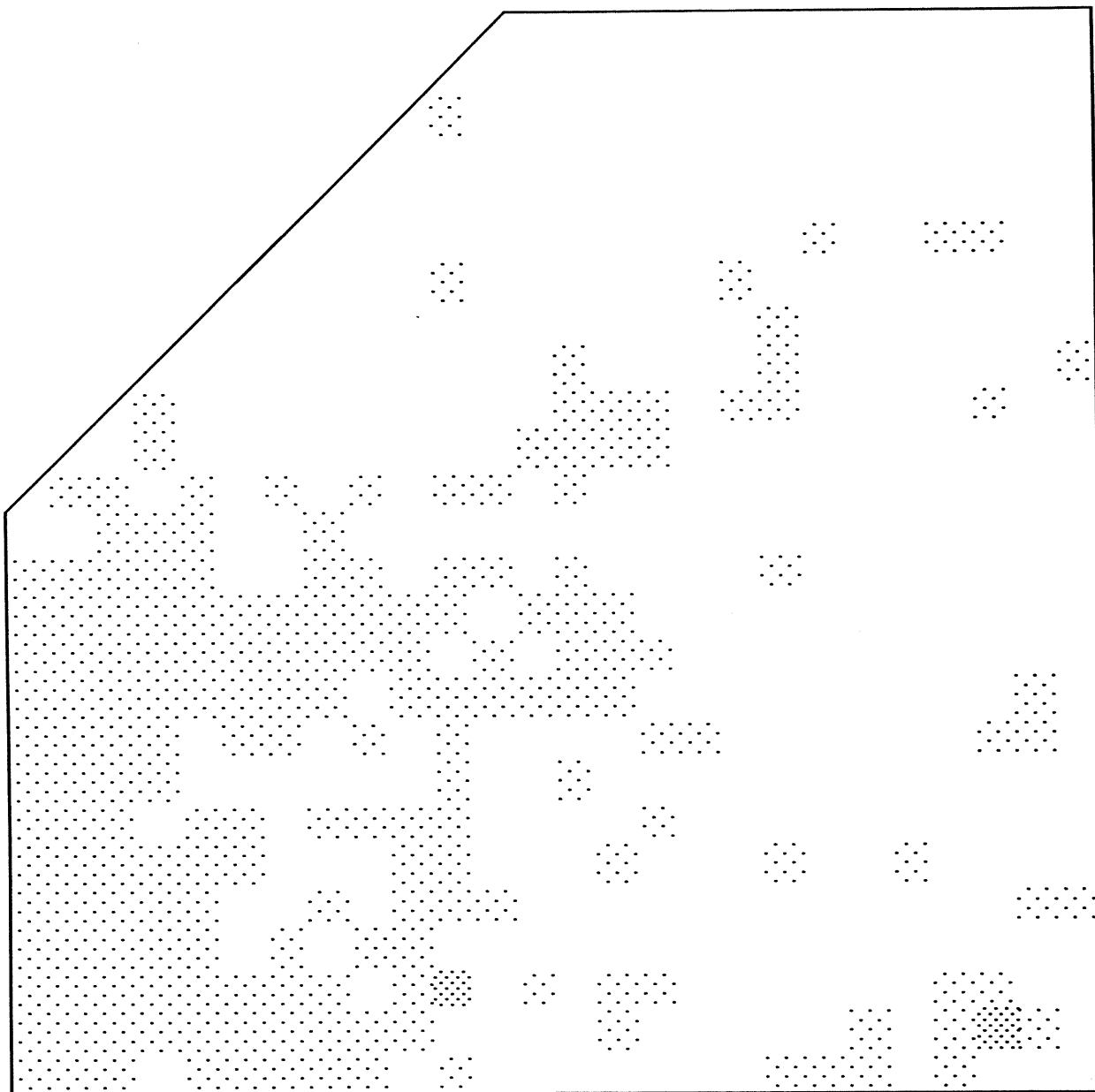


CARTE	DENSITE TOTALE D'ANIMAUX:
TEXTE	TOUS LES PETITS RUMINANTS
4.13	
TEXT	TOTAL ANIMAL DENSITY:
MAP	ALL SMALL RUMINANTS

No./km²

- 100 +
- 50-100
- 20-50
- 10-20
- 5-10
- 2.5-5
- 0.1-2.5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

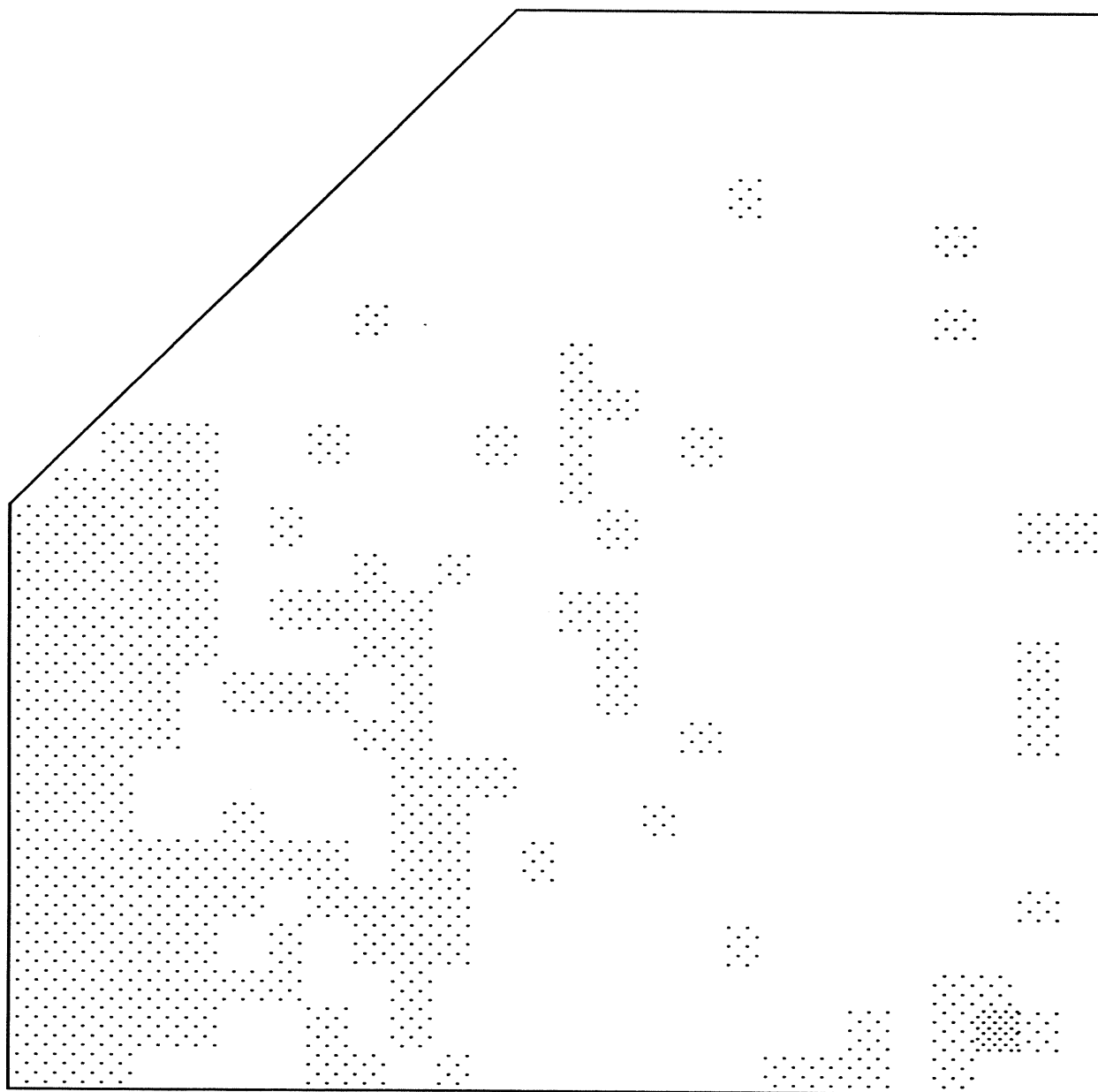


CARTE	DENSITE TOTALE D'ANIMAUX:
TEXTE	CHEVAUX
4.14	
TEXT	TOTAL ANIMAL DENSITY:
MAP	HORSES

No./km²

- 100 +
- 50-100
- 20-50
- 10-20
- 5-10
- 2.5-5
- 0.1-2.5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

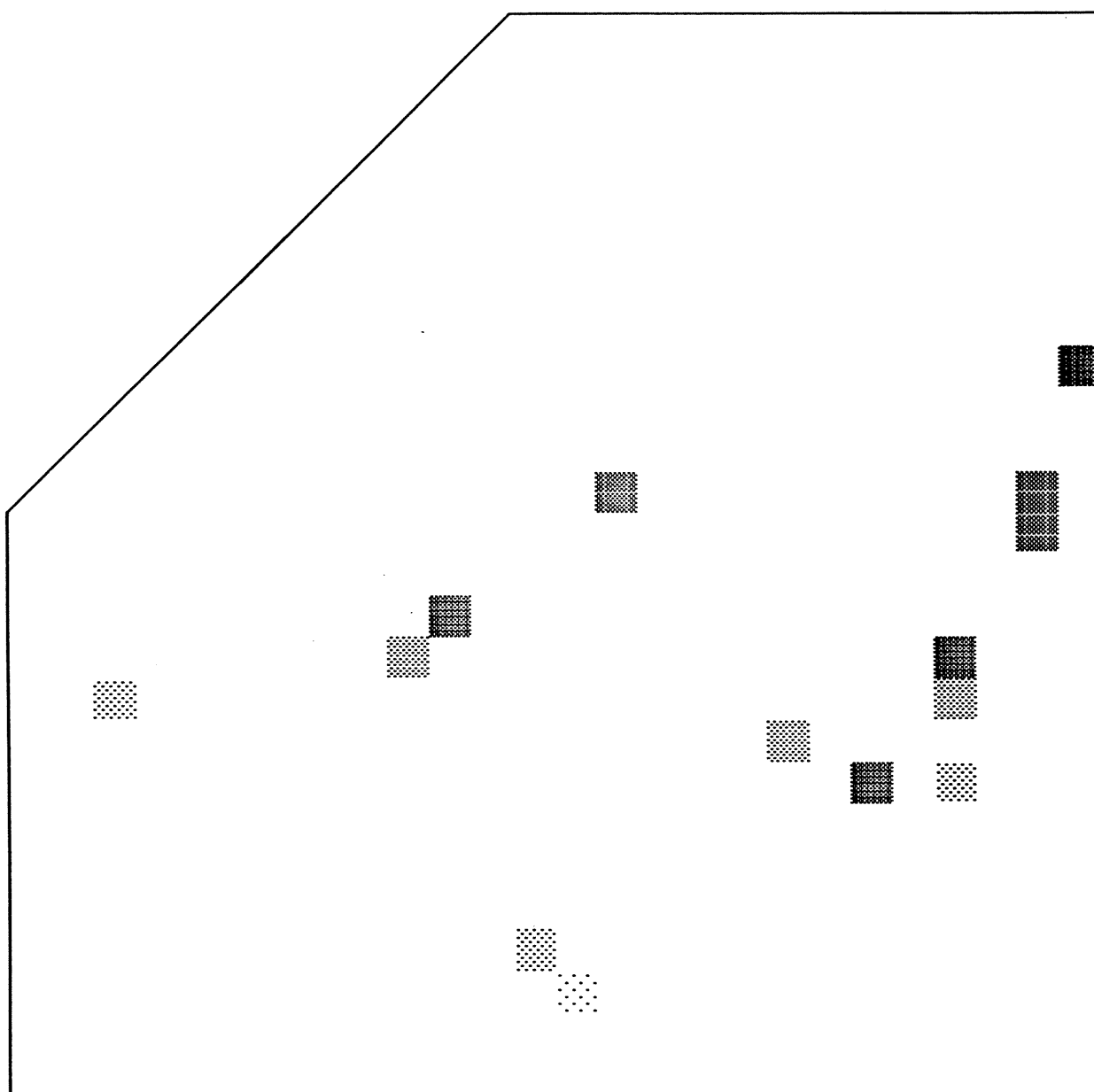


CARTE	DENSITE TOTALE D'ANIMAUX:
TEXTE	ANES
4.15	
TEXT	TOTAL ANIAML DENSITY:
MAP	DONKEYS

No./km²

- 100 +
- 50-100
- 20-50
- 10-20
- 5-10
- 2.5-5
- 0.1-2.5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991



CARTE	DENSITE D'ANIMAUX OBSERVEES:
TEXTE	MOUTONS OUDAH
4.16	
TEXT	OBSERVED ANIMAL DENSITIES:
MAP	UDA SHEEP

No./km²

- 100 +
- ▣ 50-100
- ▤ 20-50
- ▥ 10-20
- ▧ 5-10
- ▨ 2.5-5
- ▩ 0.1-2.5

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

animals. A further cautionary note is that some small sections of the survey area may be over stocked: 17 grids on the southern margins of the survey area and to the east of Moussoro, contain in excess of 50 TLU per km² (Colour Map 18), which is well above IEMVT's estimate of sustainable carrying capacity.

In other parts of Sahelian Africa, the proportion of livestock biomass contributed by each species varies with rainfall: the wetter it is, the more cattle and the fewer camels there tend to be, with the proportion of small ruminants remaining fairly constant. In other parts of the Arid Zone, cattle account for an average of 59-61% of the total livestock biomass, whilst small ruminants and camels each contribute 18-20% (Appendix 2).

In the present survey, 11.9% of livestock biomass are camels, 74.7% are cattle, 12.0% are small ruminants, and the remaining 1.4%, equines. In comparison with other ones, the present area therefore appears to support a somewhat larger proportion of cattle than might be expected.

4.6 Livestock in Relation to Habitation and Vegetation

In response to specific requests by Project personnel the numbers of livestock in relation to a number of vegetation and land use parameters assessed from the air have been calculated. These data are presented in Appendix 5.

A series of preliminary multiple regression analyses were also performed, in order to provide initial indications of the primary determinants of livestock distributions. These results are provided in full in Appendix 6, but are summarised briefly below.

Camels are the only livestock species whose distribution does not appear to be significantly correlated with any form of human habitation. The regressions performed suggest that they are largely associated with areas on the land outside depressions ('dunes'), away from dense tree cover. However, whilst highly significant in statistical terms ($p < 0.0001$), the relationships are weak, in that they explain less than 5% of the variation in camel numbers.

The numbers of TLU, cattle, and sheep in each survey grid are best predicted by the number of tents present, and secondarily by the total percentage of tree cover: these species are thus found in areas of trees in the vicinity of tents. Other vegetation parameters are significant additional predictors, but add little to the overall proportion of the variance explained. Goat numbers are most significantly correlated with the percentage of tree cover within depressions, expressed as a percentage of the depression itself, and secondarily with the number of tents. The variables included in the analysis explain 36-42% of the variation in cattle goat, and TLU numbers, but only 7.2% in those of sheep.

Equine numbers, as expected, are most effectively predicted by the numbers of habitations, particularly thatched dwellings and tents; the percentage of tree cover in depressions is also significant, though negative in its effect. Thus equines are predicted to be located close to habitation, and away from trees. In all, nearly three quarters of the variation in equine numbers can be explained by these parameters.

If human habitation numbers are excluded from the analyses, trees and shrub cover become the most important predictors of cattle and small ruminant populations, whilst cultivation and water are the most significant correlates of equine numbers. However, for all species, the omission of habitation numbers means that the predictive value of the overall regression equations is substantially reduced, though the statistical significance of the relationships remains at the 0.01% level or better.

SECTION 5. REFERENCES

- Anon (1973) L'elevage au Tchad. Bulletin Afrique Noire, 732, pp 14328-14331.
- Bourn, D.M. and Wint, F.C. (1985) Livestock and Human Habitation in the Gourma Region of Mali. RIM/CIPEA, Bamako.
- Bourn, D.M. and Wint, G.R.W. (1986) Pastoral Conditions in Central Niger following the 1983/84 Drought. RIM/ILCA, Addis Ababa.
- Cabot, J. et Bouquet, C. (1973) Le Tchad. Collection "Que sais-je?" no.1531, P.U.F., Paris.
- Chapelle, J. (1986) Le peuple Tchadien. Ses racines et sa vie quotidienne. Editions L'Harmattan, Paris.
- CIPEA (1987) Rapport du vol systematique de reconnaissance au Ferlo (Sénégal). ILCA, Addis Ababa, Ethiopia.
- ERGO (1990) Integrated Livestock Surveys of Red Sea Province, Sudan. Report to OXFAM, UK.
- FAO (1978) Production Yearbook, Vol 32. FAO, Rome.
- Goffings, J.P. et Damsou, M. (1976) Inventaire qualitatif et quantitatif du cheptel tchadien. SEDES, Paris.
- IEMVT (1986) L'atlas pastorale du Tchad. Maisons Alfort, Paris.
- IGN (1969) Carte international du monde. 1/1,000,000. N'Djamena, ND33. Edition Speciale.
- INTSH (1972) Atlas pratique du Tchad. Institut Géographique National, Paris.
- Le Houérou, H.N. (1989) The grazing land ecosystems of the African Sahel. Ecological Studies 75, Springer-Verlag, Germany.
- Le Rouvreur, A. (1962, re-ed 1989) Saheliens et sahariens du Tchad. Editions l'Harmattan, Paris.
- Louis Berger International (1988) Resultats des enquêtes sur la situation de l'elevage bovin, ovin et caprin au Tchad. BCEON.
- Marriott, F.C. and Wint, G.R.W. (1985) Sampling and Statistics in Low level Aerial Survey. Report to ILCA, Addis Ababa.
- Milligan, K. (1982a) Recensement aérien des populations humaines et animales et des conditions mésologiques d'une région du centre de la zone pastorale du Niger. ILCA, Kaduna.
- Milligan, K. (1982b) Recensement aérien des populations humaines et animales et morphologies du paysage pendant la saison des pluies d'une région du centre de la zone pastorale du Niger. ILCA, Kaduna.
- Milligan, K. (1983) Dry Season patterns of Livestock and Human Distribution in the Gourma Region of Mali. ILCA, Addis Ababa.
- Milligan, K., Keita, M. and de Leeuw, P. (1982) recensement aérien saisonier du cheptel et types de paysage du Delta Central du Niger au Mali. ILCA, Kaduna.
- Norton Griffiths, M.J. (1978) Counting Animals. A Series of Handbooks on Techniques in African Wildlife Ecology. Handbook no.1. African Wildlife Leadership Foundation, Nairobi.

REFERENCES (Continued)

- ORSTOM (1970)** La végétation du Tchad. Travaux et documents de l'ORSTOM no.6, Paris.
- Putt, S.N.H., Shaw, A.P.M., Matthewman, R.W., Bourn, D.M., Underwood, M., James, A.D., Hallam, M.J. and Ellis, P.R. (1980)** The Social and Economic Implications of Trypanosomiasis Control: a Study of the Impact on Livestock production and Rural Development in Northern Nigeria. Study no.25, VEERU, University of Reading, UK.
- RIM (1986)** Aerial Survey Computer Analysis Reference Guides. Part I:Data Entry. Part II:Mapping and Analysis. Report to ILCA, Addis Ababa.
- RIM (1987)** Un refuge dans le Sahel. Report to the Ministère des Ressources Naturelles et de l'Elevage, République du Mali.
- RIM (1991)** Livestock in Borno State. In: Nigerian National Livestock Survey, Vol 3. Report to the Federal Department of Livestock and Pest Control Services, Nigeria.
- Tchad (République) (1983)** L'évolution du cheptel tchadien et sa production. Ministère du Plan et de la Réconstruction, N'Djamena.
- Yosko, I. (1989)** Pâturages naturels sahéliens. Thèse Post-Universitaire, Université Cheikh Anta Diop, Dakar.

APPENDIX 1. TERMS OF REFERENCE

Cadre

Dans le cadre du Programme Ecologie Pastorale du Projet National d'Elevage financé par la Banque Mondiale, le Laboratoire Farcha vous invite à faire des propositions, dans le cadre d'une consultation restreinte relative à une analyse de la densité du bétail et de l'occupation humaine durant la saison pluvieuse, dans une partie de la zone d'intervention du projet.

A cet effet, nous vous prions de soumettre votre devis estimatif avant la fin d'avril 1991 au Laboratoire Farcha. L'équipe permanente chargée du programme est composée de Mr. Idriss Yosko et Mr. Paul Scholte.

La Zone présentée pour le survol est présentée en annexe (carte).

Les principales spécifications sont:

1. Les survols doivent être réalisés entre le 10 août et le 10 septembre 1991.
2. En fonction de l'importance de la saison pluvieuse la zone à survoler pourrait être décalée de 50 km, plus au nord ou plus au sud. Cependant, la longueur totale des lignes à survoler reste constante. Toutefois, la distance depuis la base des opérations peut être modifiée.
3. La longueur totale des lignes à survoler pourrait être d'environ 11600 km ou 5800 km selon la distance entre les lignes de vol qui peut être de 5 ou 10 km respectivement (deux options).
La hauteur proposée est de 250 m. 16 ou 8% de la superficie peut être échantillonnée
4. Des données doivent être axées sur:
 - le nombre de bétail et des campements et villages par carré de 25 ou 100 km² respectivement (deux options).

Les quadrants sont orientés conformément au système de projection de Mercator.

Les catégories à distinguer sont:

- Le nombre des bovins
- Le nombre des chameaux
- Le nombre des petits ruminants (ovins et caprins)
- Le nombre des ânes et des chevaux
- Le nombre des tentes et des campements
- Le nombre d'habitations et villages d'une taille de moins de 200 maisons

Les animaux et habitations des villages et villes comprenant plus de 200 maisons ne sont pas concernées par les levés aériens.

5. Pour base des opérations l'Aéroport de N'Djamena est probablement situé beaucoup plus au sud de la zone. Par contre, le terrain d'atterrissage de Moussoro présente l'avantage d'être au centre de la zone. Néanmoins, la piste d'atterrissage de Massakory et Ati, peuvent également être utilisés. Le Laboratoire Farcha prendra en charge le transport des carburants jusqu'à Moussoro, Mao, Massakory ou Ati. Les frais de carburant restent à la charge du contractant.

6.Le Laboratoire Farcha se chargera de mener les démarches nécessaires afin que les opérations de survols ne puissent s'offrir d'aucunes contraintes. Le Laboratoire vous avisera deux semaines à l'avance de votre date d'arrivée au Tchad.

Vous êtes prié en plus de devis de spécifier:

- la composition de l'équipe dans l'avion et sur le terrain (logistique)
- l'analyse statistique dont vous pensez que ce fera une partie integrale des survols
- les frais de présentation des résultats sur cartes
- les frais de présentation de 6 ficheurs sur diskettes pour chaque catégorie

APPENDIX 2. PREVIOUS SURVEYS

Since the early eighties, a number of livestock surveys have been carried out over areas that are comparable, in climatic terms, to the Bhar el Ghazal region of Tchad, in Mali, Niger, Sudan, and Nigeria. The resulting population estimates are given in Table A2.1, below.

In Mali, a series of aerial surveys have been undertaken in the Fifth Region (Appendix Map A2.1). Whilst having a very similar climate to that of the present survey area, a dominant environmental feature is the Inland Niger Delta. This is an elaborate network of lakes, channels and submerged areas of grassland resulting from the fragmentation of the Niger and Bani Rivers. The area attracts a large influx of livestock from the adjacent rangelands during the dry season, and was the subject of the 1980-82 surveys. With the Bandiagara Plateau and the flat savanna of the Koro/Bankas Plains between, the extensive rangelands of the Seno-Manga and Gourma lie in the easternmost part of the Fifth Region; this last comprises the study area of the 1983-84 surveys. The 1987 ODEM survey covered the entire Fifth Region, from the Delta to the Gourma.

A series of surveys have been carried out in the Ferlo region of Senegal, from the early eighties until 1990. The results used here for comparative purposes are those given in the CIPEA report of 1987.

Four surveys of the central pastoral zone of Niger (Appendix Map 2.1) were conducted between 1981 and 1985. Occupying almost parallel latitudes, the region has a similar climate and terrain to the present survey area, with no permanent surface water. The last of these four surveys followed the 1983-84 drought, and revealed a resultant decline of some 77% in overall livestock levels.

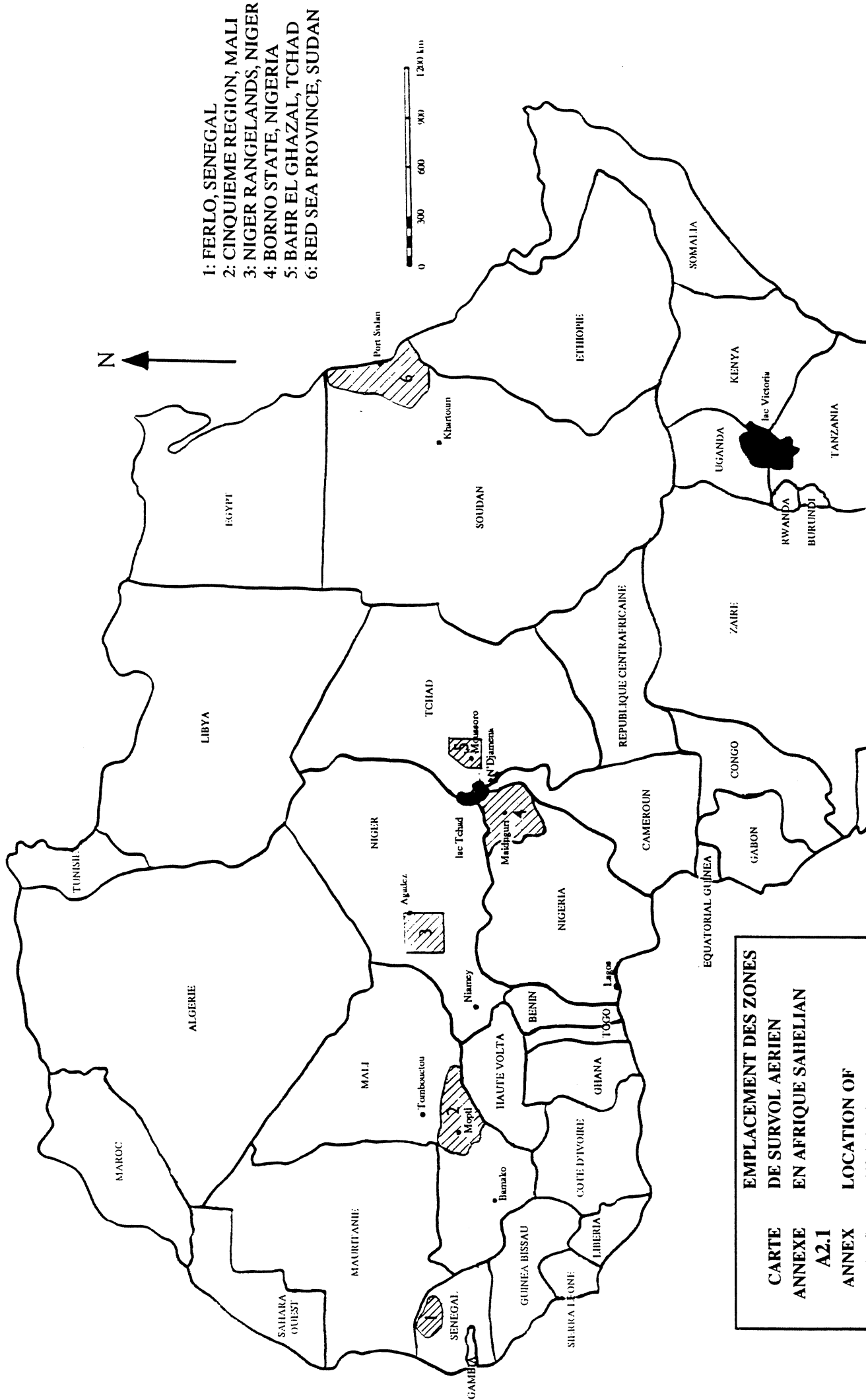
Much of the Red Sea Province in Sudan is mountainous, supporting very little vegetation; the amount and distribution of rainfall, and consequently of pasture, is unpredictable. Herders and their livestock thus tend to congregate in the deltas and khors where grazing resources are comparatively reliable. For these reasons, estimated livestock numbers obtained in the surveys of this region were expressed in relation to the amount of land that could actually support animals (effective values), as well as in absolute terms.

Borno State, north-eastern Nigeria, abuts the western shores of Lake Tchad, and is thus the closest of the previously survey areas to the present one. It is a large State, however, with considerable geographic variation. Lake Tchad itself represents a major grazing resource where, particularly during the wet season, huge numbers of cattle are found. This phenomenon elevates the densities for the State as a whole, and accounts for their comparatively high values.

TABLE A2.1: LIVESTOCK POPULATION ESTIMATES IN PREVIOUSLY SURVEYED AREAS

COUNTRY SURVEY	MALI DELTA	GOURMA	ODEM	NIGER NRL	NIGERIA BORNO STATE	SUDAN RED SEA PROVINCE	SENEGAL FERLO	TCHAD BAHR EL GHAZAL
ZONE	arid/semi-arid	arid	arid/semi-arid	arid	arid/semi-arid	arid	na	arid
AREA (km ²)	36,000	81,300	102,000	81,555	116,590	117,800	30,000	59,800
DATE	10-11/80	3/83	5-6/87	5/81	3-4/90	9/89	1980's	8/91
SEASON	early dry	early wet	early wet	early dry	early dry	mid wet	annual mean	mid wet
CATTLE DENSITY	22.5	22.5	4.3	4.6	25.3	21.4	12.0	10.1
SR	4.5	4.5	23.4	21.6	4.0	4.7	8.3	9.9
MGS	117	69	46	38	na	na	na	46
SMALL RUMINANTS DENSITY	7.1	16.0	7.0	14.1	44.7	50.3	24.6	11.4
SR	14.0	6.2	14.3	7.1	2.2	2.0	4.1	7.6
MGS	79	108	71	70	na	na	na	59
CAMELS DENSITY	na	na	0.1	1.1	0.2	0.2	0.08	1.1
SR	na	na	1,736	91	400	475	1,200	88.6
MGS	na	na	3	6	na	na	na	12
DONKEYS DENSITY	na	na	0.1	0.3	1.6	1.5	0.6	0.14
SR	na	na	1,429	400	64	65	157.9	724.8
MGS	na	na	7	6	na	na	na	3
TLU DENSITY	na	na	4.3	6.6	23.18	20.96	11.24	9.5
SR	na	na	23.0	15.3	4.31	4.77	8.90	10.5
SOURCE	Milligan et al (1982)	Milligan (1983)	Bourn & RIM (1987)	Milligan (1982a)	Bourn & RIM (1986)	ERGO (1990)	CIPEA (1987)	RIM (1991)

Density = /km²; SR = Stocking Rate (ha/hd); MGS = Mean Group Size; TLU = Tropical Livestock Unit; (figures in brackets = effective values, see text); * = mean figures for both seasons; ** = less than 0.1; na = not specified by author;



**EMPLACEMENT DES ZONES
DE SURVOL AERIEN
EN AFRIQUE SAHELIAN**

**CARTE
ANNEXE
A2.1
ANNEX
MAP**

**LOCATION OF
AERIAL SURVEY ZONES
IN SAHELIAN AFRICA**

APPENDIX 3. ITINERARIES

The air team was based in Moussoro and flew the entire survey area between 24/08/91 and 04/09/91.

The sites visited by the ground teams are given below:

SITE	DATE	GRID
Chabaka	25-08-91	1007
Madarde	25-08-91	1007
Rsguit-Bara	25-08-91	1107
Elezamanga	25-08-91	1107
Kri-Ngna	25-08-91	0805
Morounga	25-08-91	1107
Koula-Ngna	25-08-91	0805
Am-Lobook	25-08-91	1107
Oukoumagai	25-08-91	1107
Delep Doroso	25-08-91	0904
Ariariou	25-08-91	1107
Ouadiounga	26-08-91	0805
Gantour	26-08-91	0803
Tororo	26-08-91	1304
Goutioulouma	26-08-91	1003
Am Ko	26-08-91	1204
Molokh Kebir	26-08-91	1003
Fizigi	26-08-91	1202
Remele	27-08-91	0809
Am Djéména	27-08-91	2002
Am Salaya	27-08-91	2002
Rahat Salamat	27-08-91	2102
Encampment	27-08-91	1503
Méchiméré	28-08-91	0309
Ilili	28-08-91	0208
Mourzougi	28-08-91	0207
Dokora	28-08-91	0305
Lag Lakha	28-08-91	2202
Chéddra	28-08-91	0605
Dankala	28-08-91	2302
Kouri Kouri	28-08-91	0808
Abli	28-08-91	2302
Djoubak	28-08-91	2402
Ambassatna	28-08-91	2402
Encampment	29-08-91	2405
Sinetay	29-08-91	2403
Encampment	29-08-91	2206
About Idjelidj	29-08-91	2505
Encampment	29-08-91	2108
Encampment	31-08-91	1509
Encampment	31-08-91	1810
Encampment	31-08-91	1912
Encampment	01-09-91	2520
Encampment	01-09-91	2321
Encampment	02-09-91	1618
Encampment	03-09-91	1312
Encampment	03-09-91	1312
Encampment	03-09-91	1312
Encampment	03-09-91	1312
Encampment	03-09-91	1211
Moussoro	04-09-91	1107

APPENDIX 4. HIDDEN ANIMAL NUMBERS IN SELECTED SETTLEMENTS

Table A4.1 below gives the hidden animal numbers assessed by the ground teams in the settlements of Moussoro, Chèddra, Ambassatna, Am Djéména and Méchiméré. These settlements have been selected because of their relatively large size compared to other settlements and groups of dwellings in the survey area. These rooftop ratios have been separately presented here so that if data on the numbers of dwellings the settlements comprise become available, for example via taxation figures, their individual livestock populations may be calculated.

Only Ambassatna fell into the sampling band during the course of the aerial survey. Hence, its rooftop numbers (counted from the air) and rooftop ratios have been used to calculate numbers of livestock which are included in the hidden animal estimates given in Section 4.3 and illustrated on the maps in Appendix 7.

The other four towns were not sampled in the course of the aerial survey, though preliminary estimates of the numbers of rooftops in both Moussoro and Chèddra were made during reconnaissances flights. These estimates are for interest only, and so the estimated livestock populations of these towns are not included in the figures for the whole survey area, though the rooftop ratios derived from the ground teams' data have been used in calculation of hidden animal numbers.

Table A4.1: Hidden Animals in Selected Settlements

Moussoro (Grid 1107)						
Camels	Cattle	Sheep	Goats	Horses	Donkeys	
<u>Number Counted</u>	0	0	6	53	3	24
<u>Rooftop Ratios</u>						
Per Thatch (N=61)	0	0	0.007	0.015	0	0.061
Per Mud (N=330)	0	0	0.031	0.205	0.020	0.082
Per Total (N=391)	0	0	0.029	0.196	0.019	0.081
<u>Total Populations</u> (Number of houses estimated from the air = 3000)						
	0	0	46.04	406.64	23.02	184.14
Chèddra (Grid 0605)						
Camels	Cattle	Sheep	Goats	Horses	Donkeys	
<u>Number Counted</u>	1	0	0	0	0	16
<u>Rooftop Ratios</u>						
Per Thatch (N=55)	0.007	0	0	0	0	0.068
Per Mud (N=104)	0.006	0	0	0	0	0.079
Per Total (N=159)	0.005	0	0	0	0	0.071
<u>Total Populations</u> (Number of houses estimated from the air = 500)						
	3.14	0	0	0	0	50.31
Ambassatna (Grid 2402)						
Camels	Cattle	Sheep	Goats	Horses	Donkeys	
<u>Number Counted</u>	0	0	5	5	10	19
<u>Rooftop Ratios</u>						
Per Thatch (N=92)	0	0	0.04	0.03	0.06	0.13
Per Mud (N=87)	0	0	0.03	0.02	0.06	0.13
Per Total (N=179)	0	0	0.03	0.02	0.05	0.11
<u>Total Populations</u> (Number of houses estimated from the air = 620 thatch and 180 mud)						
	0	0	30.2	22.2	48.0	104.0
Am Djéména (Grid 2002)						
Camels	Cattle	Sheep	Goats	Horses	Donkeys	
<u>Number Counted</u>	0	0	33	2	3	9
<u>Rooftop Ratios</u>						
Per Thatch (N=39)	0	0	0.23	0.01	0.06	0.17
Per Mud (N=55)	0	0	0.21	0.04	0.06	0.15
Per Total (N=94)	0	0	0.19	0.04	0.05	0.14
Méchiméré (Grid 0309)						
Camels	Cattle	Sheep	Goats	Horses	Donkeys	
<u>Number Counted</u>	0	0	0	0	0	3
<u>Rooftop Ratios</u>						
Per Thatch (N=44)	0	0	0	0	0	0.04
Per Mud (N=71)	0	0	0	0	0	0.04
Per Total (N=115)	0	0	0	0	0	0.03

APPENDIX 5. LIVESTOCK AND HABITATION NUMBERS IN RELATION TO LAND USE STRATA

Project Staff specifically requested that the survey data of livestock and human habitations be presented in tabular form according to the vegetational and other strata used during the analyses. This information is presented in the following Appendix.

In each Table, the area of the stratum; the estimated population within it; the percentage of the total estimate accounted for by hidden animals (for animals only); and the percentage Standard Error of the estimate (see Section 3, Main Report) are given. Tables for the following populations have been provided:

<u>Livestock</u>	<u>Habitation</u>
Camels	Tents
Cattle	Thatched Dwellings
Sheep	Mud Roofed Dwellings
Goats	Permanent Dwellings
Horses	
Donkeys	
All Small Ruminants	

The population figures provided are estimated totals within each stratum, as opposed to the 'raw' values for the area within the nominal sample strip. They do not, therefore, require any multiplication or other modification.

Each vegetation category has been divided into five categories: 0, 0.1-25%, 25.1 - 50%, 50.1-75% and 75-100%. The absence of any of the categories within a specific Table implies a population of zero. The populations are presented according to the following Strata:

Administrative Districts
Incidence of Erosion
Incidence of Open Water

Total Tree Cover as a Percentage of the Whole Grid;
Total Shrub Cover as a Percentage of the Whole Grid;
Total Grass Cover as a Percentage of the Whole Grid;
Total Bare Ground Cover as a Percentage of the Whole Grid;
Cultivated Land as a Percentage of the Whole Grid;
Percentage of Green Depression with Tree Cover;
Percentage of Green Depression with Shrub Cover;
Percentage of Green Depression with Grass Cover;
Area of Depression as a Percentage of the Whole Grid;
Percentage of Depression which is Green;
Percentage of the Trees in Depressions which are Dum Palms;
Percentage of the Trees in Depressions which are Dead;
Percentage of the Trees outside Depressions which are Dead;

TABLE A5.1: POPULATION OF CAMELS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	67525	1.13	0.33	9.9
Administrative District (Sous-préfecture).					
Moussoro	31200	41308	1.32	0.41	12.5
Noukou	6200	6139	0.99	0.02	19.2
Mao	3400	5037	1.48	0.30	35.3
Massakory	1600	150	0.09	7.33	67.3
Bokoro	1500	16	0.01	0.01	71.7
Ati	4200	41	0.01	61.00	47.1
Djedda	11700	14835	1.27	0.00	15.3
Incidence of Erosion.					
None	44400	54352	1.22	0.35	10.9
Gully	11200	13052	1.17	0.09	20.7
Sheet	4200	122	0.03	16.39	31.6
Incidence of Open Water.					
None	32700	57295	1.75	0.02	11.1
Pool	24500	8515	0.35	2.20	16.1
River	900	19	0.02	15.79	48.4
Inundated Plain	1700	1696	1.00	1.18	84.0
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	67466	1.14	0.33	9.9
25.1 - 50.0	500	59	0.12	0.00	94.8
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	1480	1.48	0.14	73.3
0.1 - 25.0	53500	64413	1.20	0.32	10.0
25.1 - 50.0	4400	1616	0.37	0.87	23.6
50.1 - 75.0	900	17	0.02	5.88	29.7
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	3278	0.68	0.03	38.6
25.1 - 50.0	15000	8733	0.58	0.23	28.2
50.1 - 75.0	23900	35241	1.47	0.49	11.9
75.1 - 100.0	16000	20273	1.27	0.15	19.4
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	37200	34934	0.94	0.62	12.9
25.1 - 50.0	14300	23529	1.65	0.03	13.2
50.1 - 75.0	4400	6259	1.42	0.00	21.1
75.1 - 100.0	3800	2803	0.74	0.00	46.5
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	59120	1.31	<0.01	9.9
0.1 - 25.0	14700	8404	0.57	2.59	20.3
25.1 - 50.0	100	1	0.01	100.00	> 100.0

TABLE A5.1: POPULATION OF CAMELS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	44320	1.94	0.06	11.9
0.1 - 25.0	14600	10780	0.74	0.08	25.4
25.1 - 50.0	11700	5322	0.45	3.16	23.2
50.1 - 75.0	8900	5641	0.63	0.30	20.9
75.1 - 100.0	1700	1463	0.86	0.14	37.4
Percentage of Green Depression with Shrub Cover.					
0	23200	44320	1.91	0.06	11.8
0.1 - 25.0	35500	22702	0.64	0.86	15.6
25.1 - 50.0	1100	504	0.46	0.20	50.8
Percentage of Green Depression with Grass Cover.					
0	22900	44320	1.94	0.06	11.9
0.1 - 25.0	5100	4732	0.93	0.08	26.2
25.1 - 50.0	9500	3234	0.34	0.65	25.7
50.1 - 75.0	11500	7729	0.67	2.12	20.0
75.1 - 100.0	10800	7511	0.70	0.09	31.3
Area of Depression as a Percentage of the Whole Grid.					
0	22900	44320	1.94	0.06	11.9
0.1 - 25.0	27800	21323	0.77	0.89	16.5
25.1 - 50.0	8800	1882	0.21	0.37	22.4
Percentage of Depression which is Green.					
0	22900	44320	1.94	0.06	11.9
0.1 - 25.0	10200	7814	0.77	0.13	30.6
25.1 - 50.0	10400	3647	0.35	0.55	23.9
50.1 - 75.0	5400	3791	0.70	3.61	31.4
75.1 - 100.0	10900	7954	0.73	0.36	23.9
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	66954	1.36	0.08	9.9
0.1 - 25.0	6200	162	0.03	3.09	39.6
25.1 - 50.0	2900	382	0.13	41.88	31.1
50.1 - 75.0	1100	27	0.02	25.93	38.8
75.1 - 100.0	300	<1	<0.01	100.00	19.6
Percentage of the Trees in Depressions which are Dead.					
0	45400	61546	1.36	0.35	9.7
0.1 - 25.0	14100	5979	0.42	0.07	22.2
Percentage of the Trees outside Depressions which are Dead.					
0	31000	32425	1.05	0.68	17.2
0.1 - 25.0	23700	22911	0.97	0.02	12.5
25.1 - 50.0	3700	11608	3.14	0.00	19.3
50.1 - 75.0	1100	566	0.51	0.00	56.3
75.1 - 100.0	300	16	0.05	0.00	94.8

TABLE A5.2: POPULATION OF CATTLE BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	605494	10.13	0.84	7.9
Administrative District (Sous-préfecture).					
Moussoro	31200	413772	13.26	0.08	8.0
Noukou	6200	1058	0.17	12.76	75.4
Mao	3400	25949	7.63	2.04	9.0
Massakory	1600	24861	15.54	3.38	10.5
Bokoro	1500	53466	35.64	<0.01	38.4
Ati	4200	20113	4.79	16.13	16.4
Djedda	11700	66276	5.66	0.00	22.7
Incidence of Erosion.					
None	44400	378528	8.53	0.54	10.7
Gully	11200	186972	16.69	0.26	11.4
Sheet	4200	39994	9.52	6.38	36.0
Incidence of Open Water.					
None	32700	119430	3.65	0.49	19.4
Pool	24500	431526	17.61	0.35	8.1
River	900	48291	53.66	0.71	44.5
Inundated Plain	1700	6246	3.67	42.60	34.1
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	598183	10.09	0.85	8.0
25.1 - 50.0	500	7311	14.62	0.00	35.8
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	228	0.23	100.00	15.6
0.1 - 25.0	53500	508349	9.50	0.82	8.7
25.1 - 50.0	4400	77924	17.71	0.75	23.4
50.1 - 75.0	900	18993	21.10	0.58	25.5
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	18817	3.92	0.56	27.6
25.1 - 50.0	15000	167177	11.15	0.81	13.6
50.1 - 75.0	23900	349842	14.64	0.85	10.7
75.1 - 100.0	16000	69658	4.35	0.93	22.7
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	2117	21.17	0.00	1.2
0.1 - 25.0	37200	439935	11.83	1.00	9.0
25.1 - 50.0	14300	154646	10.81	0.45	16.8
50.1 - 75.0	4400	8796	2.00	0.00	19.1
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	393480	8.74	0.07	10.1
0.1 - 25.0	14700	211155	14.36	2.20	12.8
25.1 - 50.0	100	858	8.58	19.58	2.1

TABLE A5.2: POPULATION OF CATTLE BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	96006	4.19	3.88	28.5
0.1 - 25.0	14600	77601	5.32	1.17	16.5
25.1 - 50.0	11700	241205	20.62	0.12	10.9
50.1 - 75.0	8900	164806	18.52	0.09	12.9
75.1 - 100.0	1700	25877	15.22	<0.01	18.4
Percentage of Green Depression with Shrub Cover.					
0	23200	106608	4.60	3.50	25.7
0.1 - 25.0	35500	479266	13.5	0.27	07.9
25.1 - 50.0	1100	19620	17.84	0.33	32.7
Percentage of Green Depression with Grass Cover.					
0	22900	96006	4.19	3.88	28.5
0.1 - 25.0	5100	85484	16.76	0.02	15.8
25.1 - 50.0	9500	200385	21.09	0.10	13.1
50.1 - 75.0	11500	193496	16.83	0.20	11.5
75.1 - 100.0	10800	30124	2.79	2.46	29.2
Area of Depression as a Percentage of the Whole Grid.					
0	22900	96006	4.19	3.88	28.5
0.1 - 25.0	27800	352475	12.68	0.32	9.0
25.1 - 50.0	8800	150359	17.09	0.15	14.8
50.1 - 75.0	300	6654	22.18	0.00	52.4
Percentage of Depression which is Green.					
0	22900	96006	4.19	3.88	28.5
0.1 - 25.0	10200	166401	16.31	0.25	13.5
25.1 - 50.0	10400	202996	19.52	0.28	11.3
50.1 - 75.0	5400	56270	10.42	0.26	20.0
75.1 - 100.0	10900	83822	7.69	0.26	14.7
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	404499	8.20	1.19	9.4
0.1 - 25.0	6200	90729	14.63	0.17	18.7
25.1 - 50.0	2900	93609	32.28	0.09	23.1
50.1 - 75.0	1100	13972	12.70	0.05	27.4
75.1 - 100.0	300	2686	8.95	0.04	35.2
Percentage of the Trees in Depressions which are Dead.					
0	45400	379401	8.36	1.32	11.4
0.1 - 25.0	14100	225121	15.97	0.03	9.4
25.1 - 50.0	300	972	3.24	0.00	93.4
Percentage of the Trees outside Depressions which are Dead.					
0	31000	347511	11.21	1.42	11.3
0.1 - 25.0	23700	257067	10.85	0.06	10.9
25.1 - 50.0	3700	728	0.20	0.00	92.1
50.1 - 75.0	1100	188	0.17	0.00	67.0

TABLE A5.3: POPULATION OF SHEEP BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	328675	5.50	7.08	10.8
Administrative District (Sous-préfecture).					
Moussoro	31200	201246	6.45	5.53	11.7
Noukou	6200	1930	0.31	19.17	34.1
Mao	3400	21200	6.24	14.06	4.0
Massakory	1600	5018	3.14	34.42	12.2
Bokoro	1500	4952	3.30	8.08	34.1
Ati	4200	7243	1.72	65.58	33.0
Djedda	11700	87087	7.44	2.21	23.7
Incidence of Erosion.					
None	44400	175936	3.96	7.20	16.2
Gully	11200	131195	11.71	5.29	13.9
Sheet	4200	21543	5.13	17.09	29.6
Incidence of Open Water.					
None	32700	95939	2.93	4.86	20.2
Pool	24500	220283	8.99	6.15	13.2
River	900	7424	8.25	19.05	30.4
Inundated Plain	1700	5029	2.96	72.54	42.2
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	325267	5.49	7.08	10.9
25.1 - 50.0	500	3408	6.82	6.98	17.7
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	429	0.43	100.00	10.9
0.1 - 25.0	53500	297667	5.56	6.25	11.0
25.1 - 50.0	4400	28665	6.51	13.91	13.0
50.1 - 75.0	900	1914	2.13	13.90	30.3
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	3222	0.67	11.45	44.5
25.1 - 50.0	15000	105962	7.06	7.46	14.7
50.1 - 75.0	23900	163260	6.83	7.24	15.0
75.1 - 100.0	16000	56231	3.51	5.68	28.8
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	303	3.03	73.60	6.2
0.1 - 25.0	37200	196653	5.29	8.90	11.1
25.1 - 50.0	14300	128508	8.99	3.87	17.4
50.1 - 75.0	4400	3180	0.72	17.04	51.0
75.1 - 100.0	3800	30	0.01	100.00	82.8
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	263128	5.85	4.80	13.5
0.1 - 25.0	14700	65236	4.44	16.04	7.9
25.1 - 50.0	100	311	3.11	64.63	3.8

TABLE A5.3: POPULATION OF SHEEP BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	48602	2.12	14.99	22.3
0.1 - 25.0	14600	79696	5.46	4.89	24.2
25.1 - 50.0	11700	84357	7.21	8.06	14.3
50.1 - 75.0	8900	76704	8.62	5.77	13.3
75.1 - 100.0	1700	39317	23.13	2.22	28.9
Percentage of Green Depression with Shrub Cover.					
0	23200	51502	2.22	14.19	21.4
0.1 - 25.0	35500	263759	7.43	5.77	12.7
25.1 - 50.0	1100	13414	12.19	5.57	28.9
Percentage of Green Depression with Grass Cover.					
0	22900	48602	2.12	14.99	22.3
0.1 - 25.0	5100	74793	14.67	3.17	21.4
25.1 - 50.0	9500	83612	8.80	7.29	12.1
50.1 - 75.0	11500	67627	5.88	8.60	14.6
75.1 - 100.0	10800	54041	5.00	3.16	32.3
Area of Depression as a Percentage of the Whole Grid.					
0	22900	48602	2.12	14.99	22.3
0.1 - 25.0	27800	195166	7.02	6.30	14.5
25.1 - 50.0	8800	75295	8.56	4.36	18.7
50.1 - 75.0	300	9612	32.04	4.24	61.9
Percentage of Depression which is Green.					
0	22900	48602	2.12	14.99	22.3
0.1 - 25.0	10200	87152	8.54	5.09	17.3
25.1 - 50.0	10400	91125	8.76	7.27	16.6
50.1 - 75.0	5400	33273	6.16	6.56	26.4
75.1 - 100.0	10900	68524	6.29	4.02	25.7
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	283604	5.75	7.10	11.5
0.1 - 25.0	6200	30190	4.87	6.42	43.5
25.1 - 50.0	2900	9521	3.28	10.28	21.6
50.1 - 75.0	1100	5182	4.71	3.71	29.9
75.1 - 100.0	300	178	0.59	21.91	33.9
Percentage of the Trees in Depressions which are Dead.					
0	45400	218815	4.82	7.92	14.3
0.1 - 25.0	14100	108489	7.69	5.31	16.7
25.1 - 50.0	300	1371	4.57	13.06	84.2
Percentage of the Trees outside Depressions which are Dead.					
0	31000	146220	4.72	11.15	16.8
0.1 - 25.0	23700	181461	7.66	3.70	14.7
25.1 - 50.0	3700	974	0.26	25.46	47.2
50.1 - 75.0	1100	20	0.02	100.00	67.0

TABLE A5.4: POPULATION OF GOATS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	354351	5.93	2.05	6.6
Administrative District (Sous-préfecture).					
Moussoro	31200	266987	8.56	1.53	7.8
Noukou	6200	3885	0.63	3.06	33.3
Mao	3400	484371	4.25	1.81	10.6
Massakory	1600	10543	6.59	5.24	11.9
Bokoro	1500	5642	3.76	2.13	33.4
Ati	4200	5915	1.41	15.98	31.0
Djedda	11700	12942	1.11	4.49	29.0
Incidence of Erosion.					
None	44400	162690	3.66	2.63	9.7
Gully	11200	1649261	4.73	1.24	6.8
Sheet	4200	26735	6.37	2.93	38.4
Incidence of Open Water.					
None	32700	101677	3.11	1.64	14.3
Pool	24500	241012	9.84	1.88	7.5
River	900	8674	9.64	4.16	28.7
Inundated Plain	1700	2988	1.76	24.20	35.7
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	350235	5.91	2.06	6.7
25.1 - 50.0	500	4116	8.23	1.75	18.0
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	86	0.09	100.00	21.8
0.1 - 25.0	53500	296109	5.53	1.95	7.6
25.1 - 50.0	4400	53916	12.25	2.25	12.2
50.1 - 75.0	900	4241	4.71	4.79	8.9
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	4459	0.93	3.43	46.6
25.1 - 50.0	15000	122804	8.19	2.03	10.3
50.1 - 75.0	23900	193639	8.10	1.91	7.7
75.1 - 100.0	16000	33449	2.09	2.84	30.3
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	169	1.69	39.64	10.4
0.1 - 25.0	37200	256270	6.89	2.14	7.8
25.1 - 50.0	14300	92186	6.45	1.66	12.7
50.1 - 75.0	4400	5717	1.30	3.17	60.8
75.1 - 100.0	3800	9	<0.01	100.00	82.8
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	193948	4.31	1.93	9.2
0.1 - 25.0	14700	160027	10.88	3.90	8.9
25.1 - 50.0	100	376	13.76	0.90	3.4

TABLE A5.4: POPULATION OF GOATS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	22245	0.97	8.01	17.9
0.1 - 25.0	14600	51706	3.54	2.31	15.5
25.1 - 50.0	11700	116283	9.94	2.09	11.6
50.1 - 75.0	8900	123809	13.91	1.28	10.6
75.1 - 100.0	1700	40307	23.71	0.70	17.8
Percentage of Green Depression with Shrub Cover.					
0	23200	27377	1.18	6.70	16.3
0.1 - 25.0	35500	310134	8.74	1.69	46.9
25.1 - 50.0	1100	16840	15.31	1.28	28.1
Percentage of Green Depression with Grass Cover.					
0	22900	22245	0.97	8.01	17.9
0.1 - 25.0	5100	87424	17.14	0.89	10.9
25.1 - 50.0	9500	126437	13.31	1.66	10.2
50.1 - 75.0	11500	94570	8.22	2.22	12.6
75.1 - 100.0	10800	23674	2.19	2.21	19.9
Area of Depression as a Percentage of the Whole Grid.					
0	22900	22245	0.97	8.01	17.9
0.1 - 25.0	27800	235051	8.46	1.71	8.3
25.1 - 50.0	8800	899431	0.22	1.50	11.4
50.1 - 75.0	300	71122	3.71	1.73	42.9
Percentage of Depression which is Green.					
0	22900	22245	0.97	8.01	17.9
0.1 - 25.0	10200	1143391	1.21	1.30	11.5
25.1 - 50.0	10400	1162731	1.18	1.91	11.4
50.1 - 75.0	5400	40779	7.55	2.14	14.6
75.1 - 100.0	10900	60714	5.57	1.51	17.7
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	296345	6.01	1.95	7.4
0.1 - 25.0	6200	24928	4.02	2.86	24.6
25.1 - 50.0	2900	22133	7.63	2.76	17.0
50.1 - 75.0	1100	10494	9.54	1.53	35.6
75.1 - 100.0	300	451	1.50	6.65	53.9
Percentage of the Trees in Depressions which are Dead.					
0	45400	214741	4.73	2.39	8.3
0.1 - 25.0	14100	138035	9.79	1.52	10.6
25.1 - 50.0	300	1575	5.25	3.43	56.1
Percentage of the Trees outside Depressions which are Dead.					
0	31000	199119	6.42	2.51	9.2
0.1 - 25.0	23700	154225	6.51	1.42	9.5
25.1 - 50.0	3700	1001	0.27	7.49	57.2
50.1 - 75.0	1100	6	0.01	100.00	67.0

TABLE A5.5: POPULATION OF HORSES BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	7904	0.13	24.41	13.7
Administrative District (Sous-préfecture).					
Moussoro	31200	4762	0.15	2.06	16.3
Noukou	6200	224	0.04	47.32	42.2
Mao	3400	834	0.25	28.90	14.2
Massakory	1600	496	0.31	62.10	14.1
Bokoro	1500	159	0.11	0.63	51.6
Ati	4200	1191	0.28	98.66	48.0
Djedda	11700	238	0.02	0.00	33.1
Incidence of Erosion.					
None	44400	4518	0.10	17.97	18.1
Gully	11200	2106	0.19	7.12	12.9
Sheet	4200	1279	0.30	75.61	53.6
Incidence of Open Water.					
None	32700	2147	0.07	11.18	32.9
Pool	24500	4521	0.18	12.30	10.6
River	900	243	0.27	57.61	27.7
Inundated Plain	1700	993	0.58	100.00	56.2
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	7765	0.13	24.84	14.0
25.1 - 50.0	500	138	0.28	0.00	43.9
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	93	0.09	100.00	0.0
0.1 - 25.0	53500	6943	0.13	22.20	15.3
25.1 - 50.0	4400	761	0.17	36.40	17.9
50.1 - 75.0	900	106	0.12	16.04	25.8
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	27	0.01	62.96	57.9
25.1 - 50.0	15000	2027	0.14	24.12	17.5
50.1 - 75.0	23900	4914	0.21	23.63	17.6
75.1 - 100.0	16000	936	0.06	27.99	26.3
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	20	0.20	0.00	76.3
0.1 - 25.0	37200	5651	0.15	30.54	14.4
25.1 - 50.0	14300	2203	0.15	9.21	31.4
50.1 - 75.0	4400	30	0.01	0.00	83.1
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	3200	0.07	1.91	15.4
0.1 - 25.0	14700	4633	0.32	39.00	18.3
25.1 - 50.0	100	71	0.71	85.92	25.7

TABLE A5.5: POPULATION OF HORSES BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	1955	0.09	71.56	34.9
0.1 - 25.0	14600	1123	0.08	16.83	18.2
25.1 - 50.0	11700	2865	0.24	6.14	21.6
50.1 - 75.0	8900	1653	0.19	8.65	15.2
75.1 - 100.0	1700	307	0.18	6.84	24.4
Percentage of Green Depression with Shrub Cover.					
0	23200	1956	0.08	71.57	35.1
0.1 - 25.0	35500	5810	0.16	7.42	13.2
25.1 - 50.0	1100	138	0.13	71.01	60.8
Percentage of Green Depression with Grass Cover.					
0	22900	1955	0.09	71.56	34.9
0.1 - 25.0	5100	932	0.18	4.61	21.2
25.1 - 50.0	9500	2366	0.25	7.31	23.5
50.1 - 75.0	11500	1858	0.16	13.19	13.5
75.1 - 100.0	10800	792	0.07	8.71	22.0
Area of Depression as a Percentage of the Whole Grid.					
0	22900	1955	0.09	71.56	34.9
0.1 - 25.0	27800	3785	0.14	12.60	10.2
25.1 - 50.0	8800	2045	0.23	2.54	26.0
50.1 - 75.0	300	119	0.40	0.00	50.1
Percentage of Depression which is Green.					
0	22900	1955	0.09	71.56	34.9
0.1 - 25.0	10200	2488	0.24	8.60	21.0
25.1 - 50.0	10400	1931	0.19	8.91	15.2
50.1 - 75.0	5400	729	0.13	10.01	22.0
75.1 - 100.0	10900	801	0.07	8.86	16.2
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	5842	0.12	30.97	14.1
0.1 - 25.0	6200	825	0.13	8.24	27.4
25.1 - 50.0	2900	1122	0.39	4.19	42.8
50.1 - 75.0	1100	72	0.07	4.17	37.5
75.1 - 100.0	300	41	0.14	4.88	29.7
Percentage of the Trees in Depressions which are Dead.					
0	45400	5960	0.13	31.43	18.0
0.1 - 25.0	14100	1914	0.14	2.93	13.5
25.1 - 50.0	300	30	0.10	0.00	94.8
Percentage of the Trees outside Depressions which are Dead.					
0	31000	5384	0.17	34.58	16.0
0.1 - 25.0	23700	2520	0.11	2.62	25.8

TABLE A5.6: POPULATION OF DONKEYS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	8251	0.14	55.23	11.6
Administrative District (Sous-préfecture).					
Moussoro	31200	3196	0.10	20.34	11.7
Noukou	6200	159	0.03	50.31	54.9
Mao	3400	1913	0.56	78.83	10.8
Massakory	1600	852	0.53	88.38	19.9
Bokoro	1500	17	0.01	5.88	1.6
Ati	4200	1628	0.39	96.13	47.3
Djedda	11700	487	0.04	0.00	31.5
Incidence of Erosion.					
None	44400	4509	0.10	51.67	9.4
Gully	11200	2266	0.20	42.45	11.8
Sheet	4200	1476	0.35	85.70	58.0
Incidence of Open Water.					
None	32700	2299	0.07	41.28	14.0
Pool	24500	4446	0.18	48.65	8.3
River	900	204	0.23	85.78	32.2
Inundated Plain	1700	1301	0.77	97.54	54.0
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	8172	0.14	55.75	11.7
25.1 - 50.0	500	79	0.16	0.00	63.2
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	117	0.12	100.00	0.0
0.1 - 25.0	53500	6114	0.11	50.00	15.1
25.1 - 50.0	4400	1886	0.43	67.71	11.9
50.1 - 75.0	900	135	0.15	77.78	16.8
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	104	0.02	100.00	28.9
25.1 - 50.0	15000	2793	0.19	55.93	11.1
50.1 - 75.0	23900	4191	0.18	60.18	18.3
75.1 - 100.0	16000	1164	0.07	31.62	19.6
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	49	0.49	0.00	39.7
0.1 - 25.0	37200	6904	0.19	59.82	13.1
25.1 - 50.0	14300	1100	0.08	38.73	23.7
50.1 - 75.0	4400	198	0.04	0.00	22.7
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	2609	0.06	9.16	15.7
0.1 - 25.0	14700	5565	0.38	76.19	14.8
25.1 - 50.0	100	77	0.77	100.00	19.2

TABLE A5.6: POPULATION OF DONKEYS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	2530	0.11	69.57	31.2
0.1 - 25.0	14600	1020	0.07	61.27	18.8
25.1 - 50.0	11700	2504	0.21	44.93	11.3
50.1 - 75.0	8900	1872	0.21	48.56	13.0
75.1 - 100.0	1700	325	0.19	42.15	13.5
Percentage of Green Depression with Shrub Cover.					
0	23200	2531	0.11	69.58	31.4
0.1 - 25.0	35500	5659	0.16	48.84	68.1
25.1 - 50.0	1100	61	0.06	52.46	78.3
Percentage of Green Depression with Grass Cover.					
0	22900	2530	0.11	69.57	31.2
0.1 - 25.0	5100	646	0.13	43.50	18.8
25.1 - 50.0	9500	2481	0.26	44.05	10.1
50.1 - 75.0	11500	1891	0.16	51.03	13.0
75.1 - 100.0	10800	702	0.07	65.24	21.1
Area of Depression as a Percentage of the Whole Grid.					
0	22900	2530	0.11	69.57	31.2
0.1 - 25.0	27800	4766	0.17	51.51	8.8
25.1 - 50.0	8800	847	0.10	40.26	18.6
50.1 - 75.0	300	109	0.36	0.00	65.1
Percentage of Depression which is Green.					
0	22900	2530	0.11	69.57	31.2
0.1 - 25.0	10200	1605	0.16	48.22	15.2
25.1 - 50.0	10400	2173	0.21	50.53	12.5
50.1 - 75.0	5400	882	0.16	52.95	19.6
75.1 - 100.0	10900	1061	0.10	43.07	16.9
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	6912	0.14	54.73	13.6
0.1 - 25.0	6200	796	0.13	53.64	19.6
25.1 - 50.0	2900	459	0.16	67.76	23.3
50.1 - 75.0	1100	72	0.07	31.94	25.6
75.1 - 100.0	300	13	0.04	100.00	218.9
Percentage of the Trees in Depressions which are Dead.					
0	45400	6490	0.14	64.73	14.4
0.1 - 25.0	14100	1682	0.12	21.11	15.5
25.1 - 50.0	300	79	0.26	0.00	14.0
Percentage of the Trees outside Depressions which are Dead.					
0	31000	6413	0.21	65.40	14.9
0.1 - 25.0	23700	1686	0.07	21.53	15.4
25.1 - 50.0	3700	152	0.04	0.00	50.1

TABLE A5.7: POPULATION OF ALL SMALL RUMINANTS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
All Strata	59800	683026	11.42	4.47	7.6
Administrative District (Sous-préfecture).					
Moussoro	31200	468233	15.01	3.25	8.5
Noukou	6200	5815	0.94	8.39	32.7
Mao	3400	69637	20.48	5.54	8.5
Massakory	1600	15561	9.73	14.65	13.2
Bokoro	1500	10593	7.06	4.92	33.3
Ati	4200	13157	3.13	43.28	31.3
Djedda	11700	100029	8.55	2.50	22.5
Incidence of Erosion.					
None	44400	338627	7.63	5.01	11.1
Gully	11200	296121	26.44	3.09	8.6
Sheet	4200	48278	11.49	9.25	31.5
Incidence of Open Water.					
None	32700	197616	6.04	3.20	14.3
Pool	24500	461295	18.83	3.92	9.3
River	900	16098	17.89	11.03	29.4
Inundated Plain	1700	8017	4.72	54.52	42.9
Total Tree Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	59300	675502	11.39	4.48	7.7
25.1 - 50.0	500	7524	15.05	4.12	17.9
Total Shrub Cover as a Percentage of the Whole Grid.					
0	1000	515	0.51	100.00	12.5
0.1 - 25.0	53500	593777	11.10	4.11	8.5
25.1 - 50.0	4400	82580	18.77	6.30	12.6
50.1 - 75.0	900	6154	6.84	7.60	16.4
Total Grass Cover as a Percentage of the Whole Grid.					
0.1 - 25.0	4800	7680	1.60	6.80	45.1
25.1 - 50.0	15000	228766	15.25	4.54	12.7
50.1 - 75.0	23900	356899	14.93	4.35	9.7
75.1 - 100.0	16000	89680	5.61	4.62	27.5
Total Bare Ground Cover as a Percentage of the Whole Grid.					
0	100	473	4.73	61.31	3.7
0.1 - 25.0	37200	452923	12.18	5.08	8.2
25.1 - 50.0	14300	220695	15.43	2.95	15.6
50.1 - 75.0	4400	8897	2.02	8.13	59.7
75.1 - 100.0	3800	39	0.01	100.00	82.8
Cultivated Land as a Percentage of the Whole Grid.					
0	45000	457076	10.16	3.58	10.2
0.1 - 25.0	14700	225263	15.32	6.19	8.3
25.1 - 50.0	100	687	6.87	35.23	1.8

TABLE A5.7: POPULATION OF ALL SMALL RUMINANTS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	% OF ANIMALS HIDDEN	%SE
Percentage of Green Depression with Tree Cover.					
0	22900	70847	3.09	12.80	18.0
0.1 - 25.0	14600	131402	9.00	3.88	16.5
25.1 - 50.0	11700	200640	17.15	4.60	12.2
50.1 - 75.0	8900	200513	22.53	3.00	11.2
75.1 - 100.0	1700	79624	46.84	1.45	21.2
Percentage of Green Depression with Shrub Cover.					
0	23200	78879	3.40	11.59	16.8
0.1 - 25.0	35500	573893	16.17	3.56	78.2
25.1 - 50.0	1100	30254	27.50	3.18	28.4
Percentage of Green Depression with Grass Cover.					
0	22900	70847	3.09	12.80	18.0
0.1 - 25.0	5100	162217	31.81	1.94	15.7
25.1 - 50.0	9500	210049	22.11	3.90	10.4
50.1 - 75.0	11500	162197	14.10	4.88	12.7
75.1 - 100.0	10800	77715	7.20	2.87	23.7
Area of Depression as a Percentage of the Whole Grid.					
0	22900	70847	3.09	12.80	18.0
0.1 - 25.0	27800	430217	15.48	3.80	9.5
25.1 - 50.0	8800	165238	18.78	2.80	14.6
50.1 - 75.0	300	16724	55.75	3.18	53.5
Percentage of Depression which is Green.					
0	22900	70847	3.09	12.80	18.0
0.1 - 25.0	10200	20149	19.75	2.94	13.9
25.1 - 50.0	10400	207398	19.94	4.26	11.5
50.1 - 75.0	5400	74052	13.71	4.13	17.6
75.1 - 100.0	10900	129238	11.86	2.84	19.0
Percentage of the Trees in Depressions which are Dum Palms.					
0	49300	579949	11.76	4.47	8.3
0.1 - 25.0	6200	55119	8.89	4.81	26.1
25.1 - 50.0	2900	31654	10.92	5.02	18.2
50.1 - 75.0	1100	15676	14.25	2.25	32.7
75.1 - 100.0	300	629	2.10	10.97	48.0
Percentage of the Trees in Depressions which are Dead.					
0	45400	433556	9.55	5.18	9.9
0.1 - 25.0	14100	246523	17.48	3.19	11.4
25.1 - 50.0	300	2947	9.82	7.91	88.3
Percentage of the Trees outside Depressions which are Dead.					
0	31000	345339	11.14	6.17	10.9
0.1 - 25.0	23700	335686	14.16	2.65	10.4
25.1 - 50.0	3700	1975	0.53	16.35	52.5
50.1 - 75.0	1100	26	0.02	100.00	67.0

TABLE A5.8: POPULATION OF TENTS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
All Strata	59800	31309	0.52	7.7
Administrative District (Sous-préfecture).				
Moussoro	31200	24284	0.78	8.0
Noukou	6200	484	0.08	27.7
Mao	3400	957	0.28	17.9
Massakory	1600	739	0.46	39.4
Bokoro	1500	789	0.53	61.6
Ati	4200	235	0.06	79.6
Djedda	11700	3820	0.33	21.1
Incidence of Erosion.				
None	44400	19535	0.44	9.8
Gully	11200	11335	1.01	12.5
Sheet	4200	439	0.10	37.1
Incidence of Open Water.				
None	32700	7646	0.23	10.7
Pool	24500	22011	0.90	9.1
River	900	1652	1.84	43.5
Total Tree Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	59300	30837	0.52	7.9
25.1 - 50.0	500	472	0.94	32.5
Total Shrub Cover as a Percentage of the Whole Grid.				
0	1000	79	0.08	100.3
0.1 - 25.0	53500	26560	0.50	8.1
25.1 - 50.0	4400	4011	0.91	27.8
50.1 - 75.0	900	659	0.73	16.3
Total Grass Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	4800	342	0.07	58.0
25.1 - 50.0	15000	10829	0.72	14.3
50.1 - 75.0	23900	15409	0.64	10.3
75.1 - 100.0	16000	4728	0.30	18.2
Total Bare Ground Cover as a Percentage of the Whole Grid.				
0	100	443	4.43	5.7
0.1 - 25.0	37200	21471	0.58	9.5
25.1 - 50.0	14300	8148	0.57	15.5
50.1 - 75.0	4400	1188	0.27	21.8
75.1 - 100.0	3800	59	0.02	82.8
Cultivated Land as a Percentage of the Whole Grid.				
0	45000	23793	0.53	9.4
0.1 - 25.0	14700	7516	0.51	10.9

TABLE A5.8: POPULATION OF TENTS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
Percentage of Green Depression with Tree Cover.				
0	22900	5241	0.23	16.0
0.1 - 25.0	14600	5130	0.35	20.4
25.1 - 50.0	11700	12032	1.03	11.6
50.1 - 75.0	8900	7623	0.86	16.9
75.1 - 100.0	1700	1282	0.75	21.1
Percentage of Green Depression with Shrub Cover.				
0	23200	5572	0.24	15.1
0.1 - 25.0	35500	24455	0.69	8.8
25.1 - 50.0	1100	1283	1.17	26.2
Percentage of Green Depression with Grass Cover.				
0	22900	5241	0.23	16.0
0.1 - 25.0	5100	4069	0.80	17.0
25.1 - 50.0	9500	10154	1.07	14.4
50.1 - 75.0	11500	10414	0.91	12.7
75.1 - 100.0	10800	1431	0.13	32.1
Area of Depression as a Percentage of the Whole Grid.				
0	22900	5241	0.23	16.0
0.1 - 25.0	27800	18603	0.67	10.3
25.1 - 50.0	8800	6654	0.76	15.3
50.1 - 75.0	300	810	2.70	49.4
Percentage of Depression which is Green.				
0	22900	5241	0.23	16.0
0.1 - 25.0	10200	7246	0.71	15.7
25.1 - 50.0	10400	10383	1.00	13.4
50.1 - 75.0	5400	3944	0.73	22.0
75.1 - 100.0	10900	4495	0.41	14.3
Percentage of the Trees in Depressions which are Dum Palms.				
0	49300	24619	0.50	8.8
0.1 - 25.0	6200	3031	0.49	25.9
25.1 - 50.0	2900	2546	0.88	19.7
50.1 - 75.0	1100	965	0.88	39.5
75.1 - 100.0	300	147	0.49	39.8
Percentage of the Trees in Depressions which are Dead.				
0	45400	18277	0.40	10.5
0.1 - 25.0	14100	12677	0.90	11.2
25.1 - 50.0	300	355	1.18	49.4
Percentage of the Trees outside Depressions which are Dead.				
0	31000	17432	0.56	11.0
0.1 - 25.0	23700	13345	0.56	11.2
25.1 - 50.0	3700	492	0.13	32.3
50.1 - 75.0	1100	40	0.04	67.0

TABLE A5.9: POPULATION OF THATCHED DWELLINGS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
All Strata	59800	60372	1.01	19.6
Administrative District (Sous-préfecture).				
Moussoro	31200	9385	0.30	18.8
Noukou	6200	1228	0.20	58.4
Mao	3400	15261	4.49	8.5
Massakory	1600	9110	5.69	25.1
Bokoro	1500	16	0.01	30.6
Ati	4200	25372	6.04	46.4
Incidence of Erosion.				
None	44400	29157	0.66	11.9
Gully	11200	11506	1.03	16.2
Sheet	4200	19710	4.69	59.7
Incidence of Open Water.				
None	32700	12333	0.38	17.3
Pool	24500	24898	1.02	16.0
River	900	3236	3.60	33.2
Inundated Plain	1700	19906	11.71	51.5
Total Tree Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	59300	60372	1.02	19.6
Total Shrub Cover as a Percentage of the Whole Grid.				
0	1000	2164	2.16	0.0
0.1 - 25.0	53500	43674	0.82	26.6
25.1 - 50.0	4400	13503	3.07	13.7
50.1 - 75.0	900	1031	1.15	18.1
Total Grass Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	4800	999	0.21	19.6
25.1 - 50.0	15000	19371	1.29	13.4
50.1 - 75.0	23900	33272	1.39	32.8
75.1 - 100.0	16000	6730	0.42	10.3
Total Bare Ground Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	37200	52833	1.42	21.5
25.1 - 50.0	14300	7540	0.53	44.0
Cultivated Land as a Percentage of the Whole Grid.				
0	45000	3437	0.08	50.5
0.1 - 25.0	14700	55857	3.80	21.3
25.1 - 50.0	100	1079	10.79	2.1

TABLE A5.9: POPULATION OF THATCHED DWELLINGS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
Percentage of Green Depression with Tree Cover.				
0	22900	26798	1.17	39.9
0.1 - 25.0	14600	8525	0.58	23.6
25.1 - 50.0	11700	12997	1.11	15.3
50.1 - 75.0	8900	10105	1.14	11.1
75.1 - 100.0	1700	1947	1.15	30.4
Percentage of Green Depression with Shrub Cover.				
0	23200	26812	1.16	40.1
0.1 - 25.0	35500	32971	0.93	10.5
25.1 - 50.0	1100	589	0.54	68.4
Percentage of Green Depression with Grass Cover.				
0	22900	26798	1.17	39.9
0.1 - 25.0	5100	3737	0.73	17.9
25.1 - 50.0	9500	12027	1.27	12.0
50.1 - 75.0	11500	11149	0.97	16.9
75.1 - 100.0	10800	6662	0.62	24.0
Area of Depression as a Percentage of the Whole Grid.				
0	22900	26798	1.17	39.9
0.1 - 25.0	27800	29111	1.05	11.4
25.1 - 50.0	8800	4464	0.51	24.0
Percentage of Depression which is Green.				
0	22900	26798	1.17	39.9
0.1 - 25.0	10200	9528	0.93	20.3
25.1 - 50.0	10400	12522	1.20	17.0
50.1 - 75.0	5400	5593	1.04	27.9
75.1 - 100.0	10900	5932	0.54	20.4
Percentage of the Trees in Depressions which are Dum Palms.				
0	49300	50943	1.03	23.2
0.1 - 25.0	6200	4557	0.73	21.8
25.1 - 50.0	2900	4258	1.47	32.4
50.1 - 75.0	1100	400	0.36	15.5
75.1 - 100.0	300	215	0.72	19.6
Percentage of the Trees in Depressions which are Dead.				
0	45400	56330	1.24	21.4
0.1 - 25.0	14100	4042	0.29	25.8
Percentage of the Trees outside Depressions which are Dead.				
0	31000	56686	1.83	21.7
0.1 - 25.0	23700	3687	0.16	27.0

TABLE A5.10: POPULATION OF MUD ROOFED DWELLINGS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
All Strata	59800	19638	0.33	17.9
Administrative District (Sous-préfecture).				
Moussoro	31200	2176	0.07	35.3
Noukou	6200	201	0.03	97.0
Mao	3400	10359	3.05	9.1
Massakory	1600	3955	2.47	22.8
Ati	4200	2947	0.70	81.6
Incidence of Erosion.				
None	44400	11448	0.26	14.8
Gully	11200	5156	0.46	11.2
Sheet	4200	3034	0.72	85.3
Incidence of Open Water.				
None	32700	4290	0.13	14.1
Pool	24500	12401	0.51	14.7
Inundated Plain	1700	2947	1.73	82.17
Total Tree Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	59300	19638	0.33	17.9
Total Shrub Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	53500	10582	0.20	30.1
25.1 - 50.0	4400	8303	1.89	13.6
50.1 - 75.0	900	753	0.84	27.2
Total Grass Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	4800	753	0.16	42.2
25.1 - 50.0	15000	7821	0.52	18.6
50.1 - 75.0	23900	10995	0.46	25.7
75.1 - 100.0	16000	69	<0.01	92.4
Total Bare Ground Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	37200	19353	0.52	17.1
25.1 - 50.0	14300	285	0.02	96.9
Cultivated Land as a Percentage of the Whole Grid.				
0	45000	805	0.02	57.7
0.1 - 25.0	14700	18547	1.26	18.8
25.1 - 50.0	100	287	2.87	7.2

TABLE A5.10: POPULATION OF MUD ROOFED DWELLINGS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
Percentage of Green Depression with Tree Cover.				
0	22900	4742	0.21	70.3
0.1 - 25.0	14600	2490	0.17	31.9
25.1 - 50.0	11700	6418	0.55	16.9
50.1 - 75.0	8900	5500	0.62	10.1
75.1 - 100.0	1700	489	0.29	35.0
Percentage of Green Depression with Shrub Cover.				
0	23200	4742	0.20	57.9
0.1 - 25.0	35500	14896	0.42	16.0
Percentage of Green Depression with Grass Cover.				
0	22900	4742	0.21	57.5
0.1 - 25.0	5100	1197	0.23	22.8
25.1 - 50.0	9500	6714	0.71	9.9
50.1 - 75.0	11500	5503	0.48	19.6
75.1 - 100.0	10800	1483	0.14	34.1
Area of Depression as a Percentage of the Whole Grid.				
0	22900	4742	0.21	57.5
0.1 - 25.0	27800	13384	0.48	11.4
25.1 - 50.0	8800	1512	0.17	24.9
Percentage of Depression which is Green.				
0	22900	4742	0.21	57.5
0.1 - 25.0	10200	3931	0.39	20.0
25.1 - 50.0	10400	6390	0.61	16.7
50.1 - 75.0	5400	2498	0.46	25.1
75.1 - 100.0	10900	2077	0.19	27.0
Percentage of the Trees in Depressions which are Dum Palms.				
0	49300	15635	0.32	22.1
0.1 - 25.0	6200	2740	0.44	22.2
25.1 - 50.0	2900	1223	0.42	42.0
50.1 - 75.0	1100	20	0.02	39.5
75.1 - 100.0	300	20	0.07	63.2
Percentage of the Trees in Depressions which are Dead.				
0	45400	17563	0.39	20.2
0.1 - 25.0	14100	2075	0.15	27.2
Percentage of the Trees outside Depressions which are Dead.				
0	31000	17160	0.55	20.8
0.1 - 25.0	23700	2478	0.10	26.3

TABLE A5.11: POPULATION OF ALL PERMANENT DWELLINGS BY LAND USE STRATA.

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
All Strata	59800	80010	1.34	18.9
Administrative District (Sous-préfecture).				
Moussoro	31200	11561	0.37	20.4
Noukou	6200	1430	0.23	62.2
Mao	3400	25619	7.54	11.7
Massakory	1600	13065	8.17	25.3
Bokoro	1500	16	0.01	30.6
Ati	4200	28319	6.74	49.2
Incidence of Erosion.				
None	44400	40605	0.91	12.0
Gully	11200	16662	1.49	14.2
Sheet	4200	22744	5.42	65.6
Incidence of Open Water.				
None	32700	16623	0.51	16.1
Pool	24500	37298	1.52	15.0
River	900	3236	3.60	33.2
Inundated Plain	1700	22853	13.44	54.8
Total Tree Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	59300	80010	1.35	18.9
Total Shrub Cover as a Percentage of the Whole Grid.				
0	1000	2164	2.16	0.0
0.1 - 25.0	53500	54256	1.01	27.3
25.1 - 50.0	4400	21806	4.96	13.4
50.1 - 75.0	900	1784	1.98	21.4
Total Grass Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	4800	1753	0.37	20.5
25.1 - 50.0	15000	27191	1.81	14.1
50.1 - 75.0	23900	44267	1.85	30.4
75.1 - 100.0	16000	6799	0.42	12.4
Total Bare Ground Cover as a Percentage of the Whole Grid.				
0.1 - 25.0	37200	72186	1.94	20.1
25.1 - 50.0	14300	7825	0.55	47.5
Cultivated Land as a Percentage of the Whole Grid.				
0	45000	4242	0.09	46.4
0.1 - 25.0	14700	74403	5.06	20.4
25.1 - 50.0	100	1366	13.66	1.5

TABLE A5.11: POPULATION OF ALL PERMANENT DWELLINGS BY LAND USE STRATA (cont).

STRATUM TYPE OR % COVER	AREA OF STRATUM (km ²)	TOTAL POPULATION	DENSITY (per km ²)	%SE
Percentage of Green Depression with Tree Cover.				
0	22900	31540	1.38	42.5
0.1 - 25.0	14600	11015	0.75	21.9
25.1 - 50.0	11700	19414	1.66	15.2
50.1 - 75.0	8900	15605	1.75	10.0
75.1 - 100.0	1700	2436	1.43	29.2
Percentage of Green Depression with Shrub Cover.				
0	23200	31554	1.36	42.8
0.1 - 25.0	35500	47867	1.35	10.0
25.1 - 50.0	1100	589	0.54	68.1
Percentage of Green Depression with Grass Cover.				
0	22900	31540	1.38	42.5
0.1 - 25.0	5100	4934	0.97	17.8
25.1 - 50.0	9500	18741	1.97	10.6
50.1 - 75.0	11500	16652	1.45	16.9
75.1 - 100.0	10800	8144	0.75	22.8
Area of Depression as a Percentage of the Whole Grid.				
0	22900	31540	1.38	42.5
0.1 - 25.0	27800	42495	1.53	10.9
25.1 - 50.0	8800	5976	0.68	20.2
Percentage of Depression which is Green.				
0	22900	31540	1.38	42.5
0.1 - 25.0	10200	13459	1.32	19.1
25.1 - 50.0	10400	18912	1.82	16.0
50.1 - 75.0	5400	8091	1.50	26.4
75.1 - 100.0	10900	8009	0.73	20.4
Percentage of the Trees in Depressions which are Dum Palms.				
0	49300	66578	1.35	22.7
0.1 - 25.0	6200	7297	1.18	20.2
25.1 - 50.0	2900	5481	1.89	34.6
50.1 - 75.0	1100	420	0.38	13.9
75.1 - 100.0	300	235	0.78	23.3
Percentage of the Trees in Depressions which are Dead.				
0	45400	73893	1.63	20.8
0.1 - 25.0	14100	6117	0.43	25.4
Percentage of the Trees outside Depressions which are Dead.				
0	31000	73846	2.38	21.3
0.1 - 25.0	23700	6164	0.26	24.4

APPENDIX 6. MULTIPLE REGRESSION ANALYSES

This Appendix presents the summarised results of a series of multiple regression analyses, designed to provide preliminary indications of the interrelationships between livestock numbers, habitation numbers and the vegetation parameters assessed from the air (Section 3.1). The results are summarised briefly in Section 3.6.

Tables A6.1 and A6.2 contain the correlation coefficients for all parameters included, together with their significance levels. The remaining Tables give the multiple regression equations, and the relevant statistical data associated with each. In order to provide the flexibility of interpretation that may be required in due course, four sets of regressions were carried out:

- habitation numbers with vegetation parameters;
- livestock numbers with habitation numbers;
- livestock numbers with vegetation parameters;
- livestock numbers with vegetation parameters and habitation numbers.

When examining these Tables the following should be borne in mind:

- a). The regressions carried out were stepwise, using SPSSPC, with the order of inclusion of each independent parameter determined by sequential significance levels.
- b). The value for R^2 (proportion of variance explained) given is corrected for interrelationships between the independent parameters, as is the regression coefficient. The F ratio and significance levels are derived from parallel ANOVA calculations.
- c). In order to obtain true estimates of statistical significance, all livestock and habitation numbers are included in their 'raw' form - that is as numbers within the nominal sample strip width of 1.012 km. Thus estimated numbers within the entire grid may be derived by multiplying these data by 9.8814. The livestock numbers are totals, i.e. observed plus hidden animals.
- d). It is well known that water has a marked affect on livestock numbers. However, the presence or absence of water in each survey grid was assessed from the air on a ranking system (Section 3.1), and thus could not be included directly within these calculations. In order to permit some account to be taken of this variable, the records of water availability have been transformed as follows: Pools Present = 1%; Rivers Present = 5%; Flood Plain Present = 10%.

Table A6.1a: Correlation Coefficients of Livestock and Habitation Numbers with Vegetation

	Outside Depressions (% of Grid)			% Trees Dead	% Bare Ground
Number of:	% Trees	% Shrubs	% Grass		
Habitation					
Tents	0.2012**	0.1697**	-0.0507	0.1317**	-0.1907**
Thatch	-0.0054	0.0765	0.0143	0.0819	-0.0677
Mud	-0.0340	0.2249**	-0.0446	0.0825	-0.1016*
Permanent	-0.0125	0.1156*	0.0007	0.0855	-0.0788
Livestock					
TLU	0.2066**	0.1711**	-0.0262	-0.1481**	-0.2170**
Camels	-0.1201*	-0.1118*	0.0877	0.0631	0.0890
Cattle	0.2198**	0.1833**	-0.0408	-0.1497**	-0.2163**
Sheep	0.1075*	0.0304	-0.0132	-0.0770	-0.1069*
Goats	0.1929**	0.2295**	-0.0621	-0.1477**	-0.2717**
Horses	0.0549	0.0701	0.0189	-0.1176*	-0.1473**
Donkeys	0.0114	0.1616**	0.0021	-0.1131*	-0.1309**
All S. Rum.	0.1650**	0.1287**	-0.0382	-0.1227*	-0.2016**
All Equines	0.0367	0.1286**	0.0116	-0.1279**	-0.1543**

N of cases:598 I-tailed Significance Levels: * $p < 0.01$ ** $p < 0.001$

Table A6.1b: Correlation Coefficients of Livestock and Habitation Numbers with Vegetation (continued)

	Inside Depressions (% of Grid)			% Green Patch	% Bare Ground
Number of:	% Trees	% Shrubs	% Grass		
Habitation					
Tents	0.2424**	0.1691**	0.0500	0.1608**	0.2338**
Thatch	-0.0009	-0.0243	-0.0347	-0.0288	-0.0184
Mud	0.0565	-0.0044	-0.0045	0.0200	0.0129
Permanent	0.0129	-0.0205	-0.0289	-0.0182	-0.0116
Livestock					
TLU	0.2218**	0.1075*	0.0188	0.1213*	0.2415**
Camels	-0.1046*	-0.0772	-0.1352**	-0.1527**	-0.1379**
Cattle	0.2158**	0.1121*	0.0435	0.1374**	0.2438**
Sheep	0.1391**	0.0768	0.0425	0.0997*	0.1624**
Goats	0.3731**	0.1600**	0.0092	0.1852**	0.3374**
Horses	0.1062*	-0.0135	-0.0158	0.0316	0.1481**
Donkeys	0.0814	-0.0140	-0.0204	0.0177	0.0356
All S. Rum.	0.2714**	0.1283**	0.0338	0.1560**	0.2708**
All Equines	0.1040*	-0.0153	-0.0201	0.0274	0.1017*

N of cases:598 1-tailed Significance Levels: * $p < 0.01$ ** $p < 0.001$

Table A6.1c: Correlation Coefficients of Livestock and Habitation Numbers with Vegetation (continued)

Number of:	% of Depr.	% of Green	Depression		% Trees in Depression	
	% Green	% Trees	% Shrub	% Grass	Dead	Dum Palm
Habitation						
Tents	0.0698	0.2588**	0.1894**	0.0493	0.0949	0.0660
Thatch	-0.0298	0.0107	-0.0235	-0.0344	0.0507	0.0040
Mud	0.0166	0.0919	0.0014	0.0014	0.0525	0.0102
Permanent	-0.0199	0.0307	-0.0185	-0.0263	0.0533	0.0056
Livestock						
TLU	0.0319	0.2815**	0.1358**	0.0167	0.0140	0.1003*
Camels	-0.1270**	-0.1200*	-0.0800	-0.1456**	-0.0576	-0.0992*
Cattle	0.0440	0.2682**	0.1280**	0.0402	0.0188	0.1291**
Sheep	0.0749	0.1958**	0.1353**	0.0449	0.0460	-0.0359
Goats	0.1316**	0.4916**	0.2842**	0.0484	0.0588	0.0189
Horses	-0.0169	0.1268**	0.0211	0.0113	-0.0204	0.0449
Donkeys	0.0035	0.1073*	0.0010	-0.0167	-0.0240	-0.0173
All S. Rum.	0.1137*	0.3663**	0.2271**	0.0538	0.0594	-0.0160
All Equines	-0.0074	0.1298**	0.0122	-0.0030	-0.0246	0.0152

N of cases:598 1-tailed Significance Levels: * $p < 0.01$ ** $p < 0.001$

Table A6.1d: Correlation Coefficients of Livestock and Habitation Numbers with Vegetation (continued)

	All (% of Grid)						
Number of:	% Trees	% Shrubs	% Grass	% Bare Ground	Cultiv- ation	% Depr- ession	% Water
Habitations							
Tents	0.2817**	0.1823**	-0.0414	-0.1072*	0.0490	0.2523**	0.0510
Thatch	-0.0049	0.0743	0.0074	-0.0793	0.3387**	0.0280	0.3168**
Mud	-0.0009	0.2236**	-0.0466	-0.1025*	0.3920**	0.0195	0.1452**
Permanent	-0.0041	0.1135*	-0.0054	-0.0883	0.3660**	0.0177	0.2888**
Livestock							
TLU	0.2762**	0.1788**	-0.0229	-0.1319**	0.0354	0.2381**	0.0961*
Camels	-0.1489**	-0.1174*	0.0614	0.0383	-0.0624	-0.1780**	-0.0714
Cattle	0.2842**	0.1914**	-0.0326	-0.1303**	0.0356	0.2478**	0.1055*
Sheep	0.1550**	0.0363	-0.0045	-0.0473	-0.0271	0.1692**	0.0307
Goats	0.3374**	0.2412**	-0.0616	-0.1509**	0.1458**	0.3405**	0.0346
Horses	0.0960*	0.0687	0.0161	-0.0960*	0.2173**	0.1244*	0.1993**
Donkeys	0.0483	0.1598**	-0.0021	-0.1243*	0.3554**	0.0350	0.2511**
All S. Rum.	0.2657**	0.1383**	-0.0320	-0.1036*	0.0495	0.2770**	0.0375
All Equines	0.0800	0.1268**	0.0077	-0.1222*	0.3177**	0.0883	0.2498**

N of cases:598 1-tailed Significance Levels: * $p < 0.01$ ** $p < 0.001$

Table A6.2: Correlation Coefficients of Livestock with Habitation Numbers

Animal Sp:	Number of Dwellings:			
	Thatched	Mud	Tent	Permanent
TLU	0.0344	0.0436	0.5964**	0.0381
Camels	-0.0159	-0.0260	-0.0070	-0.0190
Cattle	0.0127	0.0236	0.5833**	0.0159
Sheep	0.0379	0.0379	0.2154**	0.0395
Goats	0.0446	0.1079*	0.4043**	0.0618
Horses	0.6297**	0.4806**	0.1375**	0.6205**
Donkeys	0.8788**	0.7796**	0.1132*	0.8922**
All S. Rum.	0.0472	0.0769	0.3389**	0.0564
All Equines	0.8367**	0.6991**	0.1390**	0.8391**

N of cases:598 1-tailed Significance Levels: * $p < 0.01$ ** $p < 0.001$

Table A6.3: Multiple Regression Equations: Habitation in relation to Vegetation Parameters

Tents

$$X = 9.1222 + 0.422A - 0.089B + 0.178C - 0.593D + 0.177E$$

($R^2 = 0.127$; $F = 18.404$; $DF = 5,592$; $p < 0.0000$)

A = % Trees in Grid: B = % Grid outside Depressions: C = % Shrubs in Grid:

D = % Cultivation in Grid: E = % Shrubs in Green Depression.

Thatched Dwellings

$$X = 0.903 + 7.629A + 10.046B - 0.388C - 0.835D$$

($R^2 = 0.206$; $F = 39.685$; $DF = 4,593$; $p < 0.0000$)

A = % Cultivation in Grid: B = % Water in Grid: C = % Dum Palms (of Trees in Depression):

D = % Trees in Grid.

Mud Roofed Dwellings

$$X = 0.411 + 2.535A - 0.191B + 1.296C + 0.194D - 0.344E$$

($R^2 = 0.191$; $F = 29.220$; $DF = 5,592$; $p < 0.0000$)

A = % Cultivation in Grid: B = % Dum Palms (of Trees in Depression): C = % Water in Grid:

D = % Shrubs on land outside Depressions: E = % Trees on land outside Depressions.

Permanent Dwellings

$$X = 2.025 + 10.367A + 11.354B - 0.632C - 1.329D$$

($R^2 = 0.211$; $F = 40.958$; $DF = 4,593$; $p < 0.0000$)

A = % Cultivation in Grid: B = % Water in Grid: C = % Dum Palms (of Trees in Depressions):

D = % Trees on land outside Depressions.

NOTE:

X = Habitation Numbers in Nominal Sample Strip (10.12km²)

Independent Variables given in Stepwise Order

Table A6.4: Multiple Regression Equations: Livestock in relation to Habitation.

TLU

$$X = 46.549 + 9.348A \quad (R^2 = 0.355; F = 328.999; DF \ 1,596; p < 0.0000)$$

A: Number of Tents: B= Number of Permanent Dwellings.

Camels

No significant relationships.

Cattle

$$X = 37.362 + 12.287A \quad (R^2 = 0.339; F = 307.376; DF \ 1,596; p < 0.0000)$$

A=Number of Tents.

Sheep

$$X = 38.843 + 3.167A \quad (R^2 = 0.045; F = 28.999; DF \ 1,596; p < 0.0000)$$

A= Number of Tents.

Goats

$$X = 35.978 + 4.045A + 0.769B \quad (R^2 = 0.174; F = 64.086; DF \ 2,595; p < 0.0000)$$

A= Number of Tents: B= Number of Mud Roofed Dwellings.

All Small Ruminants

$$X = 73.354 + 7.227A + 1.187B \quad (R^2 = 0.119; F = 41.375; DF \ 2,595; p < 0.0000)$$

A= Number of Tents: B=Number of Mud Roofed Dwellings.

Horses

$$X = 0.472 + 0.050A + 0.066B \quad (R^2 = 0.423; F = 219.573; DF \ 2,595; p < 0.0000)$$

A= % Number of Thatched Dwellings: B=Number of Tents.

Donkeys

$$X = 0.304 + 0.057A + 0.061B \quad (R^2 = 0.818; F = 1349.668; DF \ 2,595; p < 0.0000)$$

A=Number of Permanent Dwellings: B= Number of Tents.

All Equines

$$X = 0.778 + 0.107A + 0.127B - 0.050C \quad (R^2 = 0.737; F = 557.841; DF \ 3,594; p < 0.0000)$$

A=Number of Permanent Dwellings: B= Number of Tents: C=Number of Mud Roofed Dwellings.

NOTE:

X= Animal Numbers in Nominal Sample Strip (10.12km²)

Independent Variables given in Stepwise Order

Table A6.5: Multiple Regression Equations: Livestock in relation to Vegetation Parameters

TLU

$$X = 14.826 + 1.607A + 5.747B + 1.629C + 8.504D$$

($R^2 = 0.113$; $F = 20.127$; $DF\ 4,593$; $p < 0.0000$)

A = % Trees in Green Depression: B = % Trees outside Depression: C = % Shrubs in Grid:

D = % Water in Grid.

Camels

$$X = 0.365A - 0.765B - 0.092C - 14.434 \quad (R^2 = 0.042; F = 9.691; DF\ 3,594; p < 0.0000)$$

A = % Land outside Depressions: B = % Trees on land outside Depressions: C = % Green (of Depression).

Cattle

$$X = 9.460A + 3.227B + 2.668C + 1.572D - 6.377$$

($R^2 = 0.119$; $F = 21.120$; $DF\ 4,593$; $p < 0.0000$)

A = % Trees in Grid: B = % Bare Ground (of Depression): C = % Shrubs in Grid: D = % Dum Palms (of Trees in Depression).

Sheep

$$X = 28.901 + 1.477A - 1.292B \quad (R^2 = 0.045; F = 15.000; DF\ 2,595; p < 0.0000)$$

A = % Trees (of Green Depression): B = % Dum Palms (of Trees in Depression).

Goats

$$X = 1.885A + 2.951B - 1.170C + 3.800D + 1.934E - 4.054$$

($R^2 = 0.288$; $F = 49.284$; $DF\ 5,592$; $p < 0.0000$)

A = % Trees (of Green Depression): B = % Shrubs (of Green Depression): C = % Dum Palms (of Trees in Depression): D = % Cultivation in Grid: E = % Trees in Grid.

All Small Ruminants

$$X = 12.581 + 3.314A - 1.986B + 5.257C + 4.149D$$

($R^2 = 0.166$; $F = 30.703$; $DF\ 4,593$; $p < 0.0000$)

A = % Trees (of Green Depression): B = % Dum Palms (of Trees in Depression): C = % Shrubs (of Green Depression): D = % Trees outside Depressions.

Horses

$$X = 0.157 + 0.341A + 0.476B + 0.067C \quad (R^2 = 0.094; F = 21.527; DF\ 3,594; p < 0.0000)$$

A = % Cultivation in Grid: B = % Water in Grid: C = % Bare Ground (of Depression).

Donkeys

$$X = 0.124 + 0.626A + 0.584B - 0.046C + 0.015D$$

($R^2 = 0.140$; $F = 49.409$; $DF\ 2,595$; $p < 0.0000$)

A = % Cultivation in Grid: B = % Water in Grid: C = % Dum Palms (of Trees in Depression): D = % Trees (of Green Depression).

All Equines

$$X = 0.480 + 1.004A + 1.039B + 0.088C - 0.052D$$

($R^2 = 0.158$; $F = 29.037$; $DF\ 3,594$; $p < 0.0000$)

A = % Cultivation in Grid: B = % Water in Grid: C = % Bare Ground (of Depressions): D = % Dum Palms (of Trees in Depression).

NOTE:

X = Animal Numbers in Nominal Sample Strip (10.12km²)

Independent Variables given in Stepwise Order

Table A6.6: Multiple Regression Equations: Livestock in relation to Habitation and Vegetation Parameters

TLU

$X = 22.108 + 8.716A + 0.982B + 7.900C$ ($R^2 = 0.375$; $F = 120.587$; $DF\ 3,594$; $p < 0.0000$)
 A= Number of Tents: B= % Trees (of Green Depressions): C= % Water in Grid.

Camels

$X = 0.365A - 0.765B - 0.092C - 14.434$ ($R^2 = 0.042$; $F = 9.691$; $DF\ 3,594$; $p < 0.0000$)
 A= % Land outside Depressions: B= % Trees on land outside Depressions: C= % Green (of Depression).

Cattle

$X = 11.391A + 5.649B + 1.630C - 1.005$ ($R^2 = 0.361$; $F = 113.337$; $DF\ 3,594$; $p < 0.0000$)
 A=Number of Tents: B= % Trees in Grid: C= % Dum Palms (of Depression).

Sheep

$X = 21.758 + 2.579A + 1.77B - 1.267C$ ($R^2 = 0.072$; $F = 16.447$; $DF\ 3,594$; $p < 0.0000$)
 A= Number of Tents: B= % Trees (of Green Depression): C= % Dum Palms (of Trees in Depression).

Goats

$X = 1.788A + 2.918B - 1.340C + 5.254D + 2.328E - 3.666$
 ($R^2 = 0.360$; $F = 68.238$; $DF\ 5,592$; $p < 0.0000$)
 A= % Trees (of Green Depression): B= Number of Tents: C= % Dum Palms (of Trees in Depression): D= % Cultivation in Grid: E= % Shrubs (of Green Depression).

All Small Ruminants

$X = 17.656 + 2.949A + 5.261B - 2.298C + 4.060D$
 ($R^2 = 0.217$; $F = 42.428$; $DF\ 4,593$; $p < 0.0000$)
 A= % Trees (of Green Depression): B= Number of Tents: C= % Dum Palms (of Trees in Depression): D= % Shrubs (of Green Depression).

Horses

$X = 0.130 + 0.050A + 0.055B + 0.063C$ ($R^2 = 0.437$; $F = 155.580$; $DF\ 3,594$; $p < 0.0000$)
 A= % Number of Thatched Dwellings: B=Number of Tents: C= % Bare Ground (of Depression).

Donkeys

$X = 0.137 + 0.056A + 0.058B + 0.008C - 0.016D + 0.078E$
 ($R^2 = 0.822$; $F = 554.061$; $DF\ 5,592$; $p < 0.0000$)
 A=Number of Permanent Dwellings: B= Number of Tents: C= % Trees (of Green Depression): D= % Dum Palms (of Trees in Depression): E= % Cultivation in Grid.

All Equines

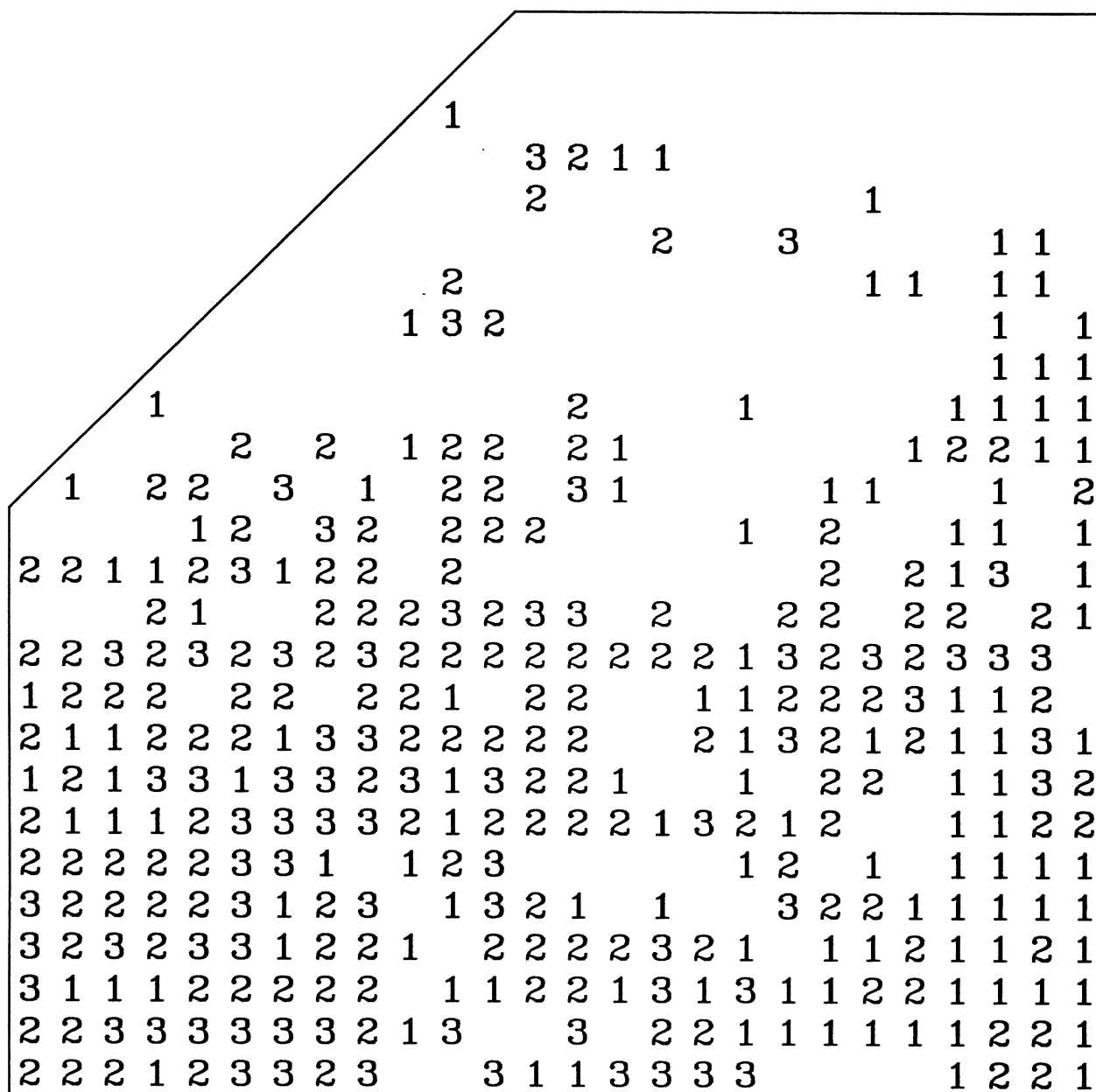
$X = 0.407 + 0.055A + 0.115B + 0.067C + 0.053D$
 ($R^2 = 0.742$; $F = 429.946$; $DF\ 4,593$; $p < 0.0000$)
 A=Number of Permanent Dwellings: B=: Number of Tents: C= % Bare Ground (of Depressions): D=Number of Thatched Dwellings.

NOTE:

X= Animal Numbers in Nominal Sample Strip (10.12km²)
 Independent Variables given in Stepwise Order

APPENDIX 7. ANCILLARY MAPS

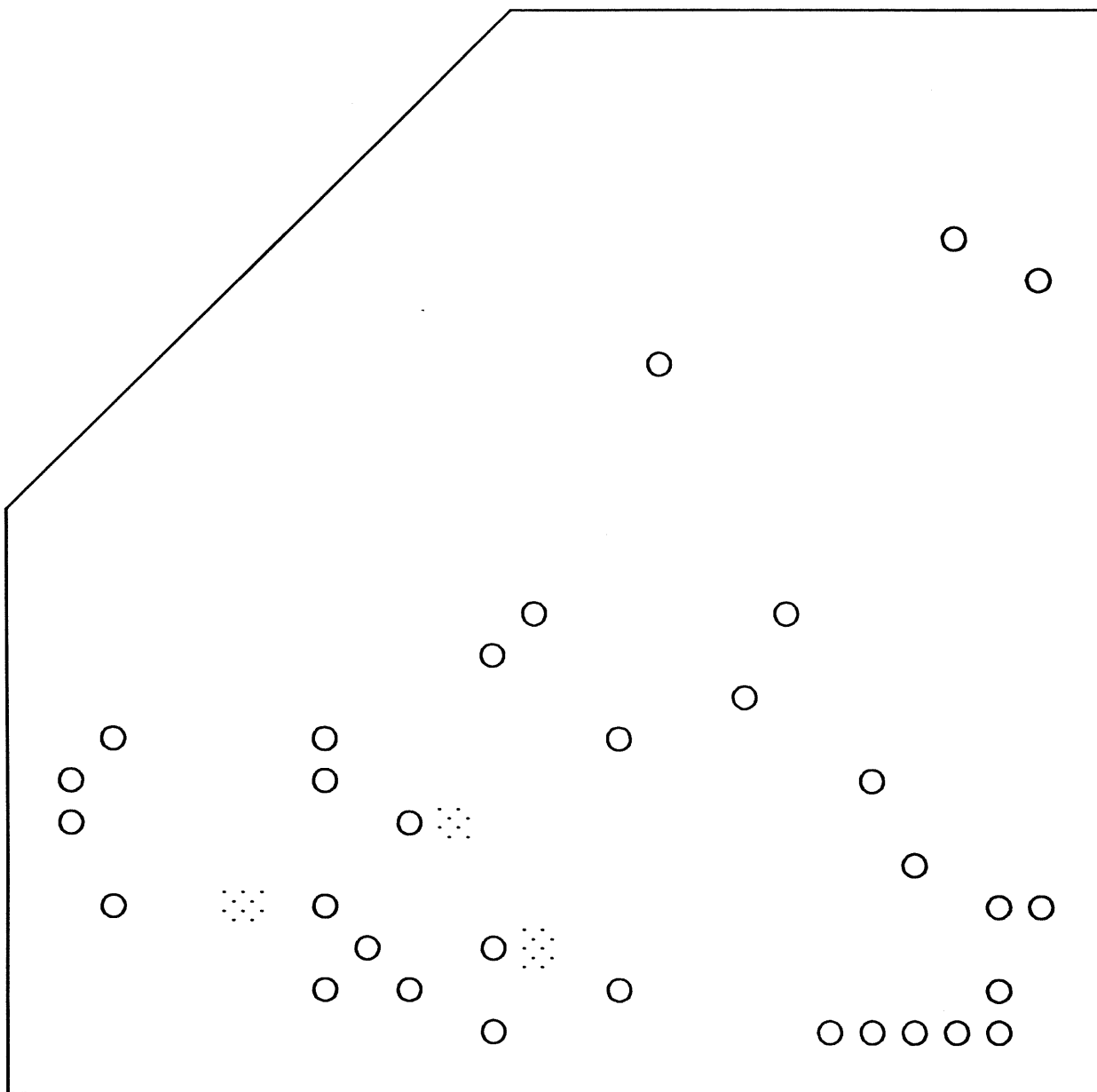
This Appendix contains a number of ancillary maps which are provided for technical information only.



CARTE
ANNEXE **PISTES EMPRUNTEES PAR LE BETAIL**
A7.1
ANNEX **LIVESTOCK TRACKS**
MAP

Peu = 1 = Few
 Quelques-uns = 2 = Some
 Beaucoup = 3 = Many

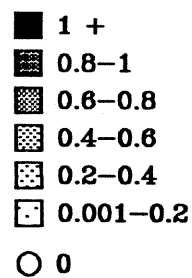
PROJET NATIONAL D'ELEVAGE
 RESSOURCES PASTORALES DANS LA REGION DU
 BAHR EL GHAZAL (TCHAD), AOUT 1991

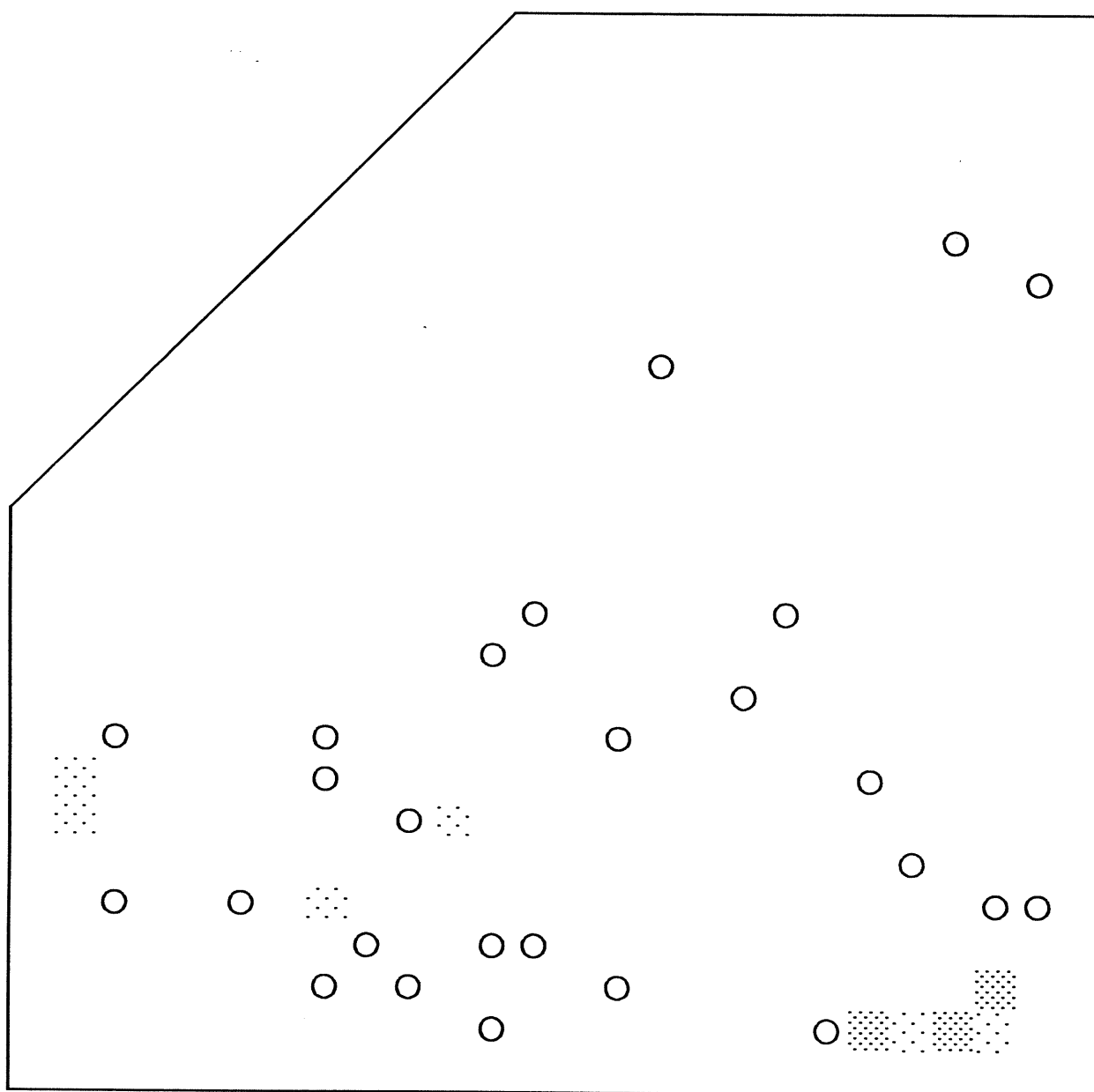


CARTE	ANIMAUX PAR HABITATION:
ANNEXE	DROMADAIRES
A7.2	
ANNEX	ANIMALS PER HABITATION:
MAP	CAMELS

PROJET NATIONAL D'ELEVAGE
RESSOURCES PASTORALES DANS LA REGION DU
BAHR EL GHAZAL (TCHAD), AOUT 1991

No/Habitation



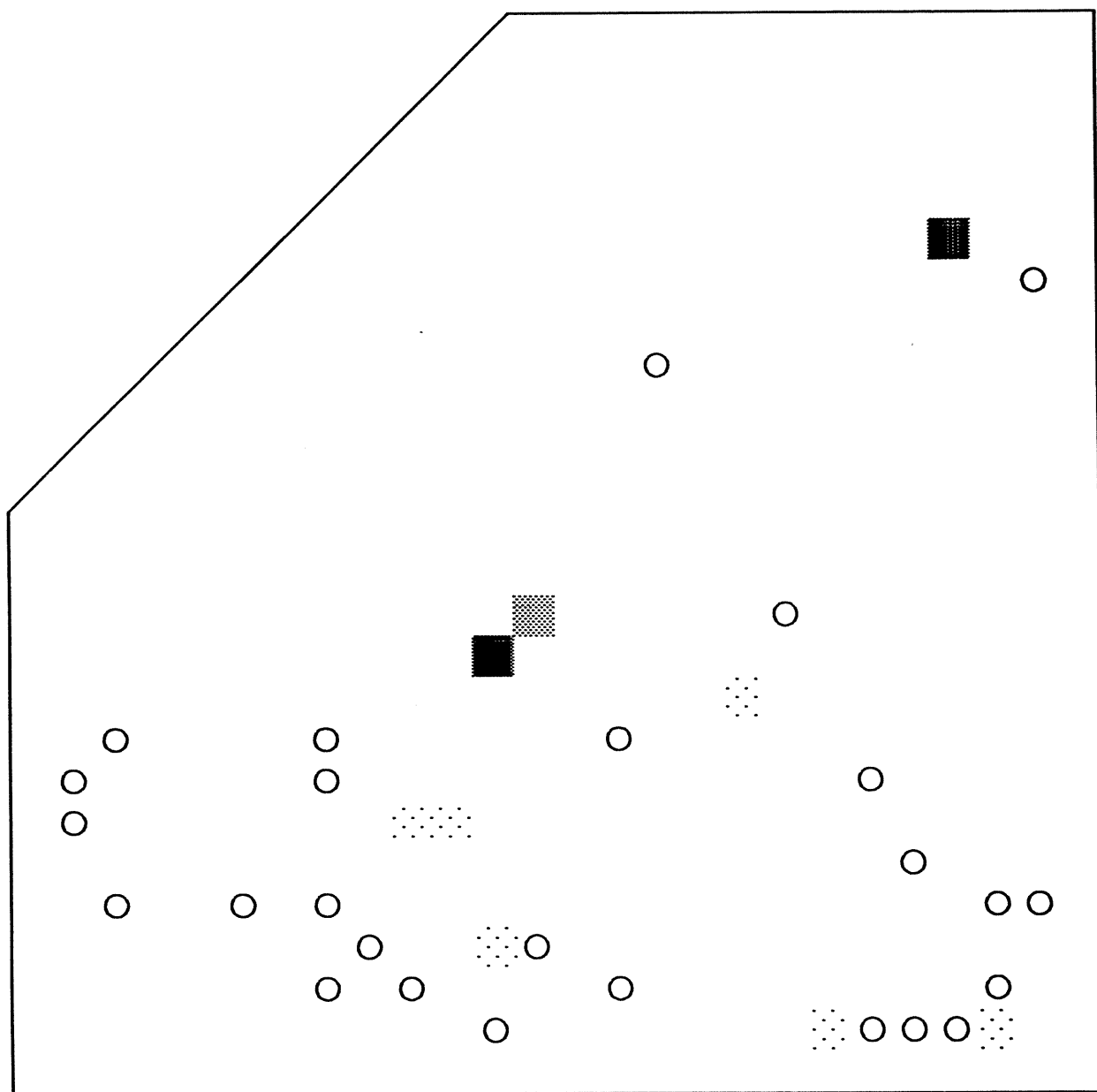


CARTE	ANIMAUX PAR HABITATION:
ANNEXE	BOVINS
A7.3	
ANNEX	ANIMALS PER HABITATION:
MAP	CATTLE

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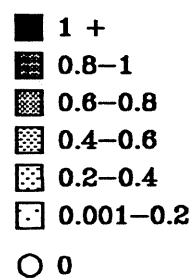
- 1 +
- ▨ 0.8-1
- ▧ 0.6-0.8
- ▩ 0.4-0.6
- 0.2-0.4
- 0.001-0.2
- 0

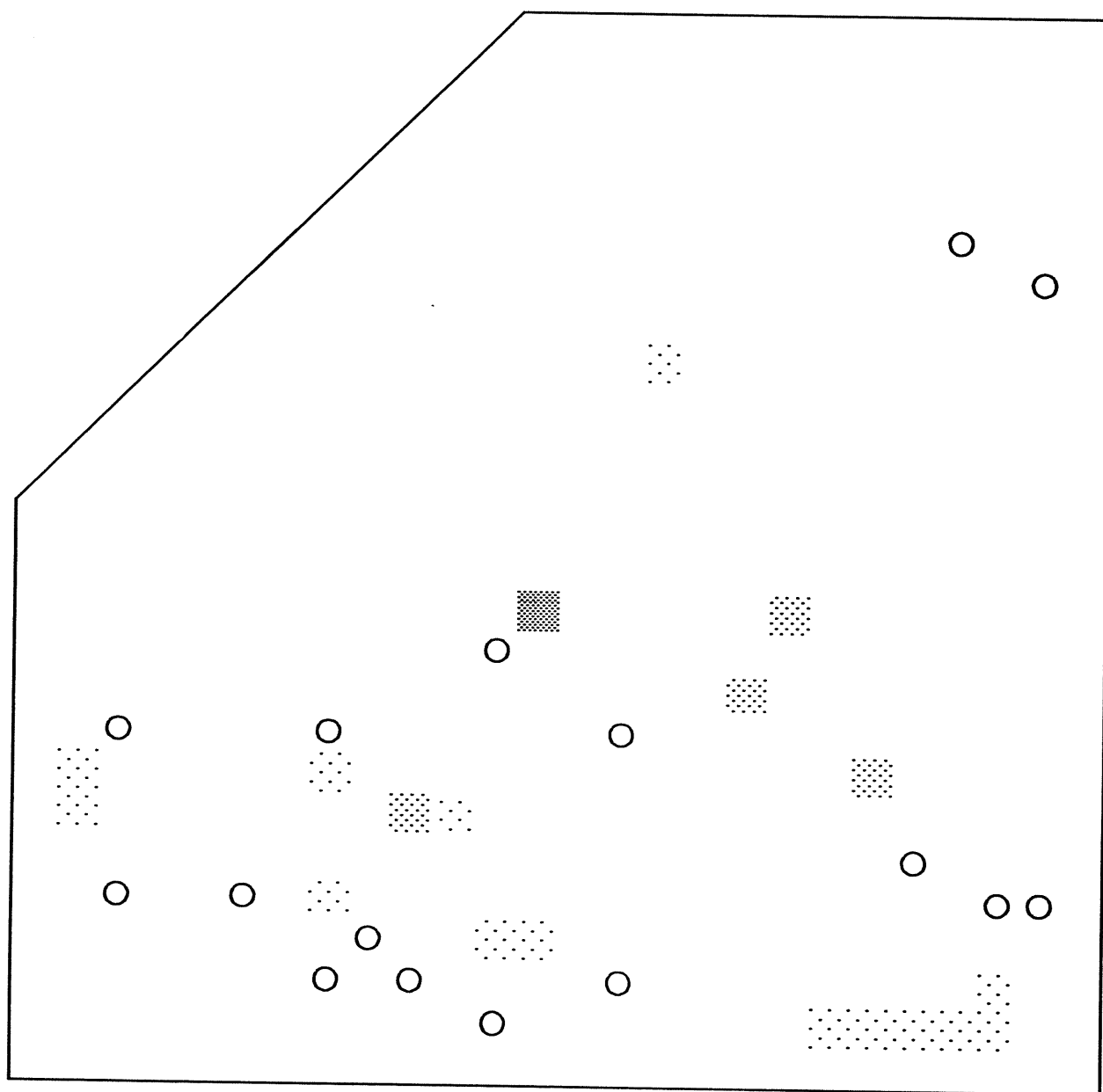


CARTE	ANIMAUX PAR HABITATION:
ANNEXE	OVINS
A7.4	
ANNEX	ANIMALS PER HABITATION:
MAP	SHEEP

PROJET NATIONAL D'ELEVAGE
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CARTE	ANIMAUX PAR HABITATION:
ANNEXE	CAPRINS
A7.5	
ANNEX	ANIMALS PER HABITATION:
MAP	GOATS

No/Habitation

- 1 +
- ▨ 0.8-1
- ▩ 0.6-0.8
- ▧ 0.4-0.6
- ▦ 0.2-0.4
- ▤ 0.001-0.2
- 0

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