AERIAL SURVEY OF CATTLE, VEGETATION, AND LAND USE
IN A REGION OF THE NIGERIAN SUB-HUMID ZONE, PRIOR TO
BIOLOGICAL CONTROL OF TSETSE BY STERILE MALE RELEASE

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AERIAL SURVEY OF BICOT PROJECT AREA.

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1. Introduction.

The Nigerian Federal Department of Pest Control Services, in co-operation with the joint division of the Food and Agriculture Organisation and the International Atomic Energy Agency of the United Nations, has established a project for the Biological Control of Tsetse (BICOT), using the sterile male release technique.

The field area selected by BICOT for demonstration and development of this novel form of tsetse control lies within the Nigerian sub-humid zone, in the lowlands between the Jos Plateau and the river Benue; (Bourn and Oladunmade, 1980). It is composed of the Akuni, Feferuwa and boundary catchments of the Dep river basin, to the north-east of Lafia town in Plateau State. (See map, figure 1.)

This lowland "middle belt" of Nigeria has in the past been characterised, in contrast to regions further to the north and south, as having relatively low levels of human population and limited agricultural activity. The Federal Government has identified the middle belt as having the greatest potential for increased arable and livestock production, and is actively promoting agricultural development projects within the region. The BICOT field area lies within the boundaries of such a project: the Lafia Agricultural Development Project, which is co-funded by the Federal and State Governments and the World Bank.

The International Livestock Centre for Africa is currently investigating livestock production systems within the "sub-humid zone", which closely corresponds to the middle belt; and has carried out a series of livestock and natural resource aerial surveys (Milligan, Bourn and Chachu, 1979; ILCA, 1980). It was decided to include the BICOT project area in this aerial survey programme because it was considered important to assess the number and distribution of cattle prior to the initiation of tsetse control operations.

This report describes the methodology and results of that aerial survey, which took place on 13 April 1982, at the end of the dry season.

2.   Methodology.

2.1 Flight Procedure.

The aerial survey of the BICOT project area was carried out from Haipang airport, using the ILCA aircraft: a high-winged, twin engine, Partenavia P68B, equipped with an OMEGA global navigation system and a radar altimeter. The four man survey team consisted of the pilot; two observers, seated behind the pilot, each responsible for recording livestock observed to the left or right of the aircraft; and a front seat observer, who navigated and recorded land use, habitation and ecological conditions.

A systematic pattern of parallel flight lines was flown at 5 km intervals over the survey zone, centred at 8 40'N and 8 45'E. Starting at the north-western corner, some 10 km north of Nassarawa Egon at the edge of the Mada escarpment, the aircraft flew alternately eastwards and westwards between the Dep river and the main Akwanga-Lafia road.

Each flight line was divided into 5 km sectors, thus enabling the information collected to be recorded on a 5 x 5 km grid, as shown in figure 2. Ten flight lines, of varying length from 40 to 50 km, were flown and 93 grid squares were covered. The total land area surveyed was 2,325 square kilometers.

2.2 Sample Procedure.

The area actually sampled along each flight line was restricted to fixed strips on each side of the aircraft. The width of these strips was determined by the projection from the observer's eye to the ground, of two parallel rods supported by the wing struts. The spacing of the two rods was calculated for each observer using the methods described by Norton-Griffiths (1978), and set to give a ground strip width of 400 meters when flying at an altitude of 800 feet (244 meters) above ground level. Thus with flight intervals of 5 km, a combined left and right sample strip width of 800 meters, an overall sampling intensity of 16% of the land area was obtained.

2.3 Information Collection.

The two back seat observers recorded the number of cattle seen within their respective sample strips on each side of the aircraft. For every herd seen, a visual estimate of the number of animals was recorded. If more than ten animals were present, a photograph was taken using a 35 mm camera fitted with a zoom lens, and 200 colour ASA film, so that subsequently the actual number of animals could be accurately counted.

The patterns of land use, vegetation and habitation were recorded by the front seat observer, who estimated the proportion of grass and tree cover, the extent of burning, the structure of the natural vegetation, the type and intensity of cultivation, and human habitation.

2.4 Information Analysis.

After the flight the exact number of animals in each photograph was accurately counted by projecting the colour slide in a micro-fiche reader. The results obtained were then compared to the visual estimates made during flight, and the bias of each observer calculated. This bias factor was then used to correct the estimates of large herds that could not be photographed, or where the quality of the photograph was too poor for counting.

After correcting all the animal estimates made during the survey, the total number of animals and herds seen along each flight line were calculated by pooling the observationas made on each side of the aircraft. Each flight line was treated as an independant sample of the total animal population, from which an overall population estimate, with confidence limits, was computed using the Ratio Method recommended by Jolly (1969) and covered in detail by Norton-Griffiths (1978).

This ratio estimate assumes that the larger the sample unit (flight line), the more reliable the count obtained from it. The calculation thus biases the overall variance in favour of the longer flight lines, by taking into account the co-variance between the individual sample areas and the animals counted in them. Estimates of the cattle population and the number of herds within the survey zone were computed using the following equations:

Population Total :
$$\hat{Y} = z . \hat{R}$$

Population Variance:
$$\text{Var} (\hat{Y}) = \frac{N (N - n)}{n} . (s_y^2 - 2.\hat{R}.s_{zy} + R.s_z^2)$$

Where:

- N = the number of sample units in the population.
- n = the number of sample units in the sample.
- Z = the area of the census zone.
- 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 area searched.

and

- sy = the variance between animals counted in all units.
- sz = the variance between the areas of all the sample units.
- syz = the covariance between counts and areas of each unit.

Other environmental information collected during the survey was converted where necessary to standard density values, plotted on separate grid distribution maps and analysed by computer.

2.5 Aerial Photography.

The most recent existing aerial photography of the BICOT project area was flown in 1972/73. During the intervening ten years considerable expansion of cultivation has occured, and substantial deforestation in riverine forests has taken place. For better assessment of the extent of tsetse habitats, and for planning BICOT's future field programme, more up to date photography was required.

Although the aircraft was not equipped for standard aerial photogrpahy, ILCA is experimenting with the use of 35 mm photography as a means of providing rapid cheap updating of existing aerial photography, so a second mission was flown in the afternoon of 13 April 1982. In order to obtain the desired coverage, without taking an inordinate number of photographs, the aircraft had to fly at a much greater altitude than during the survey, (Grimsdell, 1978.) Four series of vertical photographs were taken using a 35mm camera, a 20mm lens and 200 ASA film, from an altitude of 10,000 feet (3,048 meters) above ground level.

The first leg ran eastwards from Adogi over southern portions of the five major northern tributaries of the Akuni river. The aircraft then turned north and flew back over the northern portions. The two series of photographs thus aquired covered BICOT's Pilot Release Zone. The third leg ran north-eastwards from Akurba over the Ehula tributary to its confluence with the Feferuwa. The aircraft then turned east and flew south on the forth leg, over the Achiba tributary of the Feferuwa.

Subsequently slides and colour prints were developed, and uncorrected mosaics of overlapping colour photographs were prepared for each of the three regions of primary interest to BICOT.

3. <u>Results.</u>

The Feferuwa-Akuni aerial survey took place at the end of the dry
season (13 April,1982), and covered some 2,325 square kilometers
at 16% sampling intensity. The findings are summarised in Table 1
and in figures 3 - 14, and are briefly described in the following
paragraphs.

3.1 Cattle Population.

The number of cattle within the survey zone was estimated to be
38,138 (+/-17% standard error). The mean density was 16.4 head
per square kilometer; the stocking rate being 6.1 hectares per
head. Figures 3 and 4 show the distribution of cattle in terms
of density and stocking rate.

3.2 Cattle Herds.

The number of cattle herds within the survey zone was estimated
to be 506 (+/-13% standard error), or approximately 1 herd per 5
square kilometers (0.22 herds per square kilometer). Figure 5
shows the pattern of herd distribution.

3.3 Herd Size.

Eighty-one cattle herds were recorded during the sample survey.
The histogram in figure 6 shows the frequency distribution of
herd sizes. The mean was 75 animals per herd. This value,
however, exaggerates the number of animals in a typical herd
because it includes six large herds, each with more than 200
head. The commonest herds contained between 20 and 40 head.

3.4 Land Use.

The proportion of land under cultivation in each grid is shown in
figure 7. Land use intensity was highest around Lafia town. This
belt of high intensity cultivation extended eastwards along the
main road from Lafia to the Dep river, through most of the Akuni
catchment. Another region of intensive cultivtion occured to the
the north of the Feferuwa river and south-east of Arikiya. Little
or no cultivation was seen in the extreme south-east, north-east
and north-west.

This pattern of land use intensity is in good general agreement
with that obtained from 1972/73 aerial photography (see figure 8,
derived from LRDC, 1979); and 1976 side looking airborne radar
imagery (see figure 9, derived from FDF, 1978). Comparison of
the three maps based on information aquired over the past ten
years indicates that the extent of cultivation has gradually
expanded into former areas of natural vegetation.

3.5 Riverine Forest.

BICOT field work has demonstrated that dry season tsetse
distribution and abundance within the survey zone is closely
correlated with the extent of evergreen riverine forest
vegetation. Figure 10 shows the dendritic pattern of evergreen
forest apparent on the latest available LANDSAT imagery (LADP,
1981). The presence of evergreen forest in this region of Nigeria
is indicative of gound water at or near the surface, and thus can
be considered to be a good indicator of water availability for
both cattle and people.

3.6 Human Habitation.

A measure of human population distribution within the survey zone was obtained by recording the number of dwellings seen in each grid; those of cattle owning Fulani being distinguished from arable farmers by the type of construction. This method may underestimate Fulani distribution, because over the past few years a substantial number have settled in the region and some have adopted non-traditional building styles. Nevertheless cattle holding grounds adjacent to dwellings are distinctive. Figures 11 and 12 show the distribution of arable and Fulani habitation.

It is of interest to note that there is a substantial degree of overlap between the two distributions. In particular, areas with low levels of arable farmer habitation also have few Fulani dwellings. This is presumably a reflection of the close interdependence which exists between farmer and livestock owner, in terms of crop residue consumption, milk product marketing and water requirements.

3.7 Cultivation Type.

As well as the intensity of cultivation (shown in figure 7), the proportion of that cultivation which was ridged or mounded was also estimated during the survey. The distribution of different cultivation types is shown in figure 13.

Although a substantial degree of intercropping takes place in the area, ridged cultivation is typical of cereal crop production, whilst mounded cultivation is typical of yam production. Ridged cultivation was observed throughout the zone. Mounded cultivation was much more restricted. It predominated in the south-eastern region around Lafia, and was as common as ridged in the Uga-Assaikio-Sabon Gida area to the west of the Dep river.

3.8 Burning.

Not surprisingly, at the end of the dry season, very large areas of the survey zone had been burnt. Figure 14 shows the extent of the burning in each grid. Three-quaters of the land area had been burnt throughout; the south-eastern portion being somewhat less intensely affected than the rest.

3.9 Photomosaics.

Black and white reproductions of the colour photomosaics obtained from the high altitude aerial photography of the BICOT Pilot Release Zone, and the Ehula and Achiba river/forest systems are shown in figures 14, 15 and 16 respectively. Whilst some quality has been lost in the reprographic and enlargement processes, they nevertheless give a good indication of the extent of cultivation and riverine forest at the present time.

4. Multivariate analysis.

The maps in figures 3-13 show the individual distribution patterns of the major variables assessed during the aerial survey, but they give little indication of the underlying relationships between cattle distribution and vegetation/land use parameters. In order to elucidate these relationships, and to suggest possible explanations for the observed distribution of cattle, a series of multivariate analyses were performed by computer.

In the first instance correlation coefficients were calculated for each pair of variables. The resultant correlation matrix is given in table 2. Eight pairs of variables were found to be significantly correlated:

Of the seven variables considered, only riverine forest was positively correlated with cattle numbers.

As might be expected arable farmer habitation was positively correlated with cultivation.

Grass cover was negatively correlated with both woodland and riverine forest.

Woodland distribution was negatively correlated with scrub, cultivation and riverine forest.

Scrubland was positively correlated with cultivation.

Principal Components Analysis of the variable correlation matrix suggested two possible groupings of associated variables (see figure 17):

cultivation, arable farmer habitation and Fulani habitation;

cattle, riverine forest and scrubland.

Next, a cluster analysis was carried out, which grouped the variables on the basis of the similarity of their correlation coefficients, and suggested the following association of variables:
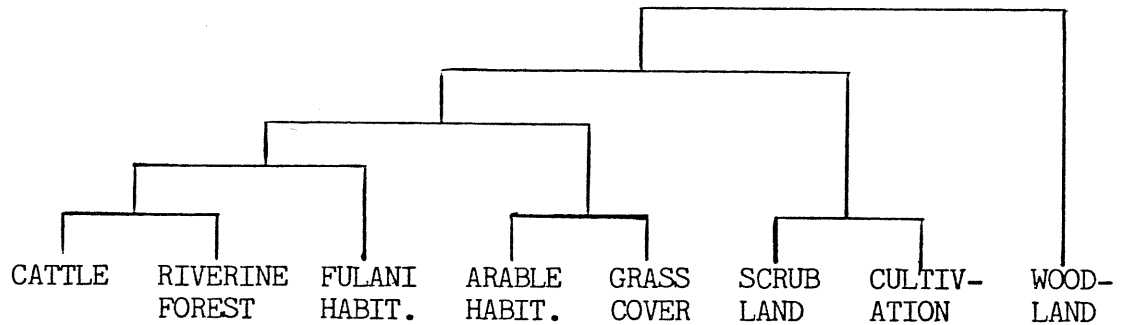
Thus the distribution of cattle was again found to be closely associated with riverine forest vegetation; this pair were then most closely associated with Fulani habitation; these three variables were most closely associated with the pair of variables: arable habitation and grass cover; these five variables were then most closely associated with the variable pair: scrubland and cultivation; and finally the preceeding seven variables were linked with woodland.

Finally a stepwise multiple regression analysis was performed, with cattle as the dependant variable. This indicated that cattle distribution was significantly positively correlated with, in descending order of importance: extent of riverine forest, scrubland, and uncultivated land. However the proportion of total variance of cattle numbers explained by these three variables amounted to less than 10% (6%, 2% and 1% respectively for each of the added variables).

5.   Discussion and Conclusions.

The dry season cattle population within the aerial survey zone was estimated to be 38,138 (+/- 17% SE); the population being made up of an estimated 506 (+/- 13% SE) herds, with a mean herd size of 75 head, but with a modal herd size of between 20 and 40 animals.

Estimated cattle density was 16.4 head per square kilometer, which is within the range of dry season densities found in other Nigerian aerial surveys: 6.6 - 37.4 head per square kilometer. (See table 3 for comparison, and figure 17 for the locations of the other survey zones.)

Whether or not cattle population within the BICOT project area is likely to increase or decrease during the wet season is a debatable point. Conventional wisdom would have it decrease as cattle herds tend to move north, and/or back onto the Jos Plateau, but as can be seen from table 3, cattle population within the neighbouring Lafia SE survey zone dramatically increased from dry to wet season.

A survey of Lafia Fulani herdsmen, carried out by questionaire during the wet season (Bourn, 1979), indicated that a high proportion had moved into the Lafia area from the north in 1974, following the Sahel drought, and had since decided to stay. Although most respondents moved their cattle from wet to dry season grazing areas, the distances involved were not great (70% moving less than 40 kilometers), and the majority of these said that their dry season grazing areas were further to the south.

What the wet season cattle population in the BICOT project area will be, must await the results of a second aerial survey.

As for the dry season cattle distribution described here, all methods of multivariate analysis indicated that it was most closely associated with that of riverine forest. At first sight this might seem surprising, in view of the findings of the BICOT field work, which has shown that: riverine forest is the most important habitat for the three species of trypanosomiasis transmitting tsetse found in the area; and that tsetse density increases with increasing extent of forest (Bourn, in prep.).

However in explanation it is suggested that riverine forest, as well as being a prime tsetse habitat, is also an indicator of moister soil conditions and the presence of water. At the end of the dry season, Fulani herd management practices are bound to favour those areas where drinking water and green forage are more readily available. Thus their cattle will be lead into the vicinity of riverine forests, and if this increases the risk of tsetse and trypanosomiasis challenge, then that must be a chance they are prepared to take.

Cluster analysis suggested that Fulani habitation was associated with the variable pair: cattle and riverine forest, but Principal Component Analysis indicated an association with arable habitation and cultivation. This apparent anomaly can be explained by hypothesising that the location of Fulani dwellings is a compromise between proximity to potential markets for their dairy products, and areas where adequate grazing is avaialable.

That the assosiation between arable habitation and cultivation was not closer than that suggested by the data is surprising, but might be due to a tendency observed on the ground for some cultivation to take place far away from, as well as close to, settlements. It is further suggested that the association of arable habitation with grass cover maybe an indication of general land clearance around settlements, which would tend to favour grass species. Finally it is suggested that the reason why cattle did not appear to be associated with grass cover, but were with scrubland, maybe due to the extensive burning that had taken place. Burnt land having little or no grass cover visible from the air, but possibly containing a post-burn flush of palatable grass attractive to cattle.

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Figure 1. BICOT Project Area.
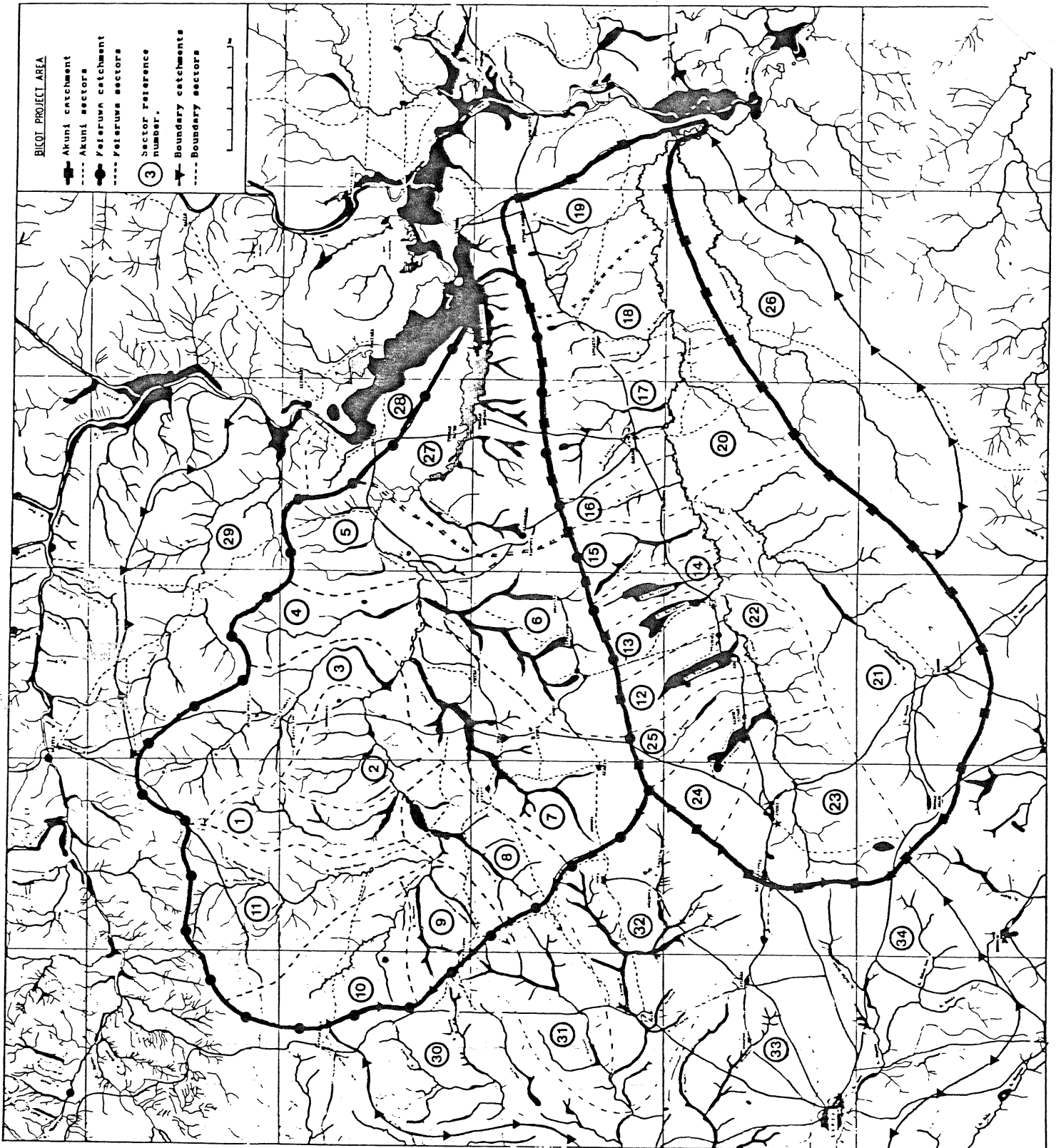
Figure 2. Aerial Survey Base Map Grid.

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.
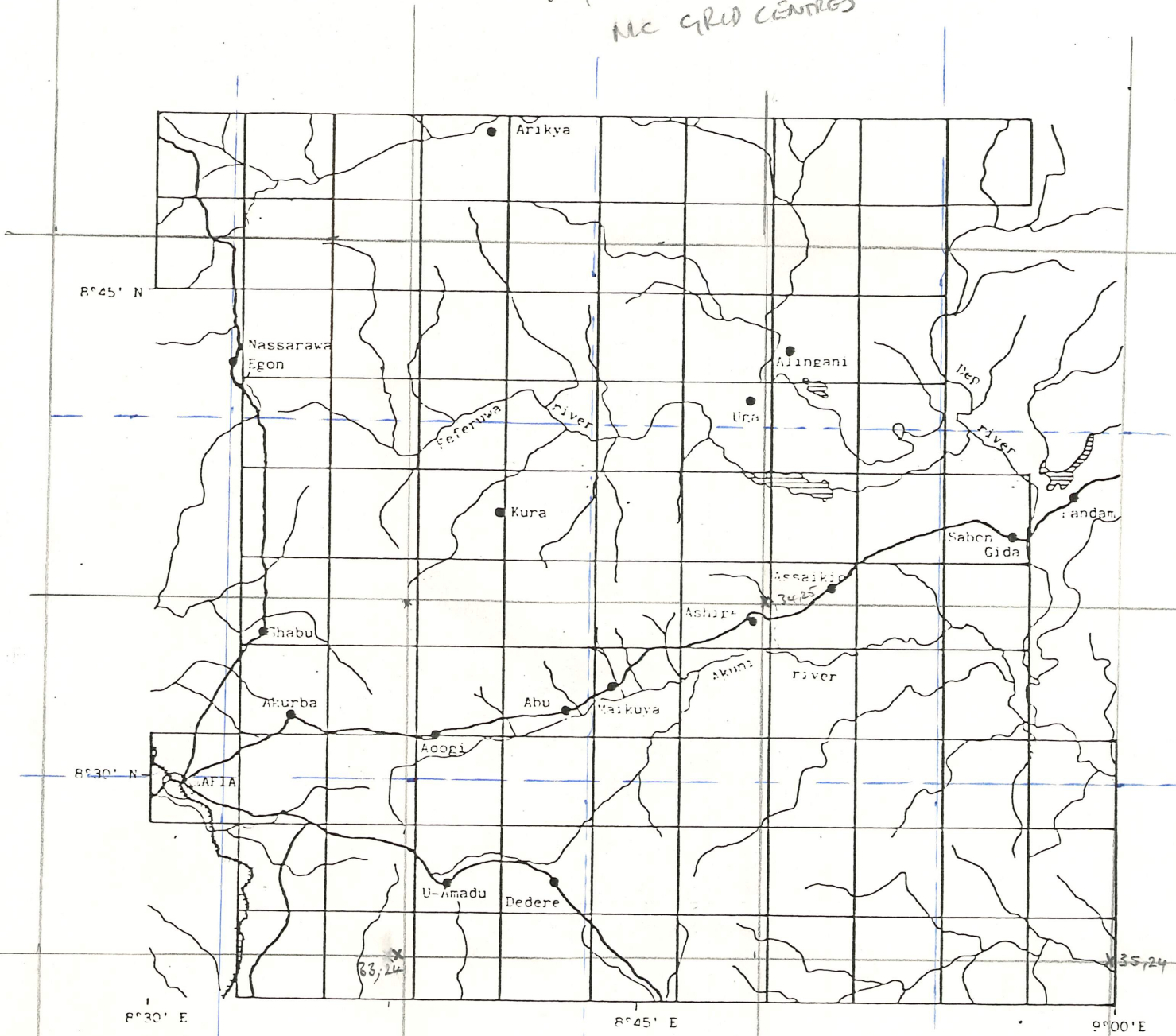
Each grid square 5km x 5km. Approximate scale 1 : 350,000

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          Major roads.

          Railway line.

          Rivers and streams.

          Lakes.
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
ILCA AERIAL SURVEY OF BICOT PROJECT AREA:

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

7.2

Figure: 3 . Cattle distribution.
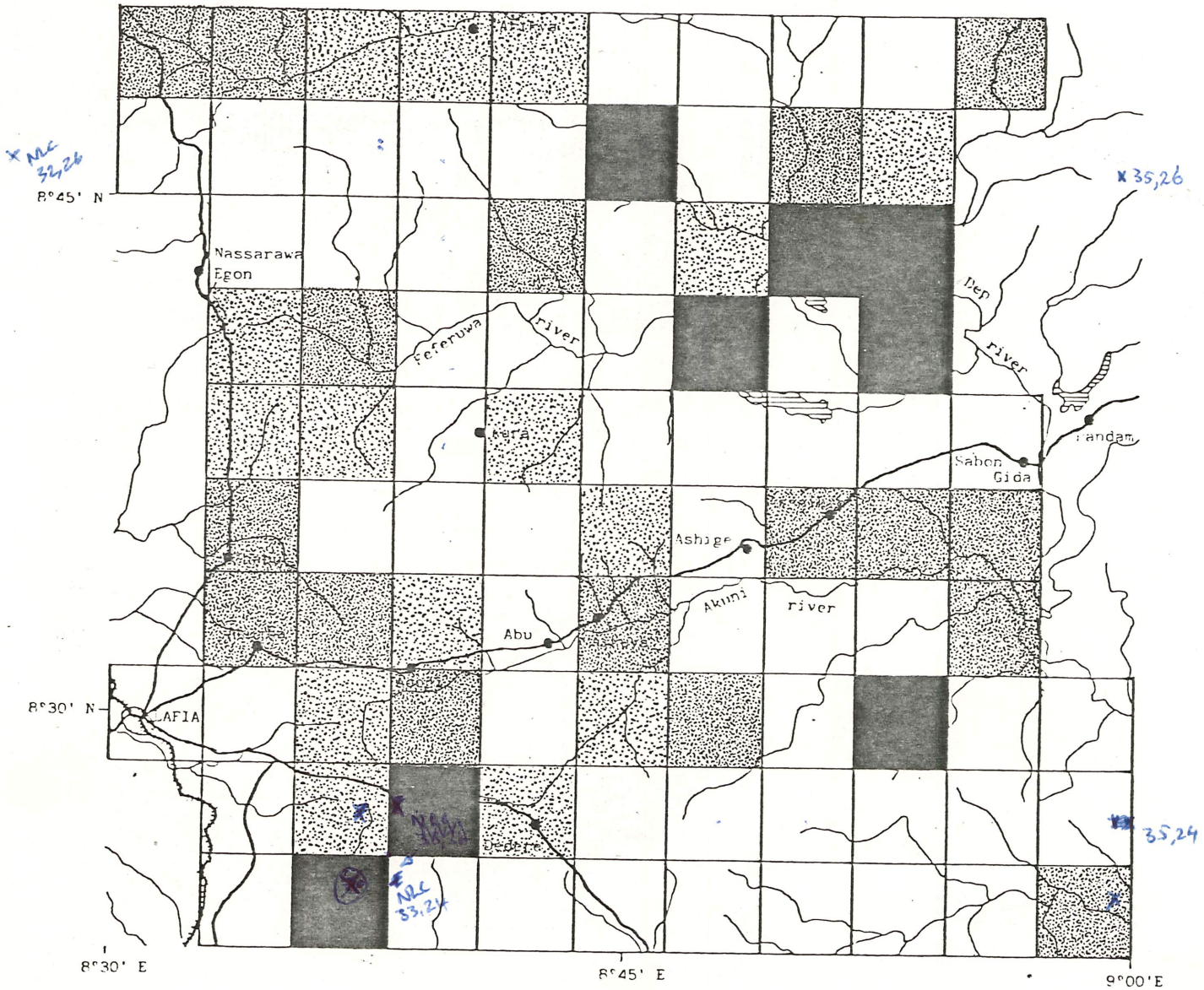
Each grid 5km x 5km.   Approximate scale 1 : 350,000.

Major roads.	>50 cattle km⁻²
Railway line.	25 - 49 cattle km⁻²
Rivers and streams.	5 - 24 cattle km⁻²
Lakes.	<4 cattle km⁻²

ILCA AERIAL SURVEY OF BICOT PROJECT AREA:

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

7.2

Figure: 3 . Cattle distribution.

Each grid 5km x 5km.   Approximate scale 1 : 350,000.

Major roads.

Railway line.

Rivers and streams.

Lakes.

>50 cattle km^{-2}

$25 - 49$ cattle km^{-2}

$5 - 24$ cattle km^{-2}

<4 cattle km^{-2}

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

Figure: 4 . Cattle stocking rate.
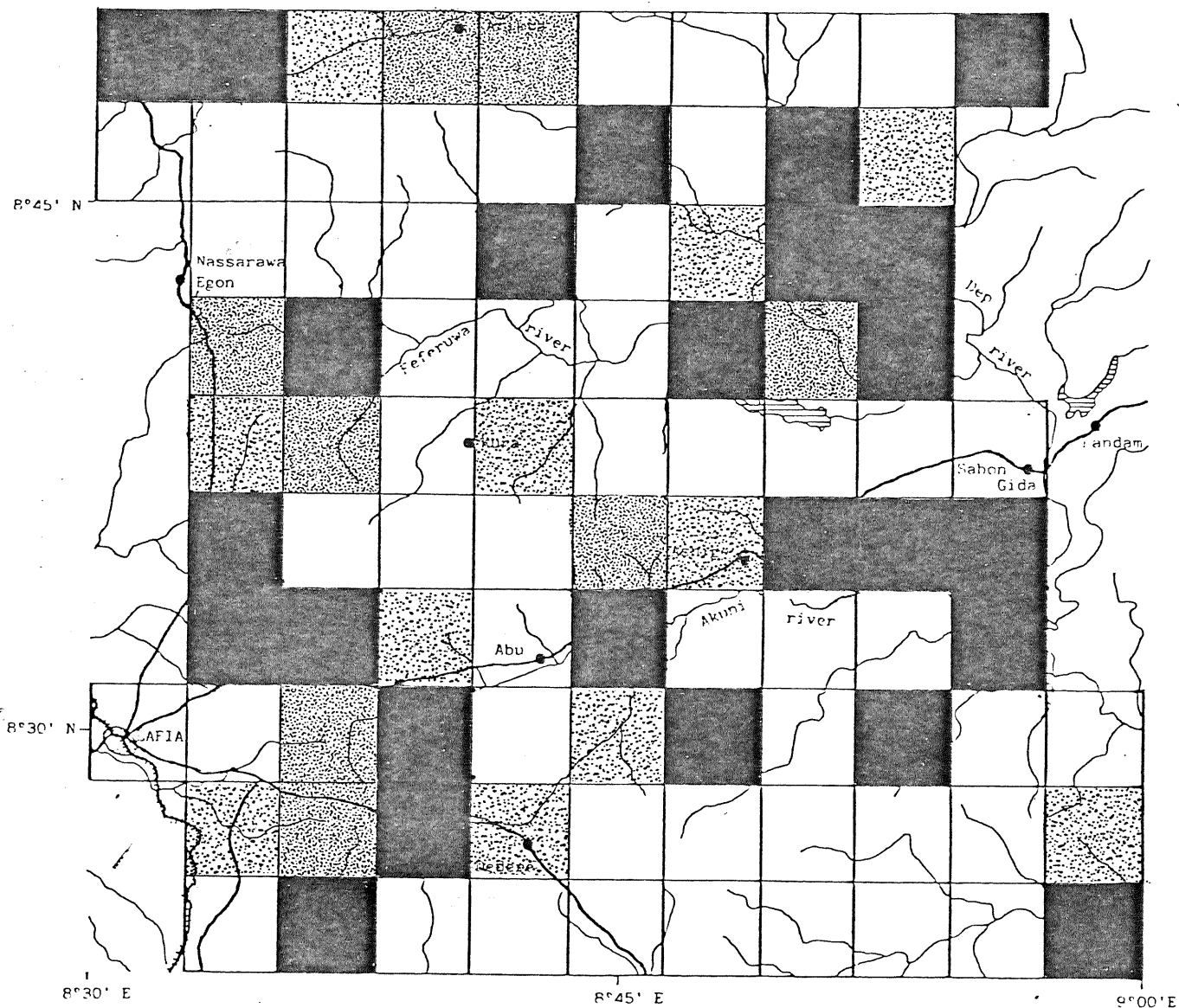
Each grid square 5km x 5km.   Scale approximately 1 : 350,000.

(dark)	< 4	hectares/head
(light dots)	5 - 9	" "
(medium dots)	10 - 49	" "
(white)	> 50	" "

Major roads.

Railway line.

Rivers and streams.

Lakes.

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

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Figure: 5. Cattle herd distribution.
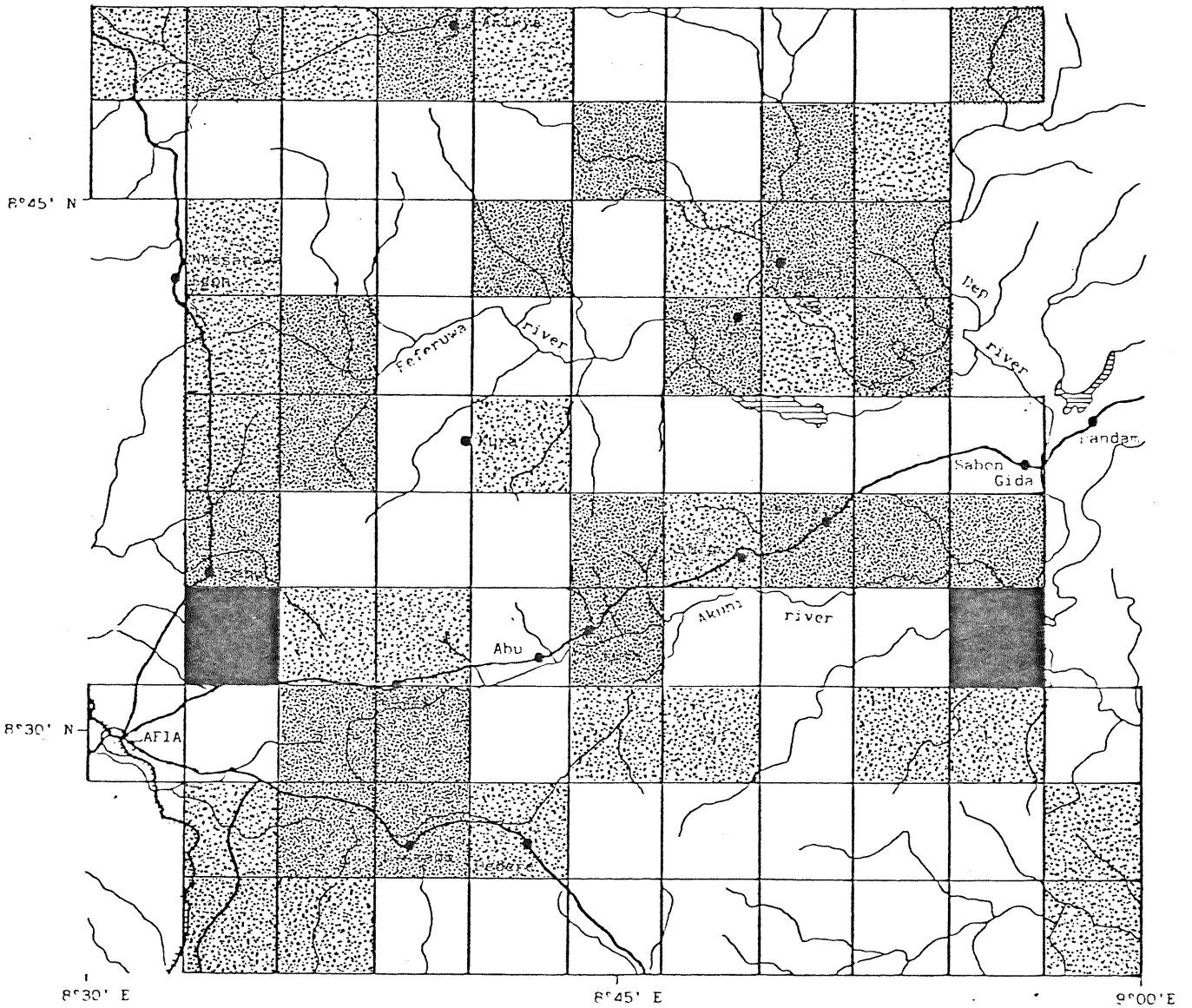
Each grid square 5km x 5km. Scale approximately 1 : 350,000.

⌒	Major roads.	▓ ≥ 10 herds/10km²
✕✕✕	Railway line.	▒ 5 - 9 " "
⌐	Rivers and streams.	░ 1 - 4 " "
⬭	Lakes.	☐ < 1 " "

Figure: 6 . Herd size frequency distribution.
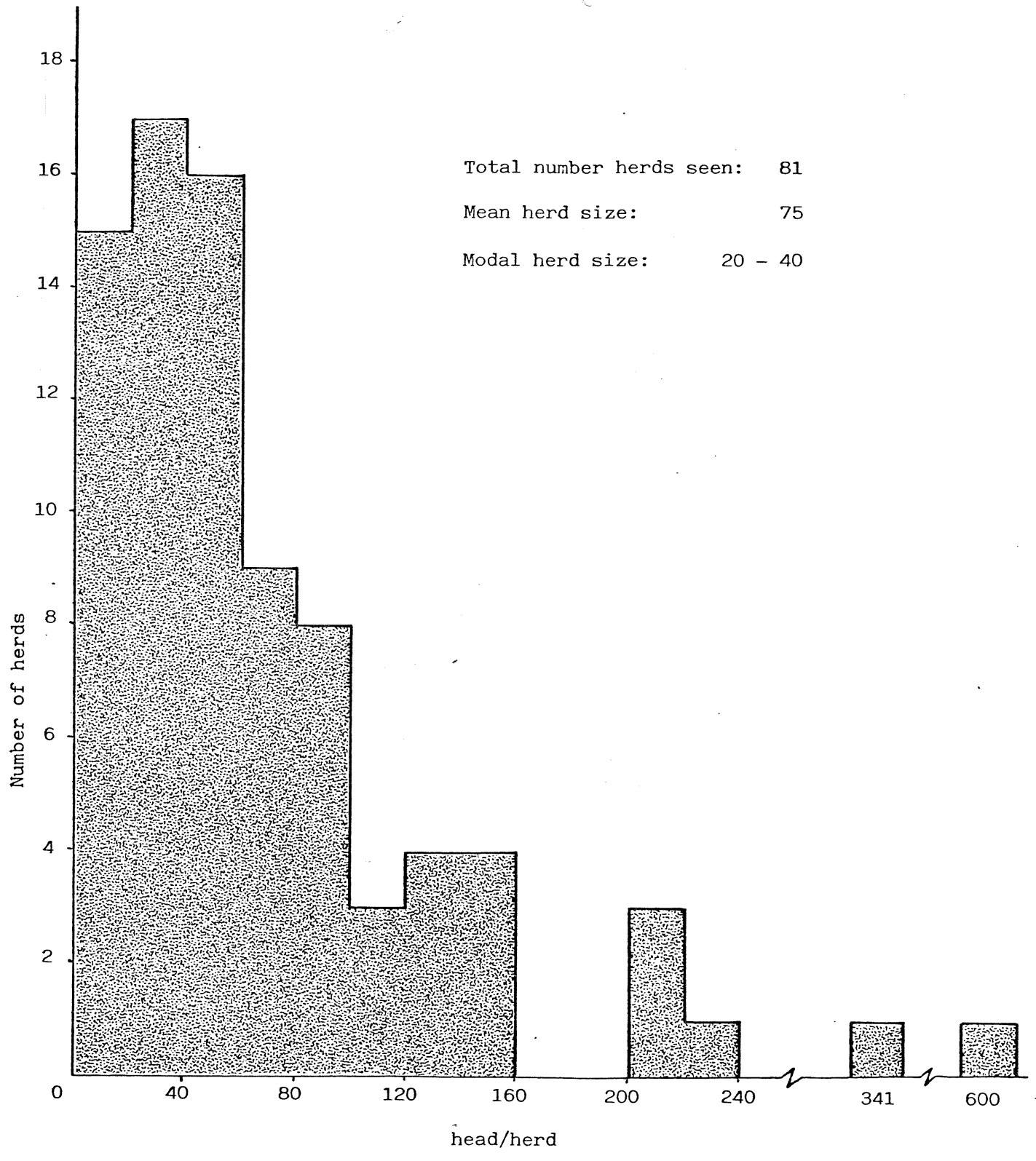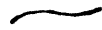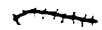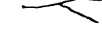
Total number herds seen: 81

Mean herd size: 75

Modal herd size: 20 – 40

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
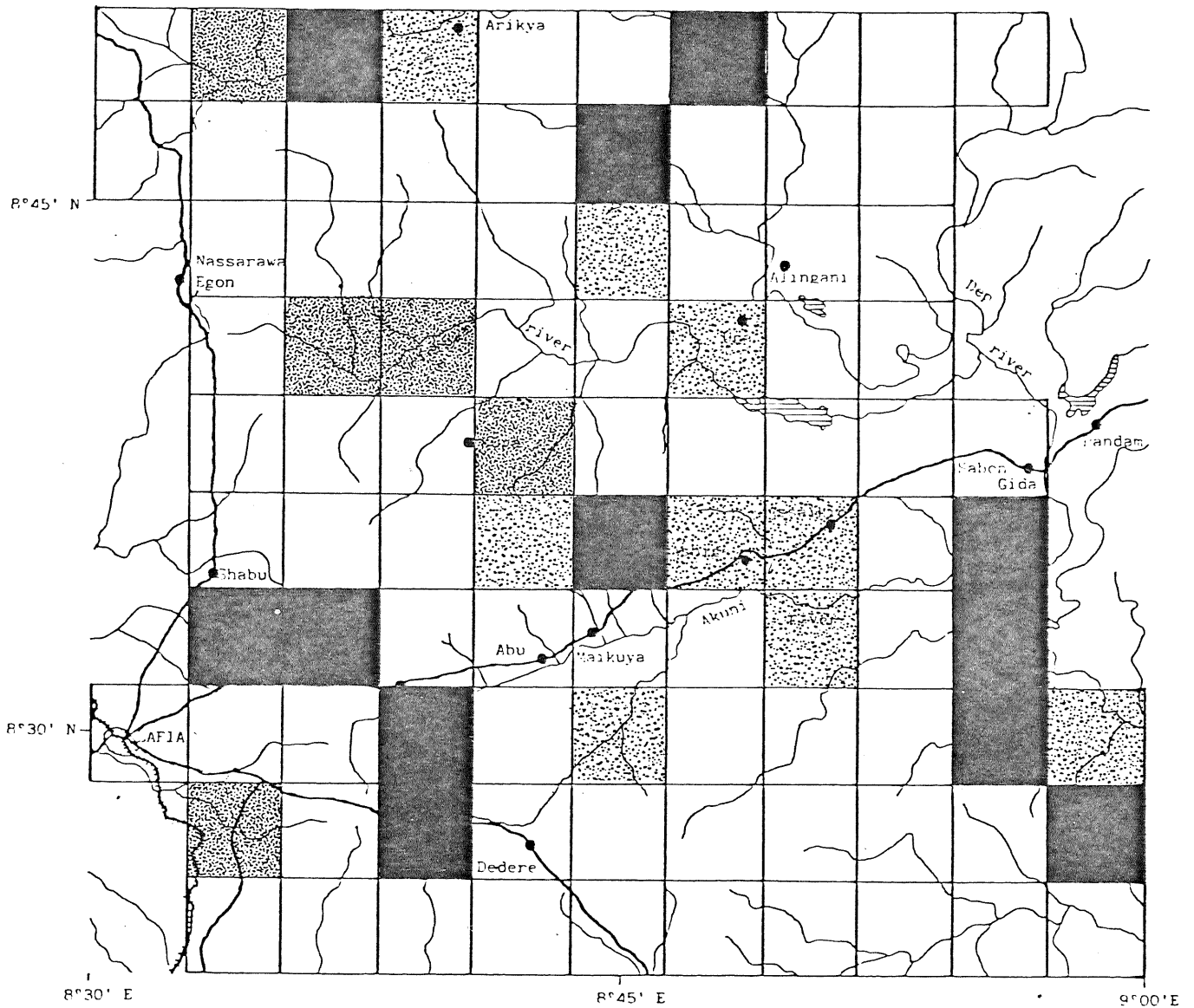Plateau State, Nigeria.

Figure 7. Land use intensity - 1982.
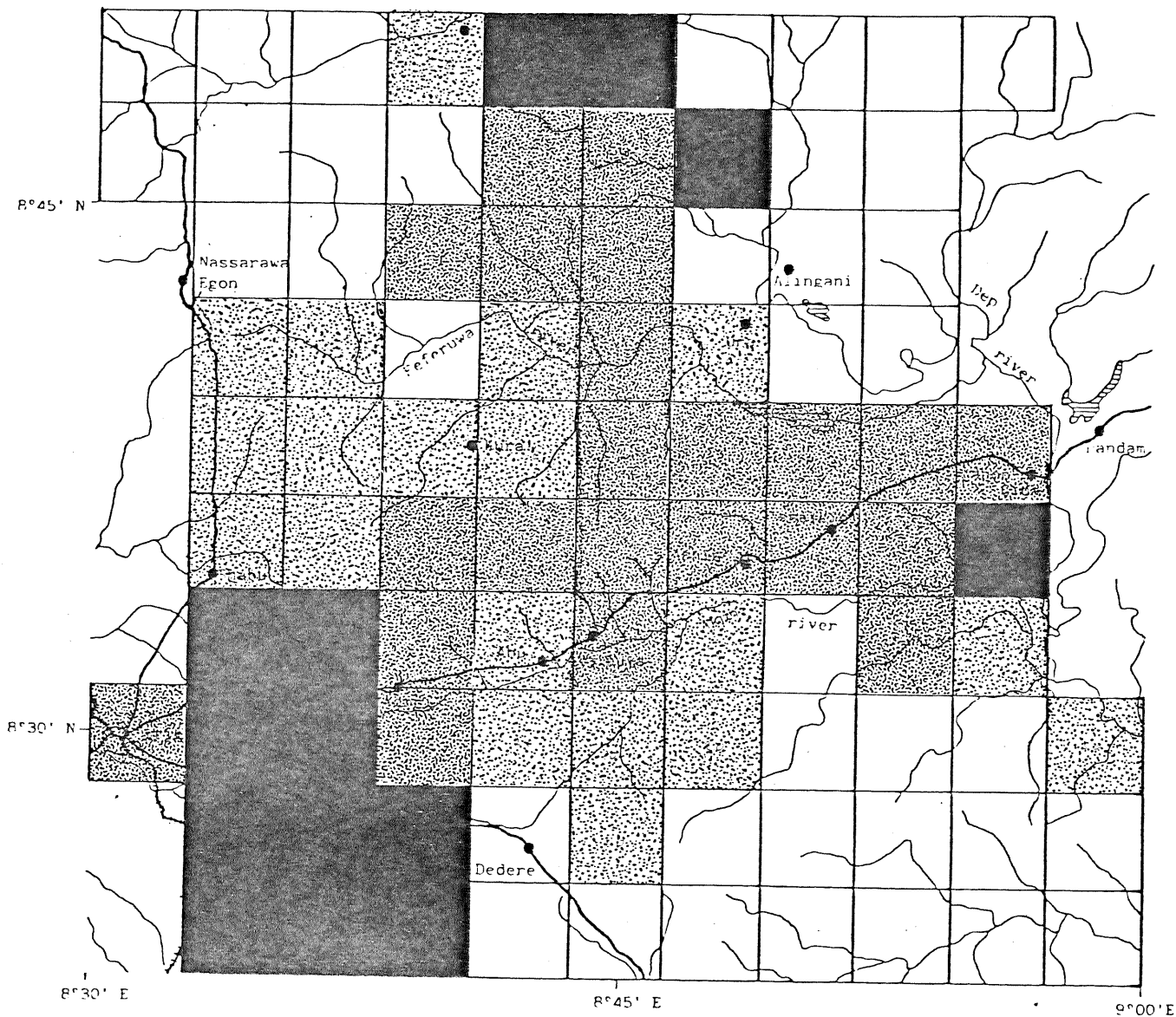
Each grid square 5km x 5km. Approximate scale 1:350,000.

Major roads.	⩾ 60% of land under cultivation.
Railway line.	40 - 59% " " " "
Rivers and streams.	20 - 39% " " " "
Lakes.	< 10% ." " " "

ILCA AERIAL SURVEY OF BICOT PROJECT AREA:

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

Figure 8 . Land use intensity - 1972/73 aerial photography.
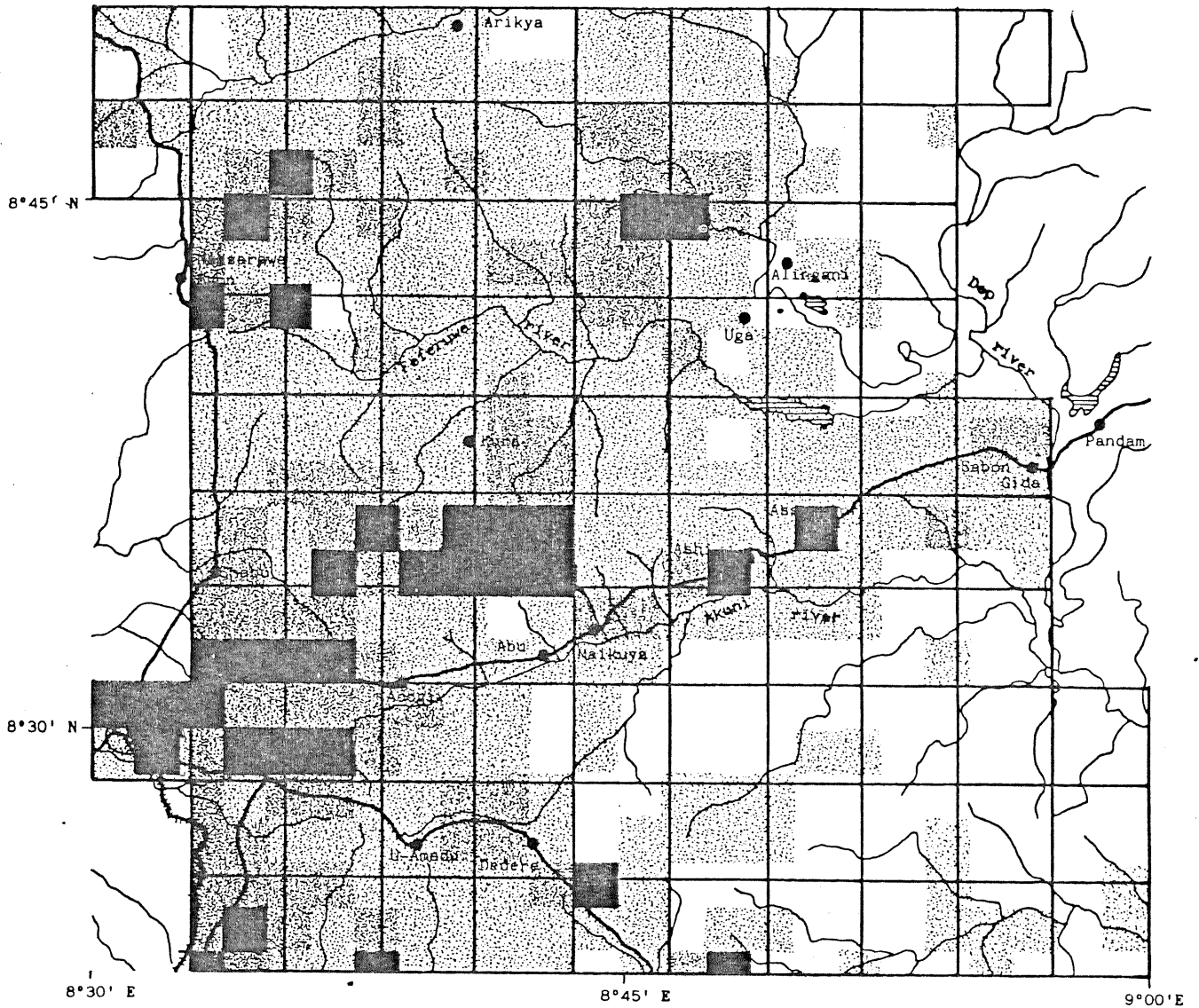
Each grid square 5km x 5km.   Approximate scale 1;350,000

⌒ Major roads.	⬛	> 60% within cultivation cycle.
⌒⊢⊢⊢ Railway line.	▨	35 - 60% " " "
⌒ Rivers and streams.	▨	10 - 34% " " "
⬡ Lakes.	☐	> 10% " " "
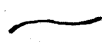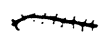
Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

Figure 9. Vegetation and land use – 1976 SLAR imagery.

8°45' N

8°30' N

8°30' E

8°45' E

9°00'E
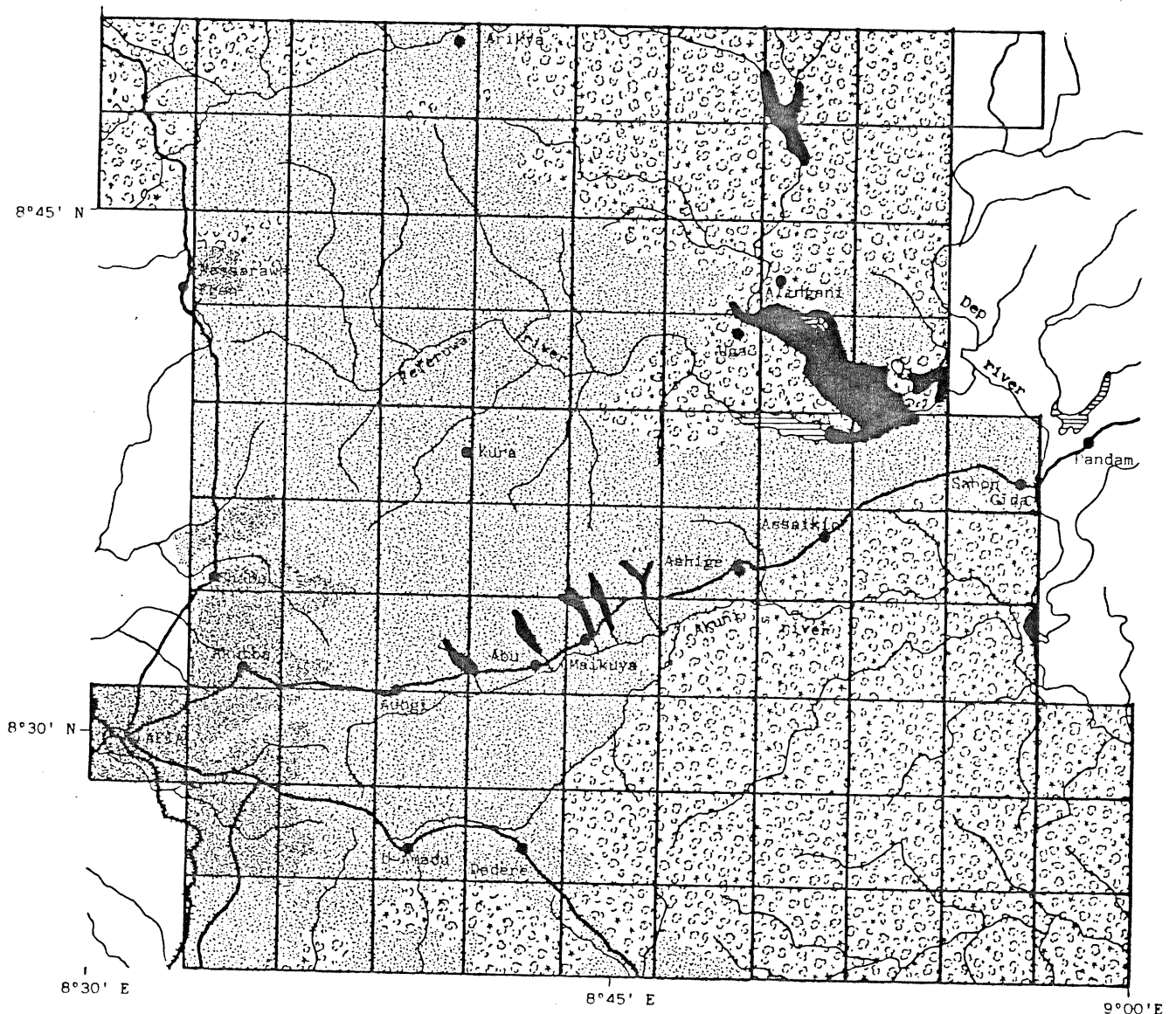
Each grid 5km x 5km. Approximate scale 1 : 350,000

|			
⌒	Major roads.	■	Riverine forest.
⊸+++	Railway line.	▨	Wooded shrub grassland.
⌇	Rivers and streams.	▨	Farmland > 60% intensity.
⬭	Lakes.	▨	Farmland 30 – 60% intensity.
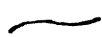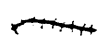
Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
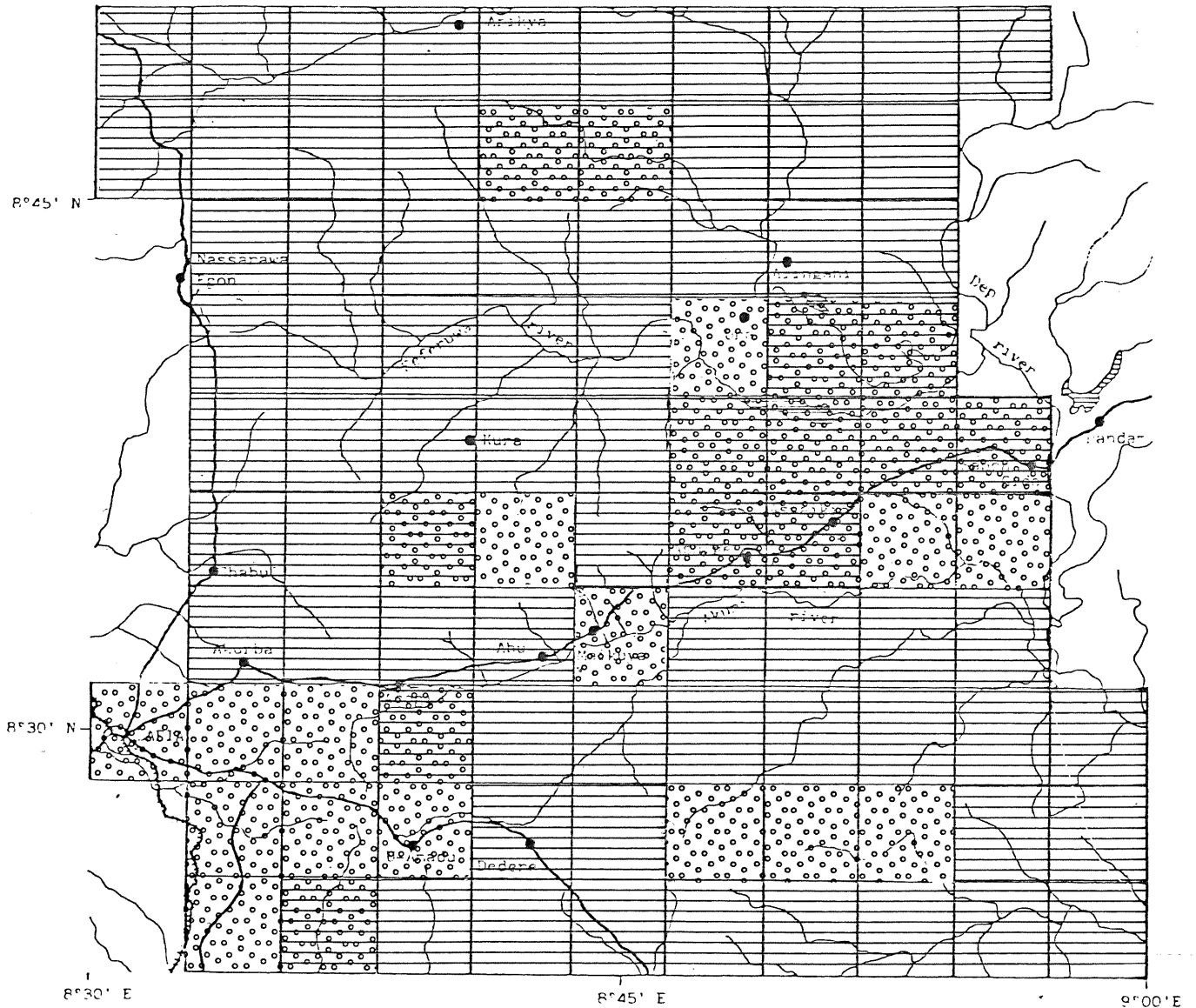Plateau State, Nigeria.

Figure 10.   Habitation - Arable Farmers.

8°45' N

8°30' N

8°30' E   8°45' E   9°00'E
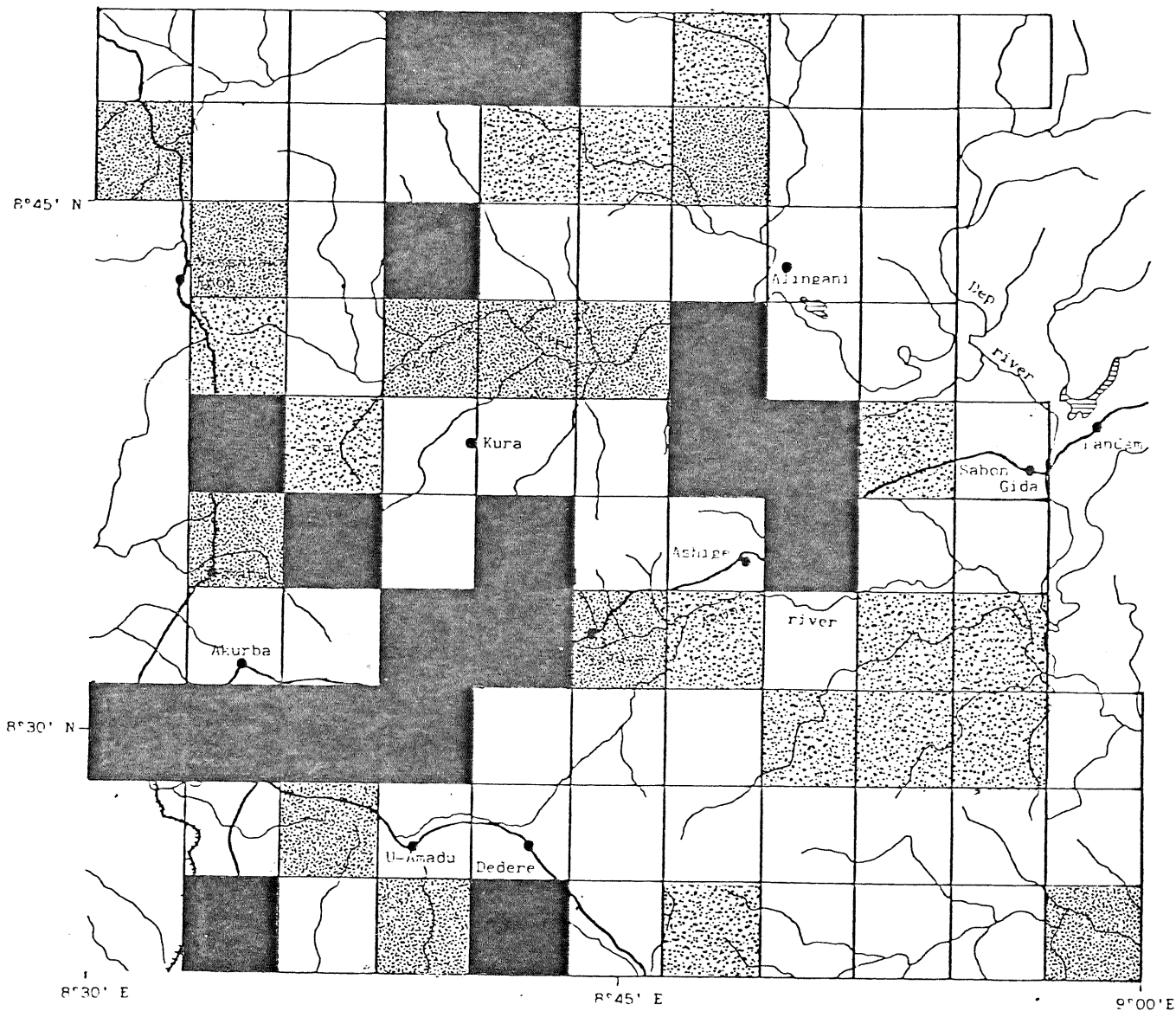
Each grid square 5km x 5km.   Approximate scale 1 : 350,000

⌐ Major roads.   ▓▓▓   ≥ 100 units per grid square.

⌐ Railway line.   ▒▒▒   50 - 99   "   "   "   "
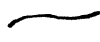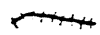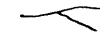
⌐ Rivers and streams.   ░░░   25 - 49   "   "   "   "

◯ Lakes.   ☐   0 - 24   "   "   "   "

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

Figure 11. Habitation - Fulani.

Each grid square 5km x 5km. Approximate scale 1 : 350,000.

Major roads.

Railway line.

Rivers and streams.

Lakes.

≥ 15 units per grid square.

10 - 14 "   "   "   "

5 - 9 "   "   "   "

0 - 4 "   "   "   "

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
Plateau State, Nigeria.

Figure 12.   Cultivation Type.

Each grid square 5km x 5km.   Scale approximately 1 : 350,000

Major roads.

Railway line.

Rivers and streams.

Lakes.

Predominately ridged cultivation.

Equal proportions.

Predominately mounded cultivation.

ILCA AERIAL SURVEY OF BICOT PROJECT AREA:

Feferuwa and Akuni catchments of Dep river
in the sub-humid zone, north east of Lafia,
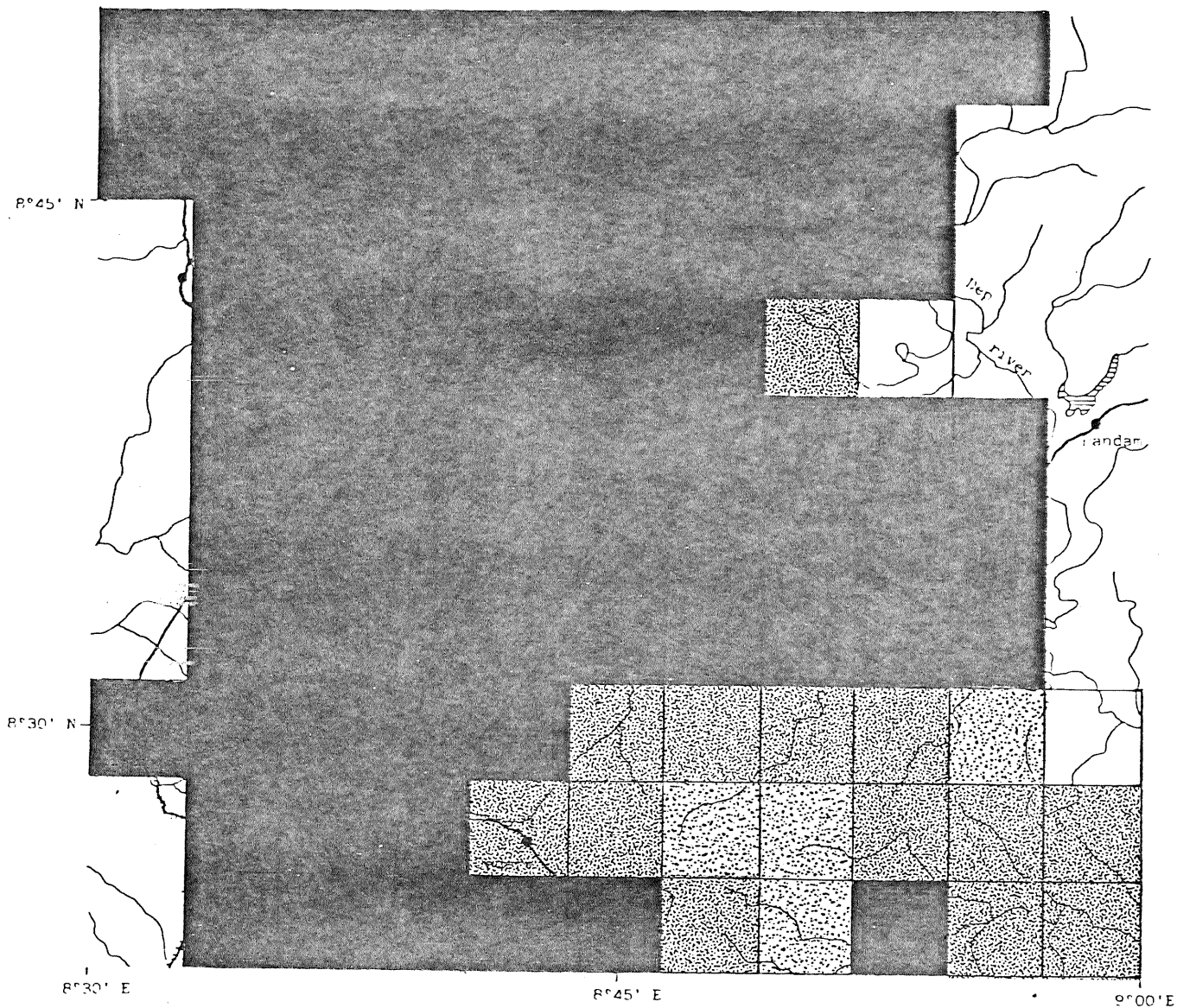Plateau State, Nigeria.

Figure 13. Burning.

Each grid square 5km x 5km. Approximate scale 1 : 350,000.

⌒ Major roads.	▨	90 – 100 % grassland burnt.
+++ Railway line.	▨	70 – 89 % " "
⌒ Rivers and streams.	▨	50 – 69 % " "
⬭ Lakes.	☐	< 50 % " "

Figure 14: PHOTOMOSAIC OF BICOT PILOT RELEASE ZONE – APRIL 1932

BICOT

N
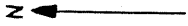
Figure 15:

PHOTOMOSAIC OF EHULA RIVER/FOREST SYSTEM - APRIL 1982

BICOT

N

BICOT

N
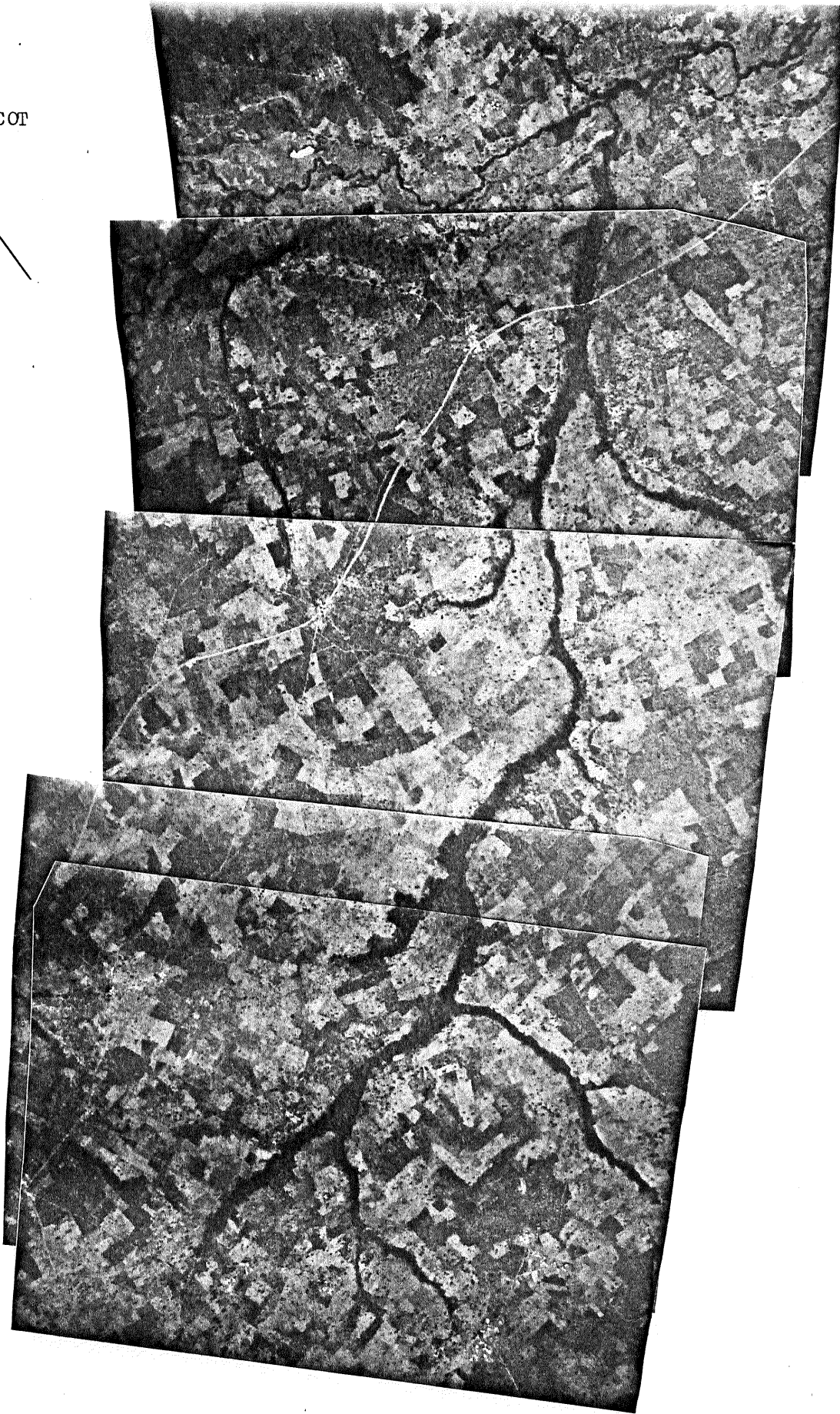
Figure 16:
PHOTOMOSAIC OF ACHIBA FOREST/RIVER SYSTEM – APRIL 1982.

Figure 17.

75   7.7

THE NIGERIAN SUB-HUMID ZONE

MAP: Location of cattle, vegetation and land use aerial survey zones

LAND OVER 1,000m

MAIDUGURI

YOLA

BAUCHI

Jos Plateau

KADUNA
Kurmin Biri
Abet

Mariga

Lafia N. E. (BACOT)

Lafia S. E.

MAKURDI

MAMA

ENUGU

OWERRI

ILORIN

BENIN CITY

AKURE

IBADAN

ABEOKUTA

IKEJA

LAGOS

40 20 0 20 40 60 80 100 120 140 160 180 Kilometres
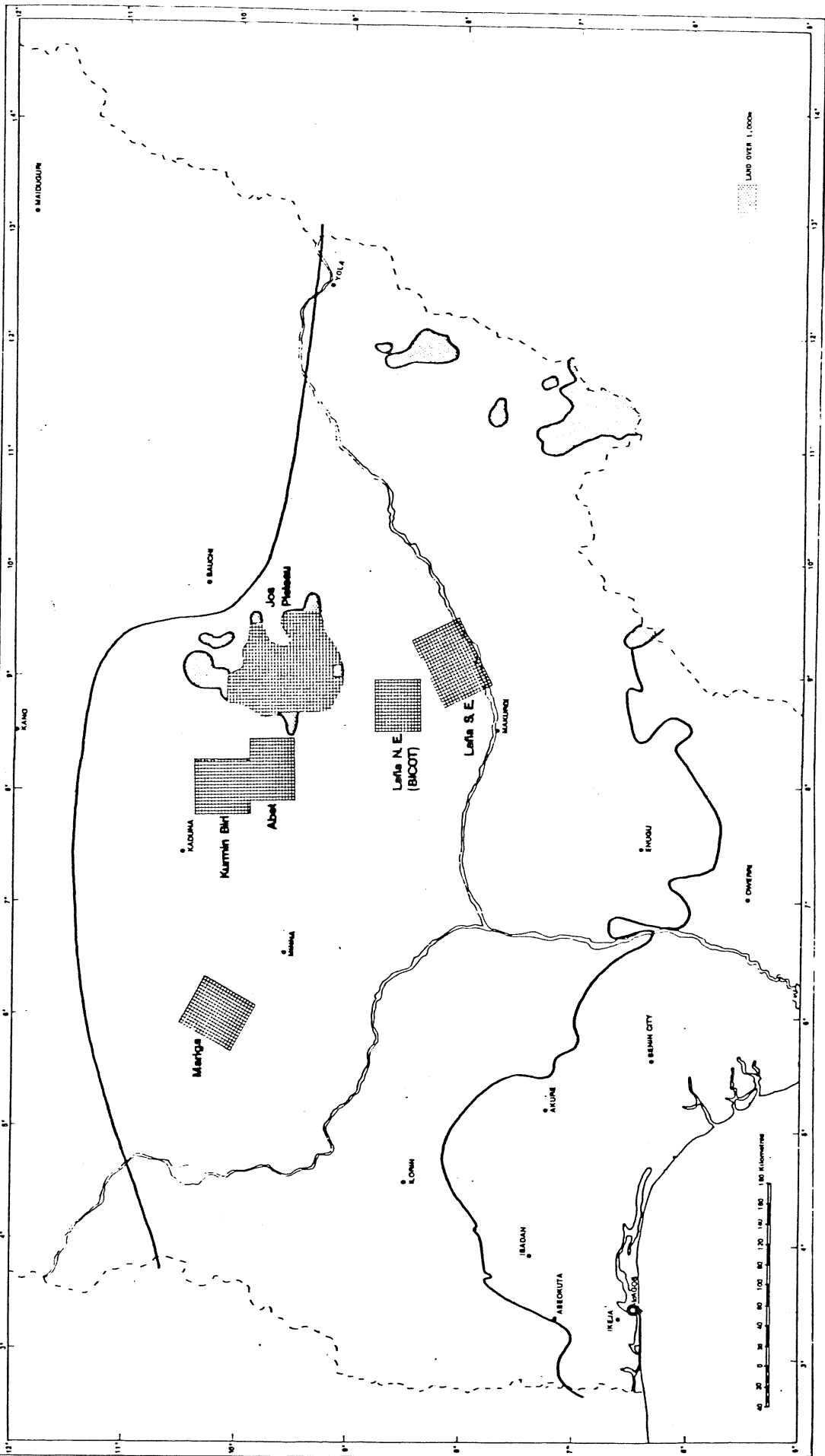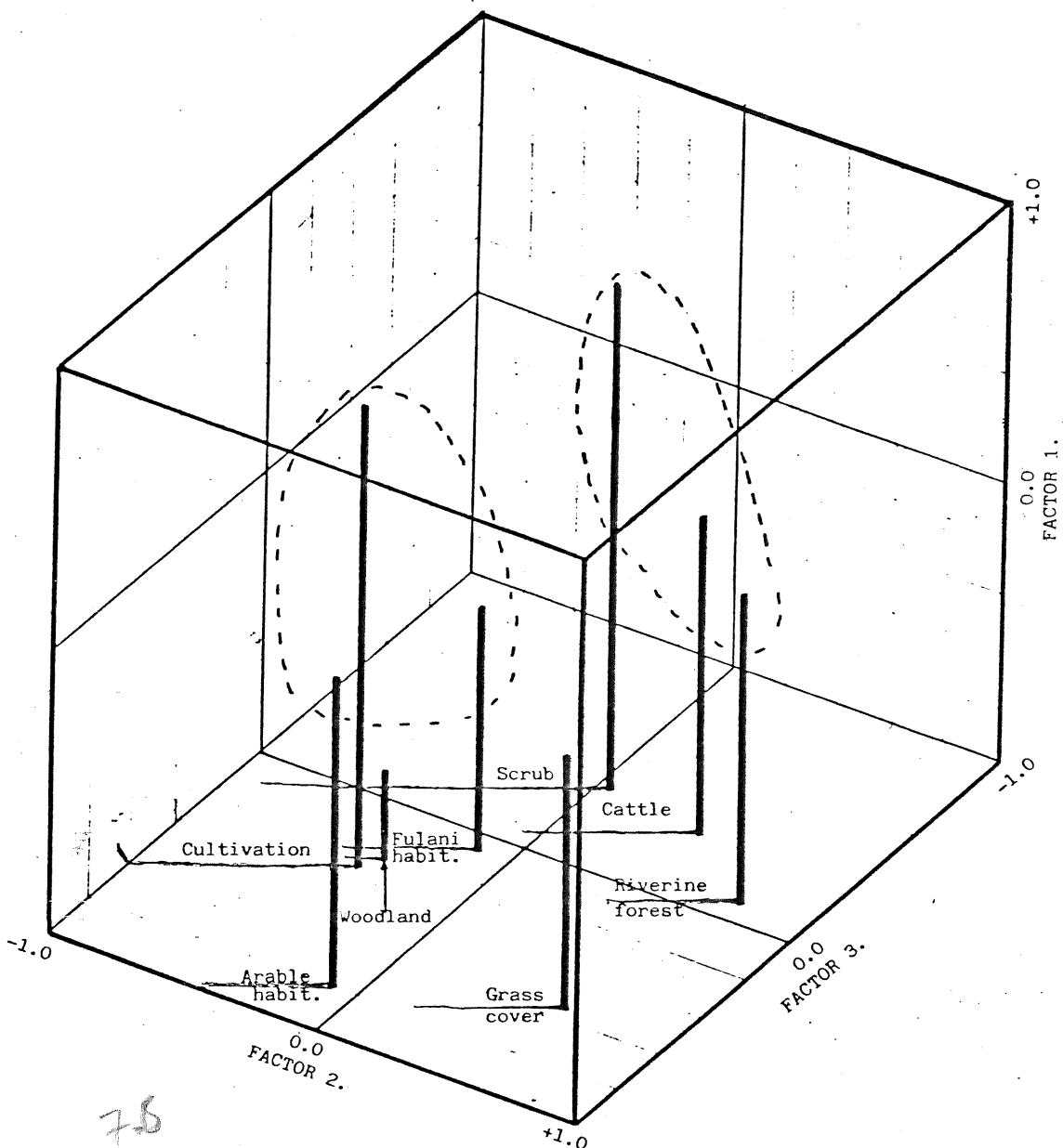
Figure 18. Three-dimensional representation of the degree of similarity of variable occurence in aerial survey grids, as revealed by Principal Components Analysis; showing: sorted, rotated factor loadings. Dashed enclosures indicate suggested groupings of associated variable.

Table 1.   Summary of results from aerial survey of BICOT project area.

Date of survey	13 April 1982
Size of survey zone, km^2	2,325
Total cattle population (+/-% SE)	38,138 (17%)
Mean cattle density, head/km^2	16.4
Stocking rate, ha/head	6.1
Total number of herds (+/-% SE)	506 (13%)
Mean herd density, herd/km^2	0.22
Mean herd size, head/herd	75.4
Modal herd size, head/herd	20 - 40

Table 2. Correlation matrix of land use/vegetation variables recorded during aerial survey of BICOT project area.

	CATTLE NUMBER	ARABLE HABIT.	FULANI HABIT.	GRASS COVER	WOOD-LAND	SCRUB-LAND	CULTIV-ATION	RIVERINE FOREST
CATTLE NUMBER	1.000							
ARABLE HABIT.	-.063	1.000						
FULANI HABIT.	.164	-.034	1.000					
GRASS COVER	.039	.163	.028	1.000				
WOOD-LAND	-.085	-.097	-.026	-.194*	1.000			
SCRUB-LAND	.160	-.126	-.097	-.110	-.358***	1.000		
CULTIV-ATION	-.083	.207**	.074	-.096	-.225**	.219**	1.000	
RIVERINE FOREST	.236**	-.107	-.071	.193*	-.203*	.048	-.083	1.000

Significance levels: * 90% probability; ** 95% probability; *** 99% probability.

Table 3. Summary of seasonal cattle population and density estimates, from low level aerial surveys in Nigeria.

SURVEY ZONE	AREA km^2	ESTIMATED CATTLE POPULATION (+/-%SE)		CATTLE DENSITY km^2		
		DRY SEASON	WET SEASON	DRY		WET
KIRMIN BIRI*	2,500	43,180 (9%)	10,410 (26%)	17.3	>	4.2
ABET*	2,475	92,440 (8%)	56,275 (6%)	37.4	>	22.7
MARIGA*	2,750	18,175 (16%)	64,485 (8%)	6.6	<	23.5
LAFIA SE*	3,500	44,420 (19%)	131,845 (14%)	12.7	<	37.7
JOS PLATEAU#	8,600	141,402 (11%)	402,096 (13%)	16.4	<	46.8
LAFIA NE (BICOT)	2,325	38,138 (17%)	52,567 (17)	16.4	<	22.9

* Milligan,Bourn and Chachu, (1979). #   ILCA, (1980).