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PASTORAL CONDITIONS IN CENTRAL NIGER FOLLOWING THE 1983/84 DROUGHT.

Results of a low level aerial survey carried out at the end of the 1985 wet season, compared with those obtained in 1981/82.

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Contents:

List of Figures:

List of Tables:

List of Maps:

PREFACE AND ACKNOWLEDGEMENTS.

At the request of the Government of Niger, Tufts University and the United States Agency for International Development, the International Livestock Centre for Africa (ILCA) was invited to assess the feasibility of developing an early warning system for the pastoral zone of Niger, using the Integrated Livestock Project area as a testing ground for the validation of satellite imagery and earth reflectance data . In addition ILCA was asked to conduct an aerial survey of livestock populations, human habitation and environmental conditions within the ILP area, following the 1983/84 drought.

A collaborative programme of integrated air and ground surveys commenced in July 1985, at the beginning of the wet season, and a preliminary report was submitted in October 1985 (de Ridder and Bourn, 1985), summarising the initial results obtained from the first season's work.

This report produced by Resource Inventory and Management Limited (RIM), on behalf of ILCA, specifically concerns the aerial survey carried out over the entire ILP area during September 1985, to assess livestock populations, human habitation and environmental conditions. A separate report on the development of an early warning system is in the course of preparation at ILCA headquarters in Addis Ababa, and will be available shortly.

The success of the first year's collaborative field programme depended on the willing cooperation of a large number of individuals, both on the ground, and in the air. In particular we would like to express our appreciation of the support given by: Maidaji Bagodou (interim ILP Project Director), Issa Denda (Head of ILP Range Management Section), Madame Maimouna Dicko (ILCA Country Representative), Charles Pase (ILP Range Management Adviser), Leroy Rasmussen (ILP Tufts University Team Leader), Nico de Ridder (ILCA Range Science Unit and Team Leader), Klass Wagenaar (ILCA Range Science Unit and Animal Production Specialist), and Bruce Wylie (ILP Range Ecologist).

As regards the aerial survey component, the following personnel were directly concerned with information collection, photo-interpretation and computer data entry:

Dr. David Bourn	-	Survey Coordinator and Navigator, RIM.
Debbie Cordery	-	Photointerpretation, RIM.
Issa Denda	-	Observer, ILP.
Habibu Kimba	-	Observer, ILP.
Captain Jaques Meunier	-	Pilot, ILCA.
Garba Neino	-	Observer, ILP.
Alou Rabo	-	Observer, FAO/ILCA.
Adrian Rayson	-	Photointerpretation, RIM.
Ibrahim Tourawa	-	Observer, ILP.
Michael Wiles	-	Photographer, RIM.
Felicity Wint	-	Photointerpretation and Data Entry, RIM.

We would like to thank them all for their hard work and enthusiasm throughout.

SUMMARY.

The work described in this report formed part of a collaborative study programme between the Government of Niger, Tufts University, the United States Agency for International Development and the International Livestock Centre for Africa, to test the feasibility of developing an environmental monitoring and early warning system based on satellite earth reflectance data and a derived index of vegetative cover.

This report describes the results of a systematic reconnaissance flight low level aerial survey of livestock populations, pastoral habitation and environmental conditions, carried out over 81,550 square kilometres of the Integrated Livestock Project in the central pastoral żone of Niger, at the end of the 1985 wet season. The findings are presented in quantitative tabular form and as distribution maps, and are compared with those of similar aerial surveys conducted before the 1984/85 drought.

Overall livestock levels had declined by some 77%; there being some 370,000 fewer Tropical Livestock Units than immediately before the drought. The cattle population had been reduced by 87% (the Bororo breed being more severely affected than the Azawak); Donkeys by 82%; Camels by 71%; and Sheep and Goats by 63%. During the drought substantial livestock mortalities occurred and the Government pursued an active destocking policy by encouraging the sale of animals for slaughter, but large numbers are also believed to have moved south out of the survey region.

These differential population reductions have brought about a significant change in livestock composition. Cattle, which previously represented some 57% of total TLU, now contribute only 29%. The proportion of camels has increased from 20% to 40%. Small stock and donkeys have remained at more or less there former levels of 25% and 2%, respectively.

The distribution of livestock within the project zone varied from species to species, but in comparison with previous surveys showed a general southward shift. Notable concentrations were evident in the Ighazir depression between Ingal and Agadez in the north-east, and in the region of Tchin Tabaraden and Abalak in the south-west.

Pastoral human populations were assessed indirectly by means of their characteristic styles of dwelling. Leather tents, typical of the Iwellemmeden Kel Dinnik Twareg, were found in similar numbers to those encountered immediately before the drought. 25% fewer grass mat structures, typical of the Kel Ayr Twareg, were observed. The most dramatic change in human habitation levels was in the number of brushwood crescent shelters, inhabited by WoDaaBe and FulBe herders, which fell from some 7,000 immediately before the drought, to 230. A major exodus of these latter pastoralists appears to have taken place.

In addition to overall livestock levels, stratified sub-population totals are presented by: ecozone; 1985 rainfall; grass cover; cultivation intensity; normalised difference vegetation index;

accessibility; administrative department; and market town catchment areas. TLU density increased with both rainfall and NDVI, and decreased with increasing remoteness.

Environmental conditions were assessed by systematic sample vertical aerial photography and radiometry. A total of some 4,500 photographs were taken and subsequently interpreted to determine land cover proportions of green grass; yellow/brown grass; trees and shrubs; cultivation; water; bare ground; roads and settlements. 31% of the total land area was covered by grass; 66% was bare ground. Distribution maps of key environmental components likely to influence earth reflectance, as detected from the air and by satellite, are presented.

1 INTRODUCTION.

1.1 Background.

The West African Sahel Zone lies on the southern fringes of the Sahara desert and has been defined as that region which receives a mean annual rainfall in the range of 100-600mm, falling within a 2-3 month period between July and September. However, a characteristic feature of Sahellian climate is the inherant unreliability of rainfall, both spatially and temporally. Since meteorological records began, around the turn of the centuary, the region has experienced varying periods of drought and plenty, with great fluctuations in annual rainfall around the long term mean. Considerable concern has been expressed about environmental changes taking place and possible climatic linkage, but with a highly variable climate the subject continues to be debated. This topic is considered in a report prepared for Advisory Committee on the Sahel (1983).

Traditionally animal husbandry and nomadic livestock production has been the predominant means of livelihood within much of the Sahel, with arable cultivation being restricted to southern regions and seasonally flooded areas. More recently, with the increase in human population, the extent of cultivation has tended to spread northwards into more marginal lands with even less reliable rainfall and greater risk of crop failure.

In the post colonial period the Sahel became the focus of attention of the international community during the extensive drought experienced in the late sixties and early seventies. As a result a wide range of agricultural development and land conservation projects were initiated in countries across the zone, which have met with varying degrees of success.

One such project, the Niger Range and Livestock (NRL) project, funded by the United States Agency for International Development (USAID), was established in the late seventies. However, it differed from many others in that its initial phase was considered to be an exploratory one intended to evaluate available resources; examine animal production systems; and test various possible forms of intervention; with the ultimate goal of increasing income and improving the well-being of traditional herders within the Pastoral Zone of Niger (Swift ed., 1984).

Amongst a variety of recommendations made on completion of the NRL project was a proposal that development of a drought early warning and environmental monitoring system should be given high priority. The start up of the second phase, known as the Integrated Livestock Project (ILP), coincided with another period of drought in 1983 and 1984, which has given further impetus to the development of such a system.

1.2 Objectives.

Following discussions between ILP and the International Livestock Centre for Africa a collaborative work programme was initiated during the 1985 wet season, the major components of which were:

calibration of NOAA-7 satellite earth reflectance data against information collected both on the ground and from the air;

assessment of livestock and human population levels over the entire project area, in order to compare results with similar surveys carried out in 1981/82 and to determine the impact of the 1983/84 drought;

training and familiarisation of national staff in remote sensing techniques and their interpretation.

A preliminary report describing the work and initial results was submitted at the end of the first season's work (de Ridder and Bourn, 1985). A more detailed account of satellite reflectance calibration studies is currently being prepared. This present report concerns the low level aerial survey of livestock, human habitation and environmental conditions conducted over the ILP area during September 1985, and presents the findings following more detailed photointerpretation and computer analysis that has now been completed.

1.3 Survey Region.

The Integrated Livestock Project area is situated in a central region of the Niger Pastoral Zone and occupies a rectangular block of land between latitudes 14 50' to 17 20' North and longitudes 5 15' to 8 00' East, covering a total land area of some 81,550 square kilometres. (See Map 1.) Administratively, it falls within the boundaries of four Departments (Agadez, Maradi, Tahoua, and Zinder) and six Arrondissements (Agadez, Dakoro, Keita, Tahoua, Tanout, Tchin Tabaraden).

Project headquaters are located in Tahoua in the south-east corner, with Agadez at the edge of the north-eastern sector. A main tarmacadam road connects these two major administrative centres and diagonally bisects the project area. On the eastern perimeter a laterite road runs south from Agadez to Aderbissinat, and from there south-east to Tanout, outside the project area. In the west another laterite road strikes north from the main Tahoua-Agadez road to Kao and Tchin Tabaraden. From there a "piste" continues northwards to Tassara. A bituminous spur road joins Ingal to the main Tahoua-Agadez road. Numerous minor tracks criss-cross the regions, especially in the south.

Long term mean annual rainfall ranges from some 350mm in the south to 100mm in the north, but varies considerably from year to year. Typically in the south the rains may be expected to commence in July and end during September, while in the north their duration is even shorter.

The terrain generally is of a gently undulating nature of stabilised sand dunes. Mountainous areas are restricted to the south-west, the north-east where the foothills of the Air massif impinge, and in the vicinity of Ingal, with a major semi-circular fault line represented by the Tiggidit escarmpent running south and east from Ingal to the project boundary.

1.4 Previous Aerial Surveys.

During the previous phase of the project ILCA carried out three low level aerial surveys of the entire project area, using a standardised technique of Systematic Reconnaissance Flight (SRF), in order to assess the distribution and abundance of livestock populations, human habitation and environmental conditions (Milligan, 1982 a and b). These surveys took place in May 1981 (late dry season), October 1981 (early dry season) and September 1982 (end of wet season). Many of the resultant distribution maps have been reprinted in the Pastoral Zone Atlas of Central Niger (Swift and Campbell, 1984).

Livestock population estimates for the zone varied from season to season and are given in Table 1 and 2, together with number of contributary grazing units. In chronological sequence the populations were for cattle: 289,000, 377,000 and 331,000; sheep and goats: 780,000, 1,148,000 and 830,000; camels: 70,000, 89,000 and 156,000; donkeys 14,000, 20,000 and 23,000. Using standard conversion factors of 0.7 for cattle; 0.1 for sheep and goats; 1.0 for camels and 0.5 for donkeys the number of Tropical Livestock Units (TLU) was 357,000, 478,000 and 482,000 for each survey respectively. Taking the project area as a whole this represents a stocking rate of between 15-25 hectares per head, or alternatively a density of 4-6 TLU per square kilometre.

Pastoral human habitation estimates are summarised in Table 3.

2 METHODOLOGIES.

2.1 Aerial Survey Procedures.

Two international workshops have been held to consider the role of light aircraft and low level aerial survey techniques for evaluation and monitoring natural resources. The proceedings of the first were published in 1969 as a special issue of the East African Agricultural and Forestry Journal and those of the second were published in 1981 by the International Livestock Centre for Africa. Norton-Griffiths (1978), Grimsdel (1978) and Western and Grimsdell (1979) provide excellent descriptions of the methods available for counting animals, ecological monitoring and measuring the distribution of animals in relation to the environment from light aircraft.

More recently Milligan and de Leeuw (1983), de Leeuw and Milligan (1984), and Blench, Bourn and Wint (1985) have described the integration of low level aerial and ground surveys in livestock production system studies. A review of ILCA's West African aerial survey programme over the past six years is to be published in 1986, (Wint, Bourn and Blench (in prep.)).

The aerial survey of the entire ILP zone, considered in this report, was conducted at the end of the wet season between 15-29 September 1985, and covered the same area as previous surveys carried out in May 1981, October 1981 and September 1982 (Milligan 1982 a and b). As before, the aerial sampling technique of Systematic Reconnaissance Flights (SRF) was employed, using the ILCA aircraft - a high-winged, twin-engined Patenavia P68B, fitted with an OMEGA global navigation system, radar altimeter, twin vertical 35 mm Nikon cameras, and a four channel Exotech radiometer. Survey flights were carried out between 08.00 and 14.00 local time.

Following the procedures described by Milligan (1982a) the aerial survey design was based on the most comprehensive existing 1:200,000 scale topographical maps of the region published by the "Institut Geographique National de Paris" (IGN) - the region of interest lying between 5 15 to 8 00 East and 14 50 to 17 20 North. Starting in the north and working progressively southwards, a series of parallel flight lines, alternating in direction from east to west and west to east, was flown across the entire ILP area. The northern transects being carried out from Agadez, and the southern lines from Tahoua airport.

As in the previous surveys a total of 30 flight lines were flown at intervals of 5 minutes of latitude apart. Each flight line was 165 minutes of longitude in length, and was divided into 33 sectors, each five minutes long. Thus, a regular sampling grid with overall dimensions 30 by 33, containing a total 990 cells, was established over the survey region, each representing an area of 5 by 5 minutes . Because of the earth's curvature the northernmost flight line was marginally (1%) shorter than the most southerly, 293 kilometres as opposed to 297 kilometres. A total of approximately 9,000 on-line kilometres were flown. The surveyed region had a land area of some 81,550 square kilometres, and thus the mean grid cell size was 82.3 square kilometres.

The aerial survey team consisted of a crew of four: a pilot, a front seat navigator/observer and two back seat observers. Reliable navigation, over often uniform, featureless terrain and sometimes in very poor visibility, was made possible by means of an onboard OMEGA navigation system, which enabled the pilot to fly the aircraft between the coordinates of two predetermined geographical "waypoints" representing the beginning and end of each flight line, with an accuracy of two nautical miles (approximately 3.6 kilometres). This was confirmed by periodic position fixes taken from recognisable ground features identified on the 1:200,000 IGN maps. The OMEGA was also used to indicate the "distance to go" to the end of the flight line, and thus entry/exit of each grid sector, which was also confirmed by map reading. For the purposes of the survey the desired flying height was 800 feet (244 meters) above ground, which was maintained as closely as possible by reference to a digital radar altimeter, the readings of which were recorded in flight for each grid.

2.2 Information Collection.

Three forms of information were collected during the aerial survey those derived from: direct visual observation; vertical photography; and radiometry measurement.

2.2.1 Visual Observation.

The two back seat observers were responsible for assessing livestock and pastoral habitation falling within fixed ground strips on either side of the aircraft. These strips were defined by externally mounted viewing frames set to give a combined ground strip width of 884m at a flying height of 800 feet, equivalent to a sampling intensity of 9.5%. For each group of animals or dwellings seen within the sample strip of a given grid, the observers estimated and recorded their number. Wherever possible, for those groups exceeding 10, oblique photographs were taken with a hand held 35 mm Nikon Camera fitted with a 200 mm lens for subsequent accurate counting and bias determination.

As in previous surveys the following livestock species were recorded: Camels; Cattle, as predominantly Azawak or Bororo (an additional mixed group category was also recorded); Donkeys; Horses; and Sheep and Goats, which were treated as a combined small ruminant category.

Four styles of pastoral dwellings/camps were distinguished: leather tents, characteristic of the Iwellemmeden Kel Dinnik Twareg herders, and a small number of other Twareg and Arab herders; grass mat structures, characteristic of the Kel Ayr Twareg herders, as well as Igdalen and some Kel Gress; cloth tents characteristic of Arab herders; brushwood crescent shelters, characteristic of the Wodaabe and FulBe (Swift and Campbell, 1984). As the latter structures tend to persist well after their occupants had left them a distinction was made between those that were occupied and those that appeared to be abandoned.

In addition the front seat observer estimated the proportion of land under cultivation and the percentage grass cover within each grid as a whole.

Observer records were summarised at the end of each day's flying to provide preliminary uncorrected population estimates and distribution maps. Subsequently all observer information was transfered to computer for detailed analysis and mapping (see section 2.4 below).

2.2.2 Vertical Photography.

Two identical vertically mounted Nikon F3 35mm cameras were used to provide sample photographic coverage of the entire ILP area. Each camera was fitted with a 250 frame, motor-driven, bulk film data-back and a 24 mm wide angle lens, and was linked to an intervalometer which automatically triggered exposures at regular time intervals. Before take-off cameras were checked and loaded with a cassette of fresh film. Data-backs were set to the correct date and local time, and inserts were labelled to indicate flight line direction and number; flight line 1 being the most northerly, and flight line 30 being the most southerly. A single camera was used for each flight line and as only two flight lines were flown each day no inflight film changes were required.

Photographs were taken every 30 seconds with the intention of providing five frames per survey grid cell, at the aircraft's nominal ground speed of 120 knots (220 kilometres per hour). In reality, however, ground speed and thus the number of photographs per cell varied slightly with wind speed and direction. This was corrected for during subsequent analysis by allocation of photographs on the basis of recorded time of cell entry and exit, matched against the sychronised data-back time indicated on each exposure. A total of 4,500 photographs were taken during the survey, equivalent to a mean of 150 per flight line and 4.5 per grid cell.

The land area represented in a given photograph depends on the focal length of the lens and the aircraft's height above ground, which was recorded from the radar altimeter during flight. With a 24 mm lens, at a mean flying height for the whole survey of 841 feet above ground, the average land area covered by each photograph was a rectangle 256m by 385m or 9.86 hectares. Thus, for the entire survey zone a photographic sample proportion of 0.54% was obtained.

Kodak Ektachrome 200 ASA Professional film was used thoughout and processed in a London laboratory on completion of the survey.

2.2.3 Photointerpretation.

A point sampling method of photointerpretation was used to assess the proportions of: bare ground; green grass; brown/yellow grass; trees and shrubs; cultivation; water; roads and settlements. Photographs were also used to determine the density of trees.

Each slide, in turn, was projected and enlarged to fill an 1.1m x 1.7m matt white screen in a darkened room, by means of a Rank Aldis zoom lens slide projector, modified to take uncut reels of developed film. An 8 by 5 rectangular array of 40 sampling points, regularly spaced at 20cm intervals on the screen, indicated the locations at which photointerpreters had to decide which land cover category was represented. In addition to the rectangular array of sampling points a central circle with a radius of 26.5 cm was also marked on the screen, indicating the area in which the number of trees and shrubs had to be counted. The actual area of land represented by this circle depended on flying height, which was corrected for during subsequent analysis, but at the average survey altitude of 841 feet above ground amounted to an area of just over 1 hectare.

All photointerpretation information was initially recorded on data sheets, together with any additional notes of interest, for subsequent computer data entry and analysis (see section 2.3 below).

2.2.4 Radiometry.

A vertically mounted four channel Exotech Model 100 BX radiometer was mounted alongside the two cameras on the floor of the survey aircraft, in order to measure ground reflectance. The radiometer had a 15 degree circular field of view and was fitted with TM filters. Channel 3 (0.63 - 0.69 um) and channel 4 (0.76 - 0.90 um) were utilised, representing the red and infra-red bands respectively. Attached to the radiometer was an Omnidata Polycorder model 516C-32 portable computer programmed to: activate radiometric measurements every 1.5 seconds; record the date and grid cell entry/exit time; calculate and store the means and standard deviations of the Normalised Difference Vegetation Index (NDVI), infra-red and red reflectance values, and the number of measurements taken in each grid cell.

A mean of 94 radiometry measurements were taken for each grid cell, giving a total of some 93,000 for the whole survey region. As with the aerial photographs the land area actually sampled depended on the altitude above ground from which measurements were taken. At the average height of 841 feet this area was a circle with a radius of 34 m, or just over a third of a hectare. Thus, the sampling proportion for radiometric measurement was approximately 0.4%

All radiometry information was transcribed onto data sheets at the end of each day's flying, for subsequent computer data entry and analysis (see section 2.3 below).

2.3 Computer Analysis.

A computer software package for aerial survey data entry, analysis and mapping has recently been developed by RIM for the ILCA the Hewlett-Packard HP-150 microcomputer, and was used exclusively for analysis of all data collected during the survey of the ILP area. Large files are generated during the course of data entry and analysis. Substantial data storage capacity is therefore required and a 14.6 Megabyte Winchester disk was used for that purpose. Additional hardware included an HP7475 flat bed A3 plotter, and an Epson LQ1500 letter quality dot matrix printer. The following sections outline the essential features of the aerial survey software package; for a more detailed account the interested reader is referred to the two related manuals (RIM/ILCA, 1985).

2.3.1 Data Entry.

The data entry component of the package, which utilises dBase II software and is menu-driven, caters for three levels of information input: multiple photointerpretation records of land cover per grid cell; multiple observer records of livestock and habitation per grid cell, together with corresponding photocounts; and single records of general grid characteristics.

On completion of multiple record photointerpretation data entry, information is summed on a cell by cell basis and transferred to a summary file, together with the number of contributory photographs. On completion of multiple record livestock and habitation data entry, individual observer biases are calculated for each class, by comparison of observer estimates with accurate photocounts. These biases are then applied to all estimates greater than 10, for which no photographs are available, and a summary file created containing grid totals for each parameter recorded, and the number of groups they represent. Single records of general grid characteristics are entered directly into the summary file. The summary file is in the form of a rectangular data-base, consisting of rows representing specific grids, and columns of parameter variables, which is then transfered to the mapping and analysis component of the software package.

2.3.2 Mapping.

8-10

The mapping and analysis component utilises a command language system of 30 keywords and is performed on a grid coordinate basis. Column variables can be manipulated, transformed, compared, merged and represented in a variety of ways. In the distribution maps included in this report, the magnitudes of selected livestock, habitation and environmental variables have been classed into discrete categories, which are graphically represented by circles of differing size.

2.3.3 Population Estimation.

In principle, estimating the population size of a given variable within the survey zone is a relatively simple matter of determining the total number encountered and dividing by the sample proportion. In practice the process is somewhat more complex. As described in section 2.3.1 (above) the numbers recorded by observers must first be adjusted for their counting bias. A suitable correction factor must then be applied to take account of changes in sample strip width, resulting from variation in flying altitude. Bias corrected values for each grid cell are therefore converted to a standard altitude of 800 feet by multiplication by the ratio: 800 divided by the actual flying altitude.

A measure of the precision of population estimates is obviously of value. The previous aerial survey reports (Milligan 1982 a and b) used the Ratio Method of calculating standard errors described by

Jolly (1968) which is based on the variation in individual flight line population samples. If populations are randomly distributed throughout a given region and flight lines are long, the numbers encountered on each line are likely to show little variation. Thus standard errors will be low and the precision of population estimates will be high. However, if population are not randomly distributed, but instead are clumped, as is often the case, the converse argument will be true: that is, individual flight line numbers will show considerable variation, standard errors will be high and there will be a corresponding lack of precision.

This phenomenon has been considered by Marriot and Wint (1985) and they have proposed an alternative method of standard error determination, which compares individual grid cell values with those of their immediate neighbours, instead of comparing whole flight lines. Data bases from earlier surveys of the ILP area have been reanalysed using the Marriott neighbourhood method of standard error determination and it has been confirmed that standard errors are indeed reduced and the precision of population estimate improved. Thus, where practical in the analysis described in this report, the Marriott neighbourhood method has been employed in preference to the Jolly Ratio method. The standard error equation used is:

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

where: Y = Total population estimate
i,j = Coordinates of a grid point
y = Number of items recorded for a given grid
n* = Number of grid points with four surrounding neighbours

The standard error is the square root of the variance of the estimate, 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.

It should perhaps be emphasised that although the calculated standard errors may differ, depending on the method adopted and the underlying statistical assumptions, the size of the estimated population is not affected.

2.3.4 Stratification.

As well as computing overall livestock population and human habitation estimates for the entire ILP area, the sizes of sub-populations within various strata were also determined. These stratifications were derived from information obtained from a number of sources. Some, such as: percentage grass cover, proportion of land under cultivation and the Normalised Difference Vegetation Index were collected during the survey itself. Administrative regions, ecological zones and the degree of accessibility, in terms of the distance from the nearest main road, were deduced from the

Pastoral Atlas of Central Niger (Swift and Campbell, 1984). 1985 rainfall data were provided by the National Meteorological Department. The choice of market town strata was at the request of ILP staff, who wished to have livestock population and human habitation estimates for catchments within 50 kilometre of selected towns, from which economic survey data were being collected.

3 RESULTS AND COMPARISONS.

This section describes the findings of the 1985 wet season aerial survey of the ILP area and compares them with those of similar previous surveys of the same area, carried out in May 1981, October 1981 and September 1982 (Milligan, 1982 a and b; Swift and Campbell, 1984). The results are presented in a series of tables indicating population levels and environmental conditions for the entire ILP area, and sub-population estimates within selected regions and strata. The distribution patterns of particular parameters of interest are illustrated by computer graphics overprinted onto colour base maps. The tables and maps are to be found, bound together at the end of the report.

3.1 Livestock Populations.

Tables 1 and 2 summarise overall population levels of the major livestock species considered in the four surveys, and their Tropical Livestock Unit (TLU) equivalents. Table 1 gives estimates of the total number of head and grazing units, and the mean size of each group. The term "grazing units" as seen from the air is used in order distinguish them from "herds owned". The latter may be split into a number of grazing units, or amalgamated into one. The standard error associated with each population estimate is indicated in parentheses. Table 2 compares livestock populations, in terms of their density per square kilometre, their stocking rate in hectares per head, and their relative Tropical Livestock Unit proportion.

3.1.1 Cattle.

The 1985 wet season distribution of cattle is shown in Map 2. They had a far more restricted distribution than in any of the previous surveys, being limited almost exclusively to the southern half of the project area, with only a few isolated herds present in the north.

Overall numbers had declined dramatically from 331,100 in September 1981 to 44,400, representing a reduction of some 87%. Their overall mean density was 0.54 per square kilometre, equivalent to a stocking rate of 184 hectares per head. The total number of grazing units had fallen by a similar proportion, but mean group size, at 40 head, had not changed significantly. Previous surveys distinguished grazing units as being predominantly, either Azawak or Bororo cattle. The 1985 survey distinguished an additional category of "mixed", which was the most abundant. Whereas Bororo cattle had been the most numerous in earlier surveys, they were least common in the 1985 survey. Even on the assumption that half the "mixed" category might previously have been termed predominatly Bororo, they remain the least abundant.

3.1.2 Camels.

The 1985 wet season distribution of Camels is shown in Map 3. Camels were found throughout the project area and had a more southerly distribution then in September 1982. Two major concentration areas were apparent: to the north-east in the Ighazir depression between Ingal and Agadez, where they were also concentrated in 1982; and to the south-west, in the vicinity of Tchin Tabaraden and Abalak, which had previously not been apparent as an accumulation zone. The north-western sector in the vicinity of Tassara, which had previously supported substantial numbers, had very few in 1985.

The overall camel population was some 71% lower than in the same month of 1982, 44,800 as opposed to 155,700. Their overall mean density was 0.55 per square kilometre, equivalent to a stocking rate of 182 hectares per head. The number of camel grazing units was also substantially reduced from 7,800 to 4,300, amounting to a fall of some 45%. The disparity was accounted for by a reduction in mean group size from 20 to 10.

3.1.3 Donkeys.

Although horses and donkeys could be distinguished from the air and were recorded as such, so few horses were actually seen that, for the purposes of this report, the two have been amalgamated.

The 1985 wet season distribution of equines is shown in Map 4. Comparison with previous surveys indicated that although widely dispersed they had a generally more southward distribution in 1985.

The total equine population was estimated to be some 4,200 in September 1985, representing an 82% decline on the 23,400 in September 1982. Their overall mean density was 0.05 per square kilometre, equivalent to a stocking rate of 1928 hectares per head. The mean group size fell from 11 to 5, accounting for the less dramatic 62% reduction in the number of grazing units, from 2,100 to 800.

3.1.4 Sheep and Goats.

The 1985 wet season distribution of sheep and goats is shown in Map 5. They were widely distributed, but were most abundant in the south-western quadrant of the survey zone, and in the Ighazir depression to the east of Ingal

Sheep and goats were by far the most abundant livestock, with an estimated total population of 307,400. Their overall mean density was 3.8 per square kilometre, equivalent to a stocking rate of 27 hectares per head. Nevertheless, like all other species, their overall population level had fallen substantially (63%) since the previous September 1982 survey, when 829,600 were estimated.

3.1.5 Tropical Livestock Units.

Tropical Livestock Units (TLU) were calculated on the basis of camels being taken as unity; cattle as 0.7; donkeys as 0.5; sheep and goats as 0.1 (Jahnke, 1982). The 1985 wet season TLU distribution is shown in Map 6. Comparison with the previous September 1982 survey indicates a less widely dispersed and more southerly livestock distribution in September 1985. The weighting influence of camels is reflected in concentrations in the Ighazir depression between Ingal and Agadez, and between Tchin Tabaraden and Abalak. Livestock in general were conspicuous by their virtual absence from a broad arc running from Tassara in the north-west to the Tadarest uplands, south of the Tiggidit escarpment in the east.

A total of 108,800 TLU were estimated to be in the ILP area during September 1985, representing an overall density of 1.33 per square kilometre, or a stocking rate of 75 hectares per TLU. This amounts to a 77% reduction in the levels found in September 1982, immediately preceeding the 1983/4 drought.

The changing proportions of TLU contributed by the four major livestock species within the ILP survey zone over the past four years is presented graphically in Figure 1. Whereas in May 1981 cattle formed some 57% of the total, with camels and small ruminants each representing about 20%; in September 1985 camels represented 41%, with cattle and smallstock each accounting for 28%.

3.2 Pastoral Habitation.

Table 3 summarises pastoral habitation estimates for the four aerial surveys of the ILP area. Both the number of camps and the number of constituent dwellings are given, as well as the mean camp sizes. Associated standard errors are shown in parentheses.

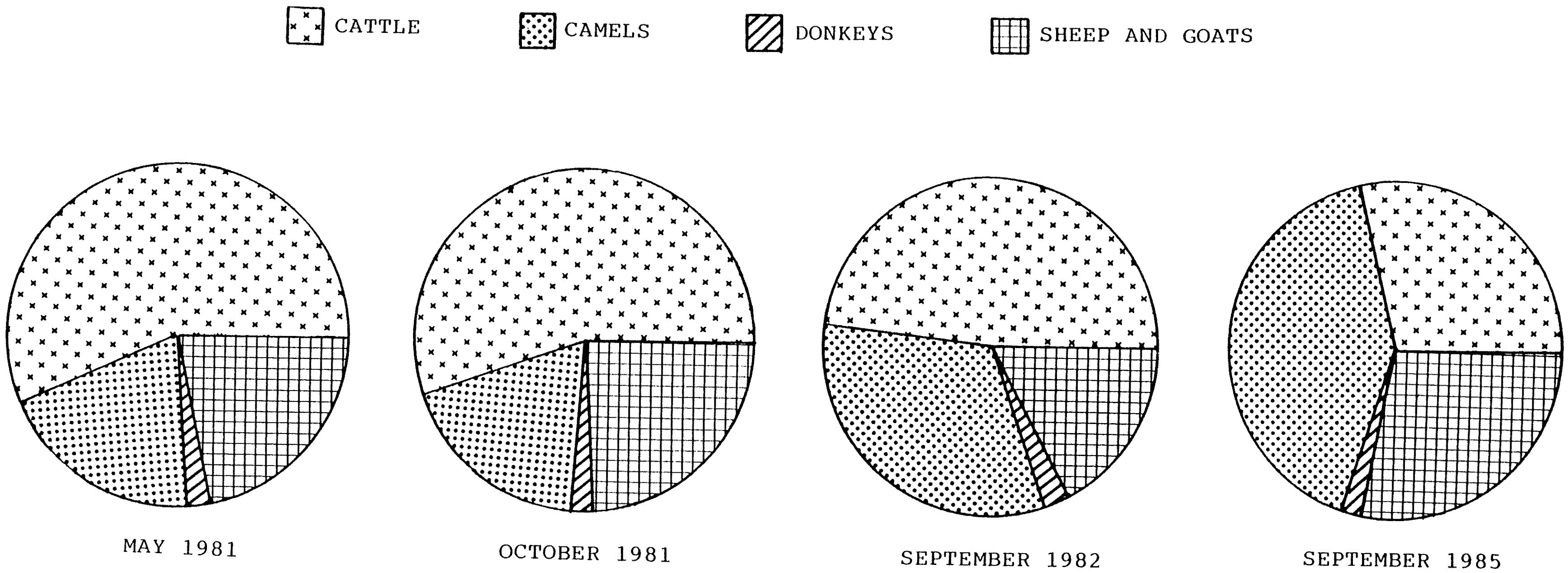
3.2.1 Leather Tents.

Within the survey region, leather tents are typically occupied by the Iwllemmeden Kel Dinnik Twareg, together with a small number of other Twareg and Arab herders (Bernus, 1981; and Swift ed., 1984). Their distribution is indicated in Map 7, from which it can be seen that in September 1985 they were scattered at low density over a wide area of the south-western part of the ILP area, concentrated in the general area of Tchin Tabaraden and Abalak. This is in marked contrast to the situation in September 1982, where such a concentration was not apparent and distribution was even more scattered.

The estimate of 7,900 leather tents (1,700 camps) in September 1985 was very similar to, and not significantly different from, that obtained in September 1982 - 7,200 (1,900 camps). However both these figures were some 25% lower than the May and October 1981 surveys - 12,000 and 10,100, respectively.

Based on ground survey information indicating a mean occupancy of 5 people per tent, Milligan (1981a and b) and Swift ed. (1984) derived figures for number of leather tent inhabitants, which were estimated to be some 60,000, 51,000 and 36,000 in May 1981, October 1981 and

FIGURE 1: CHANGES IN TLU PROPORTIONS IN ILP ZONE: 1981 - 1985



September 1982, respectively. On the same assumption the total population in 1985 was marginally greater, and in the order of 40,000.

3.2.2 Grass Mat Structures.

Within the survey region, grass mat structures are typically occupied by Kel Ayr Twareg herders, especially Kel Fadey and KelFerwan, as well as Igdalen and some Kel Gress (Bernus, 1981; and Swift ed., 1984). Their distribution is indicated in Map 8, from which it can be seen that grass mat structures were very thinly scattered over the project area, particularly in the eastern half in the vicinities of Agadez, Ingal and Aderbissinat. In September 1982 a similar eastern bias was evident, but south-western outliers were not apparent; indicating that between the two surveys there has been a south-westward movement of Kel Ayr Twareg.

The overall number of grass mat structures in 1985 was somewhat lower than that found in the earlier surveys: 4,900 as opposed to 10,200, 5,700 and 6,600 for May 1981, October 1981 and September 1982, respectively. Milligan (1981 a and b) and Swift ed. (1984) have used the mean figure of 5 people per dwelling to estimate total number of occupants at 51,100, 28,400 and 32,800. On the same assumption the total number of inhabitants of grass mat structures would be 24,500.

3.2.3 Cloth Tents.

Cloth tents are typically occupied by Saharan Arabs (Milligan, 1981a). Their distribution is indicated in Map 9, from which it can be seen that cloth tents were scattered widely but very sparsely over the project area. In contrast to October 1981, when cloth tents were restricted to the north-western corner in the vicinity of Tassara, they were found much further south in 1985.

In October 1981 the only other survey for which information is available, 880 cloth tents in 140 camps were found, as opposed to 630 in 200 camps for September 1985.

3.2.4 Brushwood Crescent Shelters.

In contrast to the other forms of pastoral habitation, which are portable and therefore leave no trace of their former presence, brushwood crescent shelters are more permanent and remain in the environment well after their occupants have left. They are typical of WoDaaBe and FulBe pastoralists (Milligan 1981 a and b; and Swift ed., 1984). During the survey their presence was recorded as either being occcupied, when distinct signs of life such as the presence of a table, bed, people or animals could be seen, or abandoned if no such signs were evident. The distribution of occupied and abandoned brushwood crescent shelters is shown in Map 10, from which it can be seen that they were found in a broad band running from south-east to north-west across the project area.

Abandoned shelters, indicated by open circles, were far more numerous than those occupied, represented by solid circles. A total of 2,900 abandoned, and only 200 occupied crescents, were estimated for the ILP project area. Previous aerial surveys, have acknowledged the existence of abandoned shelters, but not reported their number. But the fifteen-fold difference between the two, implies that a substantial reduction has taken place. Further weight to this deduction is given when the figure of 200 occupied crescents in September 1985 is compared with the 5,700, 6,200 and 7,000 found in the previous surveys, which indicates that a major exodus of WoDaaBe and Fulbe pastoralists has taken place as a result of the 1983/84 drought.

Based on an assumed occupancy of 4.2 people per crescent Milligan (1981a and b) and Swift ed., (1984) estimated a total population of 34,300, 37,500 and 41,700 for May 1981, October 1981 and September 1982, respectively. The equivalent figure for September 1985 is somewhat less than 1,000.

3.3 Environmental Conditions.

General environmental conditions across the entire ILP area were assessed by means of photointerpretation and point sampling of some 4,500 vertical aerial photographs, and multiple vertical radiometry measurement of ground reflectance. This information, together with that collected at 25 ground truth sites within the zone was obtained with the primary intention of validating NOAA-7 satellite earth reflectance data, in order to develop an Early Warning System for the pastoral zone of Niger. Tucker (1985) reviews how such reflectance data can be used to derive a Normalised Difference Vegetation Index (NDVI) for vegetation land cover mapping. Preliminary results from the 1985 Niger work (de Ridder and Bourn, 1985) are most encouraging, with good correlations between aerial and ground radiometry, NDVI and above-ground biomass production. More detailed analysis and comparison with satellite data is currently in progress and will be reported by ILCA in due course.

3.3.1 Land Cover Proportions.

This section presents the findings of photointerpretation, and assesses environmental conditions over the survey region, in terms of the ground cover proportions of certain key elements likely to influence earth reflectance as recorded by satellite. The parameters recorded during photointerpretation were the proportions of: bare ground; green grass cover; yellow/brown grass cover; tree and shrub cover; cultivation; water; and settlements and roads. In addition trees density was also measured in terms the number of woody plants per hectare with a crown diameter greater than 2 meters.

The quantitative results are summarised in Table 4, which shows the mean values for each land cover category for the entire survey region as well as stratified breakdowns by: Administrative Department; 1985 rainfall zone; the degree of accessibility; as indicated by the distance to the nearest main road; and ecozone, defined as open treeless terrain, savanna shrubland and savanna woodland in Swift and Campbell (1984).

For the project area as a whole, during the month of September at the end of the wet season, 66% of the land was bare ground; 31% was under grass cover, of which only 6% was considered to be green; cultivation accounted for just under 2%; tree and shrub cover was a mere 1% with an average density of 3 trees per hectare; with visible water, roads and human settlements representing less than 0.2%.

Considerable zonal variation was evident and a number of interesting trends were apparent from the stratified breakdowns, although none of them were particularly unexpected. The major value of the results was that upto date quantified information was provided, from which distribution maps could be generated for comparison with satellite imagery .

Both green and yellow/brown grass cover, tree and shrub cover and tree density increased on the north to south gradients represented by rainfall stata; and by those portions of Agadez, Tahoua, Maradi and Zinder Administrative Departments within the survey region. Although an increase in green grass cover from 5.3 to 6.6% by rainfall zone, and 5.8 to 8.5% by Administrative Department was detected, it is perhaps surprising that the trend was not more marked. However, this limited range in green grass proportions maybe explained by: differential maturation rates and synchronised flowering, characteristic of the Sahelian pastoral zone (Penning de Vries and Djiteye, 1982).

Cultivation levels were greatest (5.9%) in regions with highest rainfall, and in Tahoua Department (3.4%). In Maradi and Zinder Departments 2.5% of the land area was cultivated, whereas in Agadez cultivation was almost non-existent.

The proportion of bare ground increased from south to north: from 44% in highest rainfall zones to 88% in the lowest; and from 36-37% in Maradi and Zinder Departments to 74% in Agadez.

In terms of the degree of accessibility few consistent trends were evident, except for cultivation which was absent in the most remote regions and averaged 3.7% within 10 kilometres of main roads.

By ecozone the proportion of brown grass cover, tree and shrub cover and tree density increased from open treeless terrain, through savanna shrubland to savanna woodland.

3.3.2 Grass Cover.

The distribution of grass cover over the survey zone is shown in Maps 11 and 12, which indicate total grass cover, and green grass cover respectively. Overall grass cover was far from uniform, with extensive regions of high cover being restricted to the south-eastern sector. In the remainder of the project zone grass cover was generally at a much lower level and was characterised by its variability and patchy distribution. An even greater variability in green grass cover is evident from Map 12.

As mentioned earlier the proportion of green grass cover within the project zone amounted to only some 6% of the total land area and showed surprisingly little difference between strata. The reason for this apparent anomaly is evident from the randomly clumped distribution of green grass cover, which in turn may be explained, both by the restricted nature and intermittent timing of rainfall events, and by the fact that the survey took place at the end of the 1985 wet season.

3.3.3 Tree/Shrub Cover.

The distribution of tree and shrub cover over the survey zone is shown in Map 13. Cover proportions in the project zone were generally very low, never exceeding 2% for any of the strata considered in Table 4. Likewise tree density was also low reaching a maximum of only 5.8 per hectare in Zinder Department. This is reflected in the distribution map where only very few grid cells had a tree and shrub cover of greater than 10%. Nevertheless a pattern emerged, of higher cover values in the south, decreasing northwards.

3.3.4 Cultivation.

The distribution of cultivation over the survey zone is shown in Map 14. Cultivation was clearly restricted to the extreme south and south west of the survey region, which coincides well with the legal limits of arable agriculture indicated on the base map.

3.3.5 Total Vegetative Cover and NDVI.

The Normalised Difference Vegetation Index (NDVI) is essentially a measure of reflectance from photosynthetically active green plants (Tucker, 1985). Within the survey region grass, trees, shrubs and crops all contribute to the overall value as detected from the air and by satellite. A composite figure for total vegetative cover, combining the proportions of each of these potentially photosynthetic elements is therefore of interest and is represented in Map 15. In view of the preponderance of grass cover it is not surprising that Map 15 bears a strong resemblance to Map 11, but the additive effect of cultivation in the south-western corner is clearly evident.

Map 16 shows the NDVI pattern over the survey region as recorded by airborne radiometer; when compared with the distribution of green grass cover (Map 12) there is very little similarity. With total grass cover (Map 11) there is a better correspondence. However, NDVI distribution appeared to be most closely related to total vegetative cover (Map 15).

3.4 Livestock Sub-Populations by Strata.

In addition to assessing overall livestock population levels within the ILP zone, sub-population estimates were derived for various regions or strata within the project area. Those considered to be of interest were: ecological zones; 1985 rainfall levels; grass cover proportions; cultivation intensity; normalised difference vegetation index classes; accessibility; administrative regions; market town catchment areas.

The following sections briefly consider the salient features of the results, which are presented in tabular form at the end of this report, for reference and comparative purposes. Each table gives the estimated number of head and grazing units within each stratum and the associated standard error; the density per square kilometre; the stocking rate in hectares per head; the mean group size and the proportion of total TLU represented within each zone; and area of each stratum.

3.4.1 Ecological Zones.

Table 5 summarises livestock sub-population levels in each of the three ecozones considered; open treeless terrain; savanna shrubland; and savanna woodland. The number of animals of course varied with the area represented, but in general the three zones showed a surprising degree of uniformity in their livestock composition.

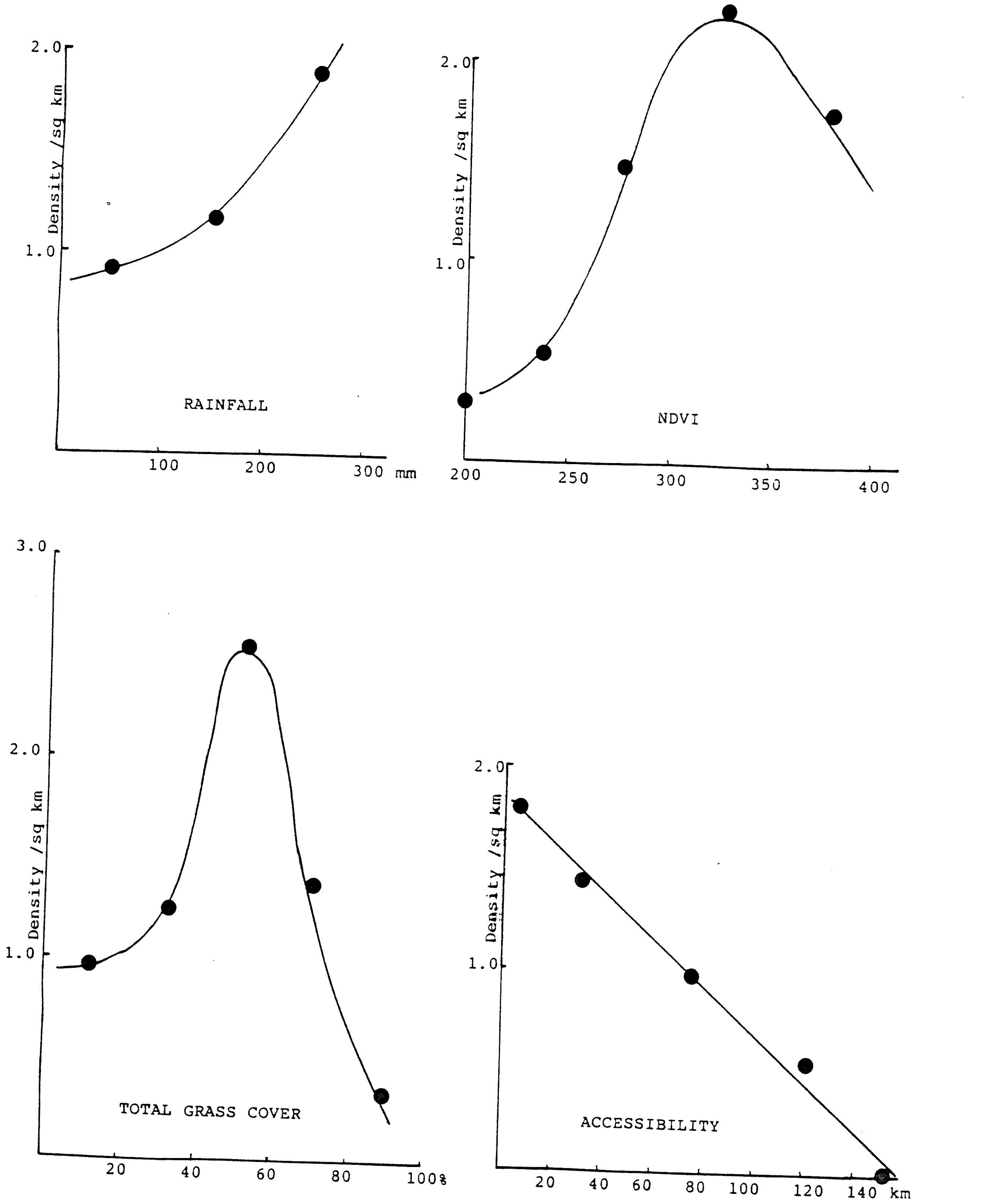
3.4.2 1985 Rainfall.

Table 6 summarises livestock sub-population levels in each of the three 1985 annual rainfall classes considered: 100 mm; 100-200 mm; and 200-300 mm. Cattle density, mean group size and proportion of total TLU increased progressively with increasing rainfall (Figure 2). The same was true for sheep and goats and TLU. The converse applied to camels and donkeys.

3.4.3 Grass Cover.

Table 7 summarises livestock sub-population levels in each of the five classes of grass cover considered: 0-20%; 20-40%; 40-60%; 60-80% and 80-100%. For all species except donkeys, densities were low where grass cover was least; densities increased to a peak at between 40-60% grass cover. Somewhat surprisingly densities were consistently lowest in areas where grass cover was highest (Figure 2). A similar pattern was evident in the mean size of all animal groups, except donkeys.

FIGURE 2: MEAN TLU DENSITY IN RELATION TO: RAINFALL, NDVI, TOTAL GRASS COVER AND ACCESSIBILITY



3.4.4 Cultivation.

Table 8 summarises livestock sub-population levels in each of the five levels of cultivation intensity considered: 0-1%; 1-5%; 5-10%, 10-20% and 20%. However, it should be emphasised that with the very limited extent of cultivation in the survey region, which was concentrated in the south and south-west, the areas represented are strongly skewed towards regions with little or no cultivation. Cattle, sheep and goat densities were generally greater in areas with more than 5% cultivation. Camel densities were highest in areas with least cultivation, where, not surprisingly, they represented the greatest proportion of TLU. Cattle contributed the highest proportion of TLU in areas with 5-10% cultivation; sheep and goats represented 60% of total TLU in areas with 1-5% cultivation.

3.4.5 Normalised Difference Vegetation Index.

Table 9 summarises livestock sub-population levels in each of the five NDVI classes considered: 225; 225-250; 250-300; 300-350 and 350-450. The densities of cattle, camels, sheep and goats and total TLU (Figure 2) show a strong positive correlation with NDVI, peaking at between 300-350 which corresponds to a similar trend identified for ground cover. The TLU proportion represented by cattle rose from 10% to 43% with increasing NDVI, while the reverse was true for camels, falling from 65% at lowest NDVI to 25% at highest NDVI. In contrast the TLU proportion of sheep and goats is fairly consistent throughout the NDVI range, fluctuating between 25-35%.

3.4.6 Accessibility.

Table 10 summarises livestock sub-population levels in each of the five accessibility classes considered: 0-9 kilometres; 10-54 kilometres; 55-100 kilometres; 101-144 kilometres; and 144 kilometres. Cattle and camels individually showed no obvious trends. However, both sheep and goats, and total TLU density declined markedly with increasing remoteness (Figure 2). The mean size of sheep and goat herds increased with decreasing accessibility.

3.4.7 Administrative Region.

Table 11 summarises livestock sub-population levels in each of the four Administrative Departments represented within the survey region: Agadez, Tahoua, Maradi and Zinder. Cattle density was lowest in Agadez and highest in Zinder. The proportion of cattle in total TLU increased in sequence with the order of Departments. Camel density, mean group size and TLU proportion decreased in sequence. Highest sheep and goat densities were found in Tahoua and the lowest in Agadez. Total TLU densities were greatest in Tahoua and Maradi, and lowest in Zinder and Agadez.

3.4.8 Market Town Catchment Areas.

Table 12 shows the totals and densities of livestock populations and pastoral dwellings within 50 kilometre radii of selected market towns, where livestock prices are being monitored by ILP economic evaluation section. It must be emphasised that the circular catchments of Aderbisinat, Agadez, Chadawanka, Tabalak and Tahoua fall partly outside the aerial survey region. For these towns, therefore, it is invalid to make comparisons using the totals indicated; density values should be used instead.

Highest cattle densities were around Kao and Chadawanka; the lowest densities were around Ingal and Agadez. Highest camel densities were around Ingal and Tchin Tabaraden; lowest were around Tahoua and Agadez. Donkey densities were highest around Tahoua, and low everywhere else. Highest sheep and goat densities were found in the vicinity of Abalak, Kao and Tchin Tabaraden; lowest were around Agadez and Tchin Taborak. Highest TLU totals were around Abalak, Kao and Tchin Tabaraden; lowest were around Agadez and Tchin Taborak. Highest densities of leather tents, characteristic of the Iwllemmeden Kel Dinnik Twareg, were around Abalak and Tchin Tabaraden; lowest were around Agadez and Ingal. Highest densities of grass mat structures, characteristic of Kel Ayr Twareg, were around Aderbissinat, Agadez, Ingal and Tchin Taborak; lowest were around Abalak, Chadawank, Tchin Tabaraden and Tofamenir.

4 DISCUSSION AND CONCLUSIONS.

The low level aerial survey described in this report was carried out over the entire 81,550 square kilometres of the Integrated Livestock Project zone during September 1985, at the end of the first reasonably good wet season following the 1983/4 drought. The same techniques of Systematic Reconnaissance Flights and information collection were used as in earlier surveys of the project area, prior to the drought in May 1981, October 1981 and September 1982 (Milligan, 1982 a and b). The results obtained are directly comparable, and the impact of the drought on livestock and human population levels can therefore be reliably assessed.

All livestock populations were substantially lower than in previous surveys. Cattle were the most severely affected, having been reduced by 87% of their September 1982 population; the Bororo breed experienced a proportionately greater decline than Azawak. The donkey population had fallen by 82%. Camels were 71% lower than two years previously. Sheep and goat populations were 63% of their former level. In terms of Tropical Livestock Units their overall number was 77% lower than immediately before the drought.

As a result of these differential population declines the composition of the livestock populations within the project area had also radically changed. As a proportion of total TLU cattle had declined from 57% in May 1981, to 55% in October 1981, 48% in September 1982, and 29% in 1985. Camels showed a corresponding increase from around 20% in May and October 1981, to 32% in September 1982, and 41% in 1985. Sheep and goat proportions ranged from 17-28%. Donkeys remained fairly constant at about 2%.

The distribution of livestock within the project zone varied from species to species, but in comparison with previous surveys showed a general southward shift. In terms of Tropical Livestock Units notable concentrations were evident in the Ighazir depression between Ingal and Agadez in the north-east, and in the Tchin Tabaraden and Abalak region to the south-west.

As regards human pastoral populations, their distribution and number were assessed indirectly during the aerial survey, by means of characteristic styles of dwelling. Leather tents, characteristic of the Iwellemmeden Kel Dinnik Twareg herders, were found at very similar levels to those encountered before the drought, indicating that the human population occupying them had not changed greatly, provided of course that the mean number of inhabitants had remained constant. However, the distribution of leather tents had shifted further south, and they were concentrated in the general region of Tchin Tabaraden and Abalak.

The number of grass mat structures, typical of the Kel Ayr Twareg herders, had fallen by some 25%. Their distribution was still predominantly to the east of the project zone and was concentrated in the vicinities of Agadez, Ingal and Aderbissinat, but appeared to have spread south-westwards.

Very few brushwood crescent shelters, inhabited by WoDaaBe and FulBe pastoralists, were seen. This was in marked contrast to their former relative abundance, and corresponded to a dramatic decline in Bororo cattle, which they typically herd. A mass exodus appeared to have taken place.

The overall decline in livestock population levels and their more southerly dispersal might well have been expected in the aftermath of the 1983/84 drought. What was previously not known was the actual effect in terms of population numbers. The aerial survey results give a very good indication of the magnitude and severity of the impact of this drought on pastoral populations.

Unfortunately, with the information available it is not possible to be certain of what happened to the third of a million Tropical Livestock Units that disappeared from the ILP zone between September 1982 and 1985. Similarly the fate of the people who kept them is not known. Such knowledge would be of great value in predicting the time scale of population recovery. It would be highly desirable for selected case histories to be obtained, and appropriate marketing, livestock control post, and cross border statistics to be assembled so that an educated judgement could be made on the likely future course of events.

During the drought it was obvious that substantial numbers of animals were dying within the project zone, but it was equally evident that alarge number of animals and people were trekking southwards in search of fodder and water. How far south they travelled is difficult to ascertain. Some definitely stayed within Niger; others almost certainly entered Nigeria. Government agencies actively encouraged a destocking policy and large numbers of animals were sold for slaughter. Traditionally Niger has been a major livestock supplier to the meat markets of Nigeria to the south. With the closure of the Nigerian boarder in 1984/85 this traffic may have been interrupted to some extent, but many animals from Niger were undoubtedly getting across and were on sale in Nigerian markets.

Clearly some animals survived and remained within the project area. Others must have survived further south, but if they were in large number it is perhaps a little surprising that more were not encounterd by the aerial survey. It has been suggested that the extensive zone of cultivation that exists to the south of the project zone may have acted as a partial barrier, at least during the cropping period. Perhaps more livestock will return to the ILP zone, after the harvest. Time will tell, but it would be well to consider extending the range of future aerial surveys into more southerly regions of Niger.

Following the previous drought of 1968/73 Swift ed. (1984) concluded that in national terms it took some ten years for livestock populations to attain their pre-drought level. However, it was also evident that this recovery coincided with a redistribution of livestock, both geographically, and in terms of herd ownership. It would be of considerable interest to determine whether this phenomenon was in the process of repeating itself following the 1983/84 drought, as it would have considerable bearing on future livestock development policy and its implementation.

A characteristic feature of the Sahelian environment is the variable cycle of alternating periods of drought and plenty. The aerial survey results considered in this report well illustrate the magnitude of the fluctuations that occured in a central region of the Pastoral Zone of Niger. It is likely that similar changes have taken place over much of the Sahel during the recent widespread drought. 1985 has been a good growing season for crops and bumper harvests are forecast by the Food and Agricultural Organisation of the United Nations. Livestock populations, however, will inevitably take longer to recover.

Regrettably there is also every reason to believe that drought will return at some time in the not too distant future. There is an obvious need for some means of drought and famine risk assessment, as well as a pastoral environmental monitoring system for determining the distribution and quantity of available fodder resources. It is hoped that the overall study, of which the work described here formed a part, will contribute to the establishment of such an early warning system.

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TABLE 1: AERIAL SURVEY LIVESTOCK POPULATION ESTIMATES, FOR THE ILP AREA; MAY 81, OCTOBER 81, SEPTEMBER 82 AND SEPTEMBER 1985. POPULATION TOTALS, GRAZING UNIT TOTALS AND MEAN GROUPS SIZES.

	HEAD				GRAZING UNITS				MEAN GROUP SIZE			
	May 81	Oct 81	Sept 82	Sept 85	May 81	Oct 81	Sept 82	Sept 85	M81	O81	S82	S85
CATTLE	288,700 [6]	376,500 [6]	331,100 [8]	44,400[17]	8,700(10)	10,000(12)	7,900(11)	1,100[10]	33	38	42	40
Azawak	135,800(12)	129,600(17)	139,100(14)	16,900[26]	4,700(10)	4,600(10)	3,900(11)	420[17]	29	28	36	38
Bororo	152,800(15)	246,900(17)	192,000(18)	9,000[24]	4,000(13)	5,400(16)	3,900(16)	260[19]	38	45	49	35
Mixed	-	-	-	18,500[29]	-	-	-	430[16]	-	-	-	43
CAMELS	70,200 (9)	89,300(8)	155,700(32)	44,800[13]	12,900 (9)	16,100(10)	7,800(13)	4,300 [6]	5	6	20	10
DONKEYS	13,500(14)	20,000(11)	23,400(12)	4,200[16]	2,000(14)	3,200 (9)	2,100 (9)	800[10]	7	6	11	5
SHOATS	780,300 (8)	1,147,900(11)	829,600 (8)	307,400 [7]	17,000 (8)	16,500(10)	10,700 (7)	5,600 [6]	46	70	77	55
TLU*	357,000	477,700	482,200	108,800 [8]								

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Aerial survey region occupied a land area of 81,550 square kilometers.

Figures are subject to rounding.

TABLE 2: AERIAL SURVEY LIVESTOCK POPULATION ESTIMATES FOR THE ILP AREA: MAY 81, OCTOBER 81, SEPTEMBER 82 AND SEPTEMBER 1985. LIVESTOCK POPULATION DENSITIES, STOCKING RATES AND TLU PROPORTIONS.

	DENSITY PER SQ. KM.				STOCKING RATE HA./HD.				PERCENTAGE TOTAL TLU.			
	May 81	Oct 81	Sept 82	Sept 85	May 81	Oct 81	Sept 82	Sept 85	May 81	Oct 81	Sept 82	Sept 85
CATTLE	3.54	4.62	4.06	0.54	28	22	25	184	56.6	55.2	48.1	28.6
Azawak	1.67	1.59	1.71	0.21	60	63	53	483	26.6	19.0	20.2	10.9
Bororo	1.87	3.03	2.35	0.11	54	33	42	905	30.0	36.2	27.9	5.6
Mixed	-	-	-	0.23	-	-	-	440	-	-	-	11.9
CAMELS	0.86	1.10	1.91	0.55	116	91	52	182	19.7	18.7	32.3	41.2
DONKEYS	0.17	0.25	0.29	0.05	588	400	345	1928	1.9	2.1	2.4	1.9
SHOATS	9.57	14.08	10.17	3.77	10	7	10	27	21.9	24.0	17.2	28.3
TLU*	4.38	5.86	5.91	1.33	23	17	17	75				

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Aerial survey region occupied a total land area of 81,550 square kilometers.

Figures subject to rounding.

TABLE 3: AERIAL SURVEY PASTORAL HABITATION ESTIMATES, FOR THE ILP AREA; MAY 81, OCTOBER 81, SEPTEMBER 82 AND SEPTEMBER 1985.
TOTAL NUMBER OF DWELLINGS AND CAMPS.

	DWELLINGS				CAMPS				MEAN CAMP SIZE			
	May 81	Oct 81	Sept 82	Sept 85	May 81	Oct 81	Sept 82	Sept 85	M81	O81	S82	S85
LEATHER TENTS	12,000(18)	10,100(18)	7,200(24)	7,900[11]	2,500(14)	2,700(17)	1,700(21)	1,900 [9]	4.8	3.8	4.3	4.3
MAT DWELLINGS	10,200(17)	5,700(20)	6,600(19)	4,900[30]	2,200(12)	1,400(15)	1,600(16)	770[14]	4.6	3.9	4.0	6.3
CLOTH TENTS		880(74)		630[27]		140(59)		200[22]		6.5		3.1
OCCUPIED CRESECENT SHELTERS	5,700(21)	6,200(20)	7,000(25)	230[48]	2,300(20)	2,900(19)	1,500(20)	70[28]	2.5	2.2	2.8	3.2
ABANDONED CRESCENT SHELTERS				2,900[28]				540[15]				5.5

This table refers only to distintive forms of pastoral habitation; mud built dwellings, villages and towns have been exluded.
See text for probable ethnic occupancy of different structures.

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Aerial survey region occupied a land area of 81,550 square kilometers.

Figures subject to rounding.

TABLE 4: GROUND COVER AND TREE/SHRUB DENSITY WITHIN ILP AREA, FROM PHOTOINTERPRETATION OF AERIAL PHOTOGRAPHY.

	Area sq.km.	PERCENTAGE Brown Grass	Green Grass	Total Grass	Trees/ Shrubs	Culti- vation	Bare Ground	Water	Roads/ Settle	Trees /ha.
ENTIRE SURVEY REGION										
	81,550	24.7	6.1	30.8	1.3	1.8	66.0	<0.1	<0.1	3.0
Jolly % SE		(4)	(5)	(4)	(4)	(18)	(2)	(29)	(18)	(5)
Marriott % SE		[1]	[3]	[1]	[4]	[7]	[1]	[27]	[11]	[3]
ADMINISTRATIVE DEPARTMENTS										
Agadez	36,986	19.3 (4)	5.8 (7)	25.0 (4)	1.0(10)	<0.1	73.9 (1)	<0.1	<0.1	2.5(10)
Tahoua	34,185	22.7 (9)	5.9 (7)	28.5 (7)	1.5 (7)	3.4(14)	66.3 (3)	<0.2	<0.1	3.0 (9)
Maradi	5,683	50.3 (5)	7.9(12)	58.2 (3)	1.6(12)	2.6(29)	37.4 (5)	<0.1	<0.1	4.2(26)
Zinder	4,695	50.5 (3)	8.5(16)	59.0 (3)	1.9 (9)	2.4(44)	36.3 (4)	0.4(61)	0.1(25)	5.8(15)
1985 RAINFALL ZONE.										
100 mm	9,967	5.5(12)	5.3(16)	10.7(12)	0.8(26)	<0.1	88.3 (2)	<0.1	<0.1(43)	1.3(23)
100-199 mm	48,765	20.9 (7)	6.1(6)	27.0 (6)	1.1 (6)	0.2(43)	71.7 (2)	<0.1	<0.1	2.9 (6)
200-299 mm	22,817	41.0 (5)	6.6(10)	47.6(5)	1.9 (6)	5.9(22)	44.2(3)	0.2(37)	0.1(23)	4.0 (7)
DISTANCE FROM NEAREST MAIN ROAD.										
0-9 km	21,829	21.9 (9)	5.2(10)	27.1 (7)	1.4(10)	3.7(32)	67.5(3)	0.1(54)	0.2(25)	3.0 (8)
10-54 km	33,856	25.2 (5)	6.1 (7)	31.3 (5)	1.4 (7)	1.1(31)	66.0 (2)	<0.1	<0.1	3.2 (6)
55-100 km	18,616	30.3(12)	7.2 (7)	37.5(10)	1.2(11)	1.0(36)	60.1 (6)	0.1(37)	<0.1	3.3 (8)
101-144 km	6,178	16.1(19)	6.5(16)	22.6(15)	0.5(23)	1.1(47)	75.7 (5)	<0.0	<0.1	1.0(16)
144 km	1,071	12.4(12)	5.5(20)	16.9(16)	1.6(73)	0.0	82.9 (3)	0.0	0.0	0.5(22)
ECOZONE										
Treeless	38,880	14.7 (6)	5.4 (7)	21.3 (6)	0.9 (8)	1.9(20)	75.7 (2)	0.1(40)	<0.1	1.9 (1)
Shrubland	23,394	31.4 (6)	7.3 (8)	38.7 (6)	1.6 (7)	2.2(22)	57.4 (9)	<0.1	<0.1	3.7 (7)
Woodland	19,275	34.1 (5)	6.3 (7)	40.3 (4)	1.7 (9)	0.9(45)	56.8 (3)	0.1(40)	<0.1	4.4 (9)

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Figures subject to rounding.

TABLE 5: LIVESTOCK SUB-POPULATIONS BY ECOZONE.

	OPEN TREELESS	SHRUBLAND	WOODLAND
AREA SQ. KM	36,880	23,394	19,275
ALL CATTLE			
Head	24,619(28)	12,463(21)	7,331(42)
Density /sq.km	0.63	0.53	0.38
St. Rate ha./hd.	159	187	263
Grazing Units	466(17)	493(19)	147(26)
Mean Group Size	53	25	50
% Total TLU	31.5	24.6	27.6
CAMELS			
Head	23,571(17)	12,933(21)	8,335(32)
Density /sq.km	0.61	0.55	0.43
St. Rate ha./hd.	164	182	233
Grazing Units	2,347(10)	1,320(14)	641(15)
Mean Group Size	10	10	13
% Total TLU	43.0	36.5	44.9
DONKEYS			
Head	1,982(25)	1,402(26)	849(46)
Density /sq.km	0.05	0.06	0.04
St. Rate ha./hd.	2,000	1,667	2,500
Grazing Units	405(17)	266(18)	125(28)
Mean Group Size	5	5	7
% Total TLU	1.8	2.0	2.3
SHEEP AND GOATS			
Head	129,659(14)	130,783(19)	46,913(16)
Density /sq.km	3.33	5.59	2.43
St. Rate ha./hd.	30	18	41
Grazing Units	2,592(11)	1,989(17)	1,006(15)
Mean Group Size	50	66	47
% Total TLU	23.7	36.9	25.2
TROPICAL LIVESTOCK UNITS			
Number	54,762(14)	35,437(17)	17912 18,583(18)
Density /sq.km	1.41	1.51	0.96
St. Rate ha./hd.	71 1.39	66 1.49	104

9865 9468

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 6: LIVESTOCK SUB-POPULATIONS BY 1985 RAINFALL CATEGORY.

	100 MM	100 - 200 MM	201 - 300
AREA SQ. KM	9,967	48,765	222,817
ALL CATTLE			
Head	449(67)	14,943(33)	29,022(14)
Density /sq.km	0.05	0.31	1.27
St. Rate ha./hd.	2,200	326	79
Grazing Units	27(61)	442(21)	636(11)
Mean Group Size	17	34	46
% Total TLU	3.4	18.4	47.6
CAMELS			
Head	7,397(38)	28,203(15)	9,240(18)
Density /sq.km	0.74	0.58	0.40
St. Rate ha./hd.	135	173	247
Grazing Units	602(19)	2,449(10)	1,257 (9)
Mean Group Size	12	12	7
% Total TLU	79.5	49.7	21.6
DONKEYS			
Head	633(49)	2,430(25)	1,169(22)
Density /sq.km	0.06	0.05	0.05
St. Rate ha./hd.	1,575	2,007	1,952
Grazing Units	120(32)	396((16)	280(19)
Mean Group Size	5	6	4
% Total TLU	3.5	2.1	1.4
SHEEP AND GOATS			
Head	12,752(25)	169,115(15)	125,494(11)
Density /sq.km	1.28	3.47	5.5
St. Rate ha./hd.	78	29	18
Grazing Units	398(21)	2,977(12)	2,213 (8)
Mean Group Size	32	57	57
% Total TLU	13.7	29.8	29.4
TROPICAL LIVESTOCK UNITS			
Number	9,304(30)	56,790(14)	42,689 (8)
Density /sq.km	0.93	1.16	1.87
St. Rate ha./hd.	107	86	53

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 7: LIVESTOCK SUB-POPULATIONS BY PERCENTAGE GRASS COVER.

	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100
AREA SQ. KM	35,091	20,346	13,921	9,308	2,883
ALL CATTLE					
Head	6,145(32)	8,353(31)	22,989(27)	6,635(36)	293(41)
Density /sq.km	0.18	0.41	1.13	0.71	0.10
St. Rate ha./hd.	571	244	89	140	984
Grazing Units	204(26)	252(21)	414(21)	209(26)	28(37)
Mean Group Size	30	33	56	32	10
% Total TLU	12.7	23.7	45.4	35.2	19.9
CAMELS					
Head	17,743(19)	10,830(22)	10,493(29)	5,396(31)	377(33)
Density /sq.km	0.51	0.50	0.52	0.58	0.13
St. Rate ha./hd.	198	188	194	173	764
Grazing Units	1,954 (9)	1,073(14)	734(17)	468(16)	78(34)
Mean Group Size	9	10	14	12	5
% Total TLU	52.4	42.9	29.6	40.9	36.5
DONKEYS					
Head	1,614(26)	1,344(32)	718(48)	485(44)	70(92)
Density /sq.km	0.05	0.07	0.04	0.05	0.02
St. Rate ha./hd.	2,174	1,514	2,832	1,918	4,085
Grazing Units	357(22)	208(19)	126(28)	94(32)	10(92)
Mean Group Size	5	6	6	5	7
% Total TLU	2.4	2.7	1.0	1.8	3.4
SHEEP AND GOATS					
Head	110,403(13)	78,989(16)	84,650(25)	29,177(19)	4,142(38)
Density /sq.km	3.15	3.88	6.08	3.13	1.44
St. Rate ha./hd.	32	26	16	32	70
Grazing Units	2,185(12)	1,453(16)	1,330(16)	506(15)	116(35)
Mean Group Size	51	54	63	58	36
% Total TLU	32.6	31.3	23.9	22.1	40.1
TROPICAL LIVESTOCK UNITS					
Number	33,892(12)	25,248(18)	35,411(17)	13,200(20)	1,032(28)
Density /sq.km	0.97	1.24	2.54	1.42	0.36
St. Rate ha./hd.	104	81	39	70	279

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 8: LIVESTOCK SUB-POPULATIONS BY PERCENTAGE CULTIVATION.

	0 - 1	1 - 5	5 - 10	10 - 20	40
AREA SQ. KM	72,900	2,388	1,729	1,400	3,129
ALL CATTLE					
Head	33,602(21)	748(65)	3,206(68)	2,046(43)	4,814(50)
Density /sq.km	0.46	0.31	1.85	1.46	1.54
St. Rate ha./hd.	217	319	54	68	65
Grazing Units	877(15)	19(64)	78(36)	76(31)	55(25)
Mean Group Size	38	40	41	27	88
% Total TLU	25.8	19.9	50.2	44.4	46.8
CAMELS					
Head	41,919(12)	473(21)	596(28)	766(36)	1,085(20)
Density /sq.km	0.58	0.20	0.34	0.55	0.35
St. Rate ha./hd.	174	504	290	183	288
Grazing Units	3,613(8)	176(20)	169(26)	82(34)	270(15)
Mean Group Size	12	3	4	9	4
% Total TLU	45.9	18.0	13.2	23.7	15.1
DONKEYS					
Head	3,688(22)	135(36)	65(48)	90(71)	254(40)
Density /sq.km	0.05	0.06	0.04	0.06	0.08
St. Rate ha./hd.	1,977	1,765	2,673	1,553	1,232
Grazing Units	602(14)	58(30)	25(53)	33(66)	78(30)
Mean Group Size	6	2	3	3	3
% Total TLU	2.0	2.6	0.7	1.4	1.8
SHEEP AND GOATS					
Head	239,735(13)	15,625(19)	15,975(28)	9,868(27)	26,490(15)
Density /sq.km	3.29	6.54	9.24	7.05	8.47
St. Rate ha./hd.	30	15	11	14	11
Grazing Units	4,222(10)	397(25)	259(19)	225(26)	484(12)
Mean Group Size	57	39	62	44	55
% Total TLU	26.3	59.5	35.7	30.6	36.8
TROPICAL LIVESTOCK UNITS					
Number	91,258(10)	2,628(25)	4,470(41)	3,229(23)	7,198(25)
Density /sq.km	1.25	1.10	2.59	2.31	2.30
St. Rate ha./hd.	80	91	39	43	44

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 9: LIVESTOCK SUB-POPULATION BY NORMALISED DIFFERENCE VEGETATION INDEX CLASSES.

	<225	225 - 250	250 - 300	300 - 350	350 - 450
AREA SQ. KM	2.553	22.405	39.127	13.344	4.118
ALL CATTLE					
Head	119(92)	1,788(72)	23,343(24)	14,759(16)	4,408(44)
Density /sq.km	0.05	0.08	0.60	1.11	1.07
St. Rate ha./hd.	2,153	1,253	168	90	93
Grazing Units	10(92)	75(60)	549(17)	397(16)	75(17)
Mean Group Size	12	24	43	37	58
% Total TLU	10.0	10.1	28.3	33.8	43.4
CAMELS					
Head	539(36)	6,398(19)	24,026(17)	12,115(26)	1,763(30)
Density /sq.km	0.21	0.29	0.61	0.91	0.43
St. Rate ha./hd.	474	350	163	110	234
Grazing Units	68(32)	965(13)	2,056(10)	990(15)	229(21)
Mean Group Size	8	7	12	12	8
% Total TLU	64.5	51.4	41.5	39.7	24.8
DONKEYS					
Head	20(90)	1,101(36)	2,124(24)	728(33)	260(37)
Density /sq.km	0.01	0.05	0.05	0.05	0.06
St. Rate ha./hd.	13,024	2,036	1,842	1,832	1,579
Grazing Units	10(90)	188(27)	367(16)	155(25)	75(30)
Mean Group Size	2	6	6	5	3
% Total TLU	1.2	4.4	1.8	1.2	1.8
SHEEP AND GOATS					
Head	2,053(62)	42,506(17)	164,198(13)	77,336(18)	21,267(14)
Density /sq.km	0.80	1.90	4.20	5.8	5.16
St. Rate ha./hd.	124	53	24	17	19
Grazing Units	48(39)	639(13)	2,836(11)	1,453(13)	413(11)
Mean Group Size	43	51	58	53	52
% Total TLU	24.6	34.1	28.4	25.3	29.9
TROPICAL LIVESTOCK UNITS					
Number	836(37)	12,449(16)	57,847(13)	30,543(15)	7,105(17)
Density /sq.km	0.33	0.56	1.48	2.29	1.73
St. Rate ha./hd.	305	180	68	44	58

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 10: LIVESTOCK SUB-POPULATIONS BY DISTANCE TO NEAREST MAIN ROAD.

	0 - 9 KM	10 - 54 KM	55 - 100 KM	101 -144 KM	144 KM
AREA SQ. KM	21,829	33,856	18,616	6,178	1,071
ALL CATTLE					
Head	19,059(32)	9,602(33)	14,439(32)	1,321(72)	0
Density /sq.km	0.87	0.28	0.78	0.21	0
St. Rate ha./hd.	115	353	129	468	
Grazing Units	420(22)	374(24)	291(27)	20(70)	0
Mean Group Size	45	26	50	67	
% Total TLU	34.6	13.7	52.9	45.3	
CAMELS					
Head	13,456(18)	27,034(18)	4,053(24)	299(530	0
Density /sq.km	0.62	0.80	0.22	0.55	0
St. Rate ha./hd.	162	125	459	2,067	
Grazing Units	1,605(12)	2,084(13)	560(13)	60(34)	0
Mean Group Size	8	13	7	5	
% Total TLU	34.9	55.1	21.2	14.7	
DONKEYS					
Head	2,155(26)	1,496(32)	410(33)	172(74)	0
Density /sq.km	0.10	0.04	0.02	0.03	0
St. Rate ha./hd.	1,013	2,264	4,544	3,602	
Grazing Units	375(17)	273(19)	126(26)	21(69)	0
Mean Group Size	6	5	3	8	
% Total TLU	2.8	1.5	1.1	4.2	
SHEEP AND GOATS					
Head	106,542(12)	146,091(21)	47,389(19)	7,338(48)	0
Density /sq.km	4.88	4.32	2.60	1.19	0
St. Rate ha./hd.	20	23	39	84	
Grazing Units	2,206(10)	2,474(17)	791(15)	117(32)	0
Mean Group Size	48	59	60	63	
% Total TLU	27.7	29.8	24.8	36.0	
TROPICAL LIVESTOCK UNITS					
Number	38,529(12)	49,111(16)	19,103(22)	2,040(52)	0
Density /sq.km	1.77	1.45	1.03	0.33	0
St. Rate ha./hd.	57	69	97	303	

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 11: LIVESTOCK SUB-POPULATIONS BY ADMINISTRATIVE DEPARTMENT WITHIN THE INTEGRATED LIVESTOCK PROJECT AREA.

	AGADEZ	TAHOUA	MARADI	ZINDER
AREA SQ. KM	36,985	34,185	5,683	4,695
ALL CATTLE				
Head	2,654(37)	28,299(24)	9,158(28)	4,303(36)
Density /sq.km	0.07	0.83	1.61	0.92
St. Rate ha./hd.	1,393	121	62	109
Grazing Units	138(38)	597(16)	183(16)	188(19)
Mean Group Size	19	47	50	23
% Total TLU	5.3	33.6	64.4	66.7
CAMELS				
Head	23,414(17)	19,850(16)	1,254(52)	323(56)
Density /sq.km	0.63	0.58	0.22	0.07
St. Rate ha./hd.	158	172	453	1,452
Grazing Units	1,808(12)	2,258(11)	166(15)	76(32)
Mean Group Size	13	9	8	4
% Total TLU	66.1	33.7	12.6	7.2
DONKEYS				
Head	2,198(30)	1,635(26)	265(52)	134(26)
Density /sq.km	0.06	0.05	0.05	0.03
St. Rate ha./hd.	1,682	2,091	2,147	3,496
Grazing Units	347(21)	349(18)	40(47)	58(23)
Mean Group Size	6	5	7	2
% Total TLU	3.1	1.4	1.3	1.5
SHEEP AND GOATS				
Head	90,441(12)	184,197(15)	21,592(27)	11,132(31)
Density /sq.km	2.45	5.39	3.80	2.37
St. Rate ha./hd.	41	19	26	42
Grazing Units	1,690(11)	3,253(12)	361(17)	284(26)
Mean Group Size	54	57	60	39
% Total TLU	25.5	31.3	21.7	24.6
TROPICAL LIVESTOCK UNITS				
Number	35,416(13)	58,896(14)	9,955(22)	4,517(23)
Density /sq.km	0.95	1.72	1.75	0.96
St. Rate ha./hd.	230	58	57	104

Figures in parentheses are percentage standard errors: [Marriott] and (Jolly).

Tropical Livestock Unit conversion factors: Camels = 1.0; Cattle = 0.7; Donkeys = 0.5; Shoats = 0.1 (Janke, 1982).

Figures subject to rounding.

TABLE 12: LIVESTOCK POPULATIONS AND PASTORAL HABITATION WITHIN 50 KILOMETER RADII OF SELECTED MARKET TOWNS.

		LIVESTOCK					HABITATION			
MARKET TOWN	AREA SQ KM	CATTLE	CAMELS	DONKEYS	SHOATS	TLU	LEATHER	MAT	CLOTH	CRESCENTS
ABALAK	7,248	11,800 1.63	7,100 0.98	270 0.04	75,300 10.39	23,900 3.30	3,000 0.42	140 0.02	70 0.01	0 0
ADERBISINAT	4,612	1,650 0.36	1,690 0.37	350 0.08	18,300 3.97	4,800 1.05	120 0.03	1,750 0.38	10 0.01	40 0.01
AGADEZ	3,871	450 0.12	1,430 0.37	220 0.06	4,600 1.19	2,300 0.60	70 0.02	650 0.17	40 0.01	0 0
CHADAWANKA	6,178	10,700 1.73	3,000 0.49	200 0.03	37,900 6.14	14,300 2.31	1,500 0.25	130 0.02	20 0.01	0 0
INGAL	7,248	320 0.04	13,200 1.82	360 0.05	30,000 4.13	16,600 2.29	60 0.01	910 0.13	0 0	0 0
KAO	7,413	16,100 2.17	8,600 1.15	570 0.08	79,200 10.69	28,000 3.78	2,200 0.29	130 0.05	20 0.01	50 0.01
TABALK	6,095	6,100 1.00	2,300 0.38	400 0.06	40,800 6.69	10,900 1.78	770 0.13	170 0.08	0 0	0 0
TAHOUA	2,553	1,700 0.65	700 0.27	370 0.14	20,700 8.09	4,000 1.58	120 0.05	150 0.06	0 0	0 0
T.TABARADEN	7,248	11,700 1.62	11,500 1.58	670 0.09	79,400 10.95	28,000 3.86	2,400 0.33	150 0.02	30 0.01	50 0.01
T.TABORAK	7,248	1,500 0.21	2,300 0.31	330 0.05	16,700 2.30	5,100 0.71	340 0.05	1,600 0.22	0 0	0 0
TOFAMENIR	7,248	6,100 0.84	3,200 0.45	450 0.06	32,500 4.48	11,000 1.51	1,600 0.22	170 0.02	70 0.01	100 0.01

Population estimates based on aerial survey grid cells falling within a 50 kilometer radius of each market town. Some catchement areas fall partly outside region surveyed. For comparative purposes densities values, indicated in lower figure of each pair and given as the number per square kilometer, should be used.