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THE DYNAMICS OF CATTLE DISTRIBUTION IN THE NIGERIAN SUB-HUMID ZONE.
An assessment based on environmental analysis and low intensity, low altitude aerial surveys.

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ABSTRACT.

As well as describing the major findings of the first low intensity, low altitude, aerial surveys to be carried out over the Nigerian sub-humid zone, this paper also outlines some of the important environmental changes taking place within the zone itself. The size of the cattle population and its seasonally changing pattern of distribution are considered in the context of long term environmental changes, brought about by an ever increasing human population and a gradual process of agricultural expansion. Finally, a simple conceptual model of the changing pattern of cattle distribution in the Nigerian sub-humid zone is described.

PREFACE.

This paper considers some of the salient features of seasonal change in cattle distribution and abundance in the Nigerian sub-humid zone. It has been prepared for consideration as a background chapter for a Systems Study Report being prepared by the International Livestock Centre for Africa, Sub-humid Zone Programme, based in Kaduna, Nigeria. Much of the information summarised here has either previously been circulated as a draft report of the ILCA Aerial Survey Unit by Kevin Milligan, entitled: Livestock Ecology in the Nigerian Sub-humid Zone; or formed part of David Bourn's doctoral thesis to Oxford University, entitled Tsetse Control, Agricultural Expansion and Environmental Change in Nigeria.

Contents:

List of figures:

List of Tables:

1 THE CHANGING ENVIRONMENT OF THE NIGERIAN SUB-HUMID ZONE.

The Nigerian sub-humid zone, as defined by ILCA (1979), is bounded to the north by the limit of the 180 day crop growing season and to the south by the interface between Derived Savanna and Forest vegetation zones (Keay, 1959), and occupies some 455,500 square kilometers, amounting to approximately one half of Nigeria's total land area.

Nigeria possesses the largest human population of any country in Africa. Whilst demographic statistics leave much to be desired, it is widely recognised that, in common with most other countries on the continent, Nigeria's human population has been growing rapidly for many years, and that it is ethnically also one of the most diverse. Since the last officially accepted census took place in 1963, the population has probably almost doubled in size, and over the past fifty years there is likely to have been a three or four fold increase. As a result there has been a progressive expansion of agricultural land, which inevitably has brought about profound and widespread changes in the Nigerian environment. The changes taking place within the sub-humid zone cannot be considered in isolation from those occurring elsewhere in the country, indeed the sub-humid zone can justifiably be regarded as an expansion area for the more densely settled and cultivated areas further to the north and south.

1.1 Human Population.

National censuses were conducted, with increasing thoroughness in: 1911, 1921, 1931, 1952/53, 1962, 1963 and 1973, but all have been subject to considerable criticism and scepticism. The census results, together with various projections are plotted in figure 1, which indicates a compound rate of growth of some 2.6% per annum for the period 1911-1973.

Complete enumeration was not possible in the early censuses because of problems of accessibility. In addition, the reliability of the information collected was open to question for a number of reasons, including a suggested reluctance on the part of the individual to divulge accurate figures of household membership for fear of legal and tax liability, or on religious grounds. Many of the early returns, therefore, cannot be considered as anything more than informed guesses.

The 1952/53 census was the first attempt at complete enumeration, but again, for the reasons outlined above, was generally believed to underestimate considerably the actual population size. Subsequent censuses have, if anything, probably suffered from overestimation, largely because, if they were not aware of it before, pre-census publicity campaigns made it clear to Nigerians that political representation and allocation of government funds were dependent on population size determined from census returns.

Both the 1962 and the 1973 censuses were declared null and void. They were never officially recognised because they were politically unacceptable and were said to have been rigged. Although the 1963 census was also disputed and strongly criticized, it was eventually accepted by the Federal Government, and Nigeria's human population was officially estimated to be 55,600,000. Their distribution and density at that time are shown in figure 2.

More than twenty years have elapsed since the last recognised census was taken. Estimates of present day population levels depend on the assumed growth rate over the intervening period, which may vary regionally and has not been well documented. An overall 2.5% growth rate has usually been applied, which would give a 1983 population of 91 million. Higher growth rates have been recorded for example in Kenya - 4.0%, and Zimbabwe - 3.2% (World Bank, 1983). If 3.5% were assumed, giving a population doubling time of 20 years, then the present population might be as high as 110 million. A growth rate of 2% would give a population of 83 million.

Given the questionable nature of the 1963 census data, the uncertain growth rate, and the time elapsed, estimates of Nigeria's present population must remain largely a matter of conjecture. It follows that the distribution of human population is similarly uncertain; particularly in view of population mobility, which although again not well documented is generally recognised to be substantial, both from rural to urban areas, and also between rural regions (Udo, 1975; and Ajaegbu, 1976).

1.2 Vegetation and Land Use.

Although Nigerian census information is a somewhat unreliable guide to present population size and distribution, a good indication of man's environmental impact, and thus an indirect measure of his overall distribution, can be obtained by remote sensing.

The most recent vegetation and land use maps, which provide complete coverage of the whole country, were derived from Side Looking Airborne Radar (SLAR) imagery acquired in 1976/77 (Hunting Technical Services, 1978). This imagery, together with that available from LANDSAT and tbe most recent conventional aerial photography, was used in conjunction with extensive ground verification to produce 69 vegetation and land use maps, published at a scale of 1:250,000 by the Federal Department of Forestry.

A single composite vegetation and land use map of the whole of Nigeria was unfortunately never published. In order to illustrate the extent and intensity of present day agricultural activity, a much simplified map has been produced from photo-reduced prints of the original 69 maps and is shown in figure 3. Whereas the original printed maps show a total of 45 separate vegetation and land use categories, many of these have been amalgamated on the composite map which shows: grassland; thicket and shrubland; woodland; forest; mangrove; and farmland; with the latter being divided into: >60% intensity, and 30% to 60% intensity.

Extensive areas of medium to high levels of land use intensity are found in northern Nigeria, stretching round in a more or less continuous arc of varying width from Mayo Faran in the east, through Gombe, Potiskum, Kano, Zaria, Katsina, Gusau, Funtua to Sokoto in the west, with highest cultivation density being associated with major towns, and in particular Kano state and northern Kaduna state (formerly Katsina province).

In the south, a similar band of extensive cultivation from Lagos, Ibadan and Ilorin in the west, stretches north of the Niger delta and south of the Niger-Benue fork, to Katsina Ala and Wukari in the east.

The land in between these two regions of extensive cultivation falls within the boundaries of the sub-humid zone. Here the pattern of vegetation and land use can best be described as a mosaic of regions of medium to high levels of cultivation, grassland, and woodland. An interconnecting patchwork of cultivation links the northern and southern cultivated regions of Nigeria, through a broad belt north of Lokoja including Bida, Minna, Abuja, Lafia, Shendam, Kafanchan, the Jos plateau, Kaduna and Saminaka. To the west and east, cultivated areas are generally more scattered with woodland vegetation tending to predominate.

1.3. Expansion of Nigeria's Major Road Network.

An indication of how rapidly changes are taking place in Nigeria, and how the environment is being opened up, is given in figure 3, which shows the expansion of the major road network since 1950. Obviously these maps considerably under-emphasize the real extent to which once remote areas have been made more accessible, because many tens, if not hundreds, of thousands of kilometers of minor roads and tracks are not shown.

1.4 Changes in Vegetation and Land Use.

The vegetation and land use map shown in figure 4 reflects environmental conditions at a fixed point in time in the mid 1970s, and thus does not demonstrate the rates of change actually taking place. This was investigated, for a 9,400 square kilometer area around the town of Lafia in the centre of the sub-humid zone, by Putt et al. (1980). In their comparative interpretation of two sets of aerial photographs taken some ten years apart - in the early 1960s and the early 1970s - the proportions of various land use categories were assessed for each series of photographs, from which the compound rates of change were determined.

The results are shown in table 1 which demonstrates that the proportion of land under active cultivation expanded at nearly 5% per annum, with roads and human settlement increasing at a similar rate. This surprisingly high rate of increase was greater than could be accounted for by natural human population growth alone, and suggested a net immigration into the area, which was supported by local human and cattle population figures, based on tax returns, which indicated rates of increase of between 4 - 6% per annum.

Table 1: LAND USE AND POPULATION CHANGES IN THE LAFIA REGION.

	% per annum
<u>Land Use Categories.</u>	
Active Cultivation	+ 4.8
Young Fallow	+ 1.5
Old Fallow	+ 2.1
Woodland	- 1.8
Grassland	- 0.8
Settlement and Roads	+ 4.6
<u>Human Population.</u>	+ 4.1 to + 5.7
<u>Cattle Population.</u>	+ 5.5

Whilst rates of change in population and land use depend on a wide range of factors and are therefore likely to vary from region to region, consideration of the general expansion of the major road network (figure 3) and the 1976 pattern of vegetation and land use (figure 4), would suggest that the changes taking place in Lafia area may be representative of a large proportion of the sub-humid zone.

1.5 <u>Tsetse and Trypanosomiasis.</u>

Tsetse <u>(Glossina spp.)</u> are the primary vectors of animal and human trypanosomiases and as such have been the subject of much scientific study over many years. Although Nigeria has had a long history of tsetse control and eradication through the application of insecticide, operations within the sub-humid zone have been relatively limited (Putt et al, 1980). Much of the eradication programme has taken place outside the zone (Davies, 1964; 1971), and the effects within have been confined to adjoining regions in the north and north-east. Various tsetse control operations have been mounted within the sub-humid zone, but in their very nature - as protective measures around a few ranches and areas of residual human sleeping sickness - have not been extensive.

Of the eleven recorded species of Nigerian tsetse (Davies,1977), six have been found within the boundaries of the sub-humid zone. Each of the main species-groups is represented: <u>G. morsitans</u> and <u>G. longipalpis</u> of the "savanna" dwelling group; <u>G. palpalis</u> and <u>G. tachinoides</u> of the "riverine forest" group; and <u>G. fusca</u> and <u>G. haningtoni</u> of the "forest" dwelling group. The latter two species are exceptional for the sub-humid zone in that they are basically rain forest species and records have been confined to atypical forest outliers. Essentially, therefore, four species predominate within the zone.

Nigerian tsetse distribution maps (FDPCS,1980; and map 16.13 in Nord, 1982) show G. morsitans occurring in a series of discontinuous belts scattered across the northern two-thirds of the sub-humid zone. The other savanna species, G. longipalpis , has been recorded over a wide area of central and south-western portions of the zone. The two riverine species occur throughout the zone, G. palpalis being absent from the extreme north-east, and G.tachinoides absent only from limited areas on the southern boundary.

As with any species, a variety of complexly interacting factors and species-specific requirements determine tsetse distribution and abundance. The availability of suitable habitats and hosts are two determinants of primary importance, both of which, in the course of time, have been greatly influenced by human activity.

Human population increase throughout Nigeria, and land pressure to the north and south, have resulted in accelerated agricultural expansion within the relatively underpopulated sub-humid zone. Natural tsetse habitats have been transformed by the combined processes of land clearance and wet season cultivation of upland savanna; removal of riverine forests for dry season cultivation; firewood collection; and extraction of valuable timber. In addition the demand for bushmeat and associated heavy hunting pressure has greatly reduced, and in many areas eliminated, the natural hosts of tsetse. The net result of these man induced environmental changes has been a overall decline in the distribution and abundance of tsetse populations (Bourn, 1983.)

The savanna tsetse species are most susceptible to the impact of agricultural expansion. As wildlife hosts are hunted out and natural woodland vegetation is turned into farmland, the distribution and abundance of G. morsitans and G. longipalpis are bound to decline. The fragmentary nature of G. morsitans belts, in an environment which would otherwise be suitable, is itself evidence of the impact of long term human activity on the availability of suitable hosts and habitats. Various advances and recessions of G. morsitans have been documented in the past (MacLennan, 1958; Wilson, 1958; and Ford, 1971), but on balance the overall trend has been one of general shrinkage, ultimately leading to disappearance (Putt et al, 1980; and also compare published and revised tsetse distribution maps 6.13 and 6.14 in Nord, 1982).

However, riverine forest and thicket vegetation is denser and more difficult to transform into farmland than woodland. As a result this vegetation type, the primary habitat of riverine species of tsetse, is initially at least more likely to remain in tact. Thus G. palpalis and G. tachinoides tend to persist even in very confined habitats surrounded by extensive areas of cultivation. Under these circumstances, however, in the virtual absence of wildlife, cattle and people are likely to become the major hosts, with tsetse populations concentrated at regularly used forest crossings or at cattle and village watering points.

As land use intensity increases, riverine forest will eventually be encroached by cultivation, logging, palm wine collection and fire. Thus suitable habitats for riverine species of tsetse are likely to dwindle and ultimately, in extreme cases, to disappear.

Under the generally prevailing conditions of declining tsetse populations, disappearing wildlife reservoirs of trypanosomes, and the increasingly sedentary nature of livestock husbandry, Putt et al. (1980) and Bourn (1983) have concluded that there has been a fundamental shift in vector-host-parasite relationships, and that the very nature of the disease had changed. It was, therefore, not surprising that the available information concerning the incidence and virulence of cattle trypanosomiasis in Nigeria indicated that, over the years, the severity of the animal disease and its economic importance had also declined.

1.6 Cattle Population.

The size and distribution of Nigeria's cattle population has long been a subject of debate and informed guesswork. Various population estimates have been derived on the basis of cattle tax (Jangali) returns; off-take rates; hide and skin exports; the number of trade cattle passing from the north to southern markets; and vaccination returns. The accuracy of these estimates of course depends on the validity of their underlying assumptions: the degree of tax evasion; the measure herd productivity; the proportion of animals imported into the country; and the efficiency of the vaccination programmes. Only in the last five years, has the more objective method of low altitude aerial survey been employed to assess the size and distribution of local cattle populations, and even then, except for the survey described in this paper, they have been on a relatively limited scale.

With the paucity and acknowledged inaccuracies in the available information, it is extremely difficult, if not to say impossible, to determine the distribution and growth trends of Nigeria's cattle population. Felton and Ellis (1978) have deduced, from somewhat nebulous historic evidence, that the cattle population in 1886 was about 9.1 million. The first devastating epidemic of rinderpest occurred in that year, and resulted in an estimated mortality of between 80% and 90%. Subsequently cattle numbers recovered to some extent before a further epidemic, following widespread drought and famine, in 1913/14, and another in 1919/20, which caused mortalities estimated to be in the region of 60%. Even in the 1920s and 1930s, when veterinary control campaigns against a range of diseases had been introduced, and rinderpest was having less severe effects, the sales of cattle were such that the overall population scarcely increased (Ford,1971).

These deductions are borne out by the Jangali cattle tax returns for the period. From 1935 onwards tax returns showed a steady increase in cattle numbers up until 1963, when the last complete records were available. Putt et al. (1980), who summarised the available information, were of the opinion that over the period 1963 to 1978, Nigeria's cattle population had remained relatively stable. Such a view, however, is not in accordance with a progressive increase in off-take recorded for that period. Jangali tax has since been discontinued. Until more detailed and extensive surveys are carried out, all estimates of the trends in cattle population growth must remain largely a matter for speculation. It is generally accepted, however, that the size of Nigeria's present cattle population is in the order of 10 - 15 million, the vast majority of which are of the humped Zebu type, owned by the Fulani people.

Traditionally, the cattle owning Fulani were regarded as living a nomadic existence, and the bulk of the cattle population was considered to inhabit the northern part of the country in the wet season, and to move southwards into the "middle belt", or sub-humid zone, during the dry season. This nomadic, or extensive transhumant, lifestyle and mode of cattle husbandry were believed to be due, in part at least, to the greater risks of contracting trypanosomiasis in more southerly tsetse infested regions. In the dry season the distribution and abundance of tsetse were greatly restricted by adverse climatic conditions, and cattle owners took advantage of the reduced tsetse challenge in order to utilise the relatively abundant forage and water resources.

Fricke (1979) and Putt et al. (1980), in independent analyses of Jangali returns, have both demonstrated that since the fifties there has been a marked southward drift in the distribution of Nigeria's cattle population; northern areas having experienced an overall reduction in tax returns, whilst more southerly areas have shown a gradual increase. This trend is likely to have been greatly encouraged by the Sahel drought of the late sixties and early seventies.

Over the years it has become increasingly apparent that the traditional nomadic existence of the Fulani cattle owner has been greatly influenced by the changing nature of his social, economic and biological environments. ILCA (1979) has estimated that about 30% of Fulani herdsmen have settled permanently, a further 50% practice a limited seasonal transhumance and that only about 20% may be truly regarded as nomadic. Oxby (1982) has reviewed this widespread phenomenon of sedentarisation in both Nigeria and Upper Volta.

In 1978 the Federal Livestock Department produced a National Cattle Distribution map indicating the estimated number of animals by state based on Jangali returns. Although somewhat conjectural in nature the map illustrated that a high proportion of the national herd was to be found in the northern states. This north-south gradation in cattle distribution, and its strong negative correlation with rainfall, is clearly indicated in figure 5, which compares mean cattle density and biomass with mean annual rainfall, state by state. This negative correlation is the reverse of the relationship between large herbivore biomass and rainfall in eastern Africa established by Coe et al. (1976). However, as they emphasised their positive correlation held only for low rainfall areas, with less than 700 mm per annum. Much of Nigeria recieves an annual rainfall well in excess of this.

In addition to Zebu cattle, which make up the bulk of Nigeria's national herd, the country also has an estimated 300,000 head of trypanotolerant cattle (ILCA/FAO, 1980). Their distribution is largely restricted to the Derived Savanna and Forest regions south of the Benue and Niger rivers. Three major breeds are recognised: 150,000-180,000 Keteku (Muturu x White Fulani Zebu); 100,000-120,000 Muturu (Dwarf West African Shorthorn); and some 15,000 N'dama. No clear boundary can be defined between the distribution of Zebu and trypanotolerant breeds, but as mentioned earlier, with the southward drift of Zebu cattle into Southern Guinea and Derived Savanna vegetation zones, there is likely to be a considerable degree of overlap.

2 A NEW APPROACH TO ASSESSMENT OF CATTLE DISTRIBUTION AND ABUNDANCE.

The settlement of Fulani cattle owners, and the relocation of Nigeria's national herd in more southerly latitudes, are two of the Federal Livestock Department's stated long term objectives (David West, 1980). Clearly in attempting to attain these objectives, an up to date assessment of the state livestock resources and the condition of livestock producers is desirable, and the major trends and future prospects of livestock production need to be identified. To this end, the International Livestock Centre for Africa instigated a study of livestock production systems within the Nigerian sub-humid zone in the late 1970s.

This programme, as well as carrying out detailed investigations on the ground, also initiated a series of wet and dry season aerial surveys of cattle over four case study areas (Milligan et al., 1979). The total land area surveyed during these flights amounted to some 11,225 square kilometers. The representativeness of such small case study areas was of course open to question, so it was decided to mount an extensive low altitude aerial survey over as much of the sub-humid zone as possible.

Time, manpower and financial constraints precluded the possibility of high sampling intensity, but nevertheless the aerial surveys that were carried out during March and July 1983 (dry and wet seasons, respectively), followed the same well established procedures of systematic low altitude aerial survey described by Norton Griffiths (1978) and Milligan et al. (1980). Essentially the ILCA aircraft, a high-winged, twin-engined, Partenavia P68B, flew a series of 16 north-south parallel flight lines of varying length, across the sub-humid zone, at intervals of half a degree of longitude, as indicated in figure 6.

At the selected flying altitude of 1000 feet above ground level, back seat observers, to the left and right of the aircraft, monitored two strips of ground, each 400 meters wide, giving a sampling intensity of 1.4%. The size of all cattle herds seen within these strips was estimated by eye, and wherever possible a 35 mm photograph was also taken, using cameras fitted with zoom lenses. Subsequently herd size was accurately counted from these photographs; observer biases were determined; and corrections were made to observer estimates. These corrected figures were then used to calculate cattle density and estimate population size by the ratio method (Jolly,1969).

It should perhaps be emphasized that the objectives of this very low intensity, low altitude aerial survey of the sub-humid zone were primarily, to put the ILCA case study areas into zonal perspective; to assess overall cattle distribution gradients; and to determine seasonal changes in cattle density and herd size. With such low intensity sampling, estimation of total cattle numbers was only of secondary importance, but nevertheless the result was of considerable general interest, as it provided the first objective measure of the size of the Nigerian sub-humid zone cattle population.

3 THE FINDINGS OF LOW INTENSITY, LOW ALTITUDE AERIAL SURVEYS.

3.1 Cattle and Herd Estimates.

The Nigerian sub-humid zone occupies an estimated land area of some 455,500 square kilometers. For logistic reasons, however, it was not possible to sample the entire zone during the aerial surveys. The area actually surveyed, at a sampling intensity of about 1.4%, amounted to some 356,510 square kilometers. Thus in table 1, which provides an overall summary of wet and dry season results, two sets of cattle and herd statistics are presented: one set of estimates for the area surveyed; and the other, projections for the sub-humid zone as a whole, based on the same density values.

No significant difference was found between seasonal mean cattle densities; the dry season estimate of 10.25 animals per square kilometer being a mere 8% higher than the wet season value of 9.4 animals per square kilometer. Thus, no major dry season influx of cattle was detected, and net seasonal cattle movement into and out of the zone appeared to be approximately in balance. This would indicate either, that seasonal immigration was more or less equal to emigration; or, as seems more likely, that, most seasonal cattle movements occurred only on a relatively modest scale and took place largely within the sub-humid zone.

Although only minor seasonal differences were found in the estimated size and density of the sub-humid zone cattle population, a substantial 25% difference in mean herd size was detected. Mean herd size in the dry season was 55, whilst in the wet season it increased to 68 animals per herd. This resulted in a marked fall in the estimated number of herds in the surveyed area from 66,000 in the dry season to 49,000 in the wet season, or 85,000 and 63,000 respectively, for the sub-humid zone as a whole. In terms of overall herd density this amounted to a decline from 18 to 14 herds per hundred square kilometers. Such seasonal changes in mean herd size have been detected in other aerial surveys within the sub-humid zone (Milligan et al., 1979) and are largely due to the Fulani management practice of herd splitting during the dry season period (Okali and Milligan, 1980).

3.2 Distribution of Cattle.

The contrasting patterns of wet and dry season cattle distribution over the sub-humid zone are represented by the three dimensional surfaces shown in figure 7, in which cattle density is indicated by apparent height.

Caution is required in the interpretation of these surfaces, as the coordinates of the sub-humid zone have been transformed in order to make the information amenable to three dimensional computer analysis. Effectively the east-west dimension has been foreshortened, and the north-south dimension has been equilibrated, so that the whole of the Nigerian sub-humid zone is represented by a square. However, as an aid to orientation and better understanding, the course of the Benue and Niger rivers, and the location of major towns have been indicated.

Table 2 : SUMMARY OF CATTLE AND HERD ESTIMATES FOR THE SUB-HUMID ZONE, DERIVED FROM LOW INTENSITY, LOW ALTITUDE AERIAL SURVEYS.

	Dry season.	Wet Season.	Combined.
Area of Sub-humid Zone km .	455,500	455,500	455,500
Area Surveyed km .	356,510	356,510	356,510
Area Sampled km .	4,959	4,536	9,495
Sample Intensity %.	1.4	1.3	2.7
Date of Survey.	March 1982	July 1982	
Cattle Density* km .	10.25 (11%)	9.44 (16%)	9.85
Cattle Stocking Rate ha .	9.8	10.6	10.2
Estimated Number of Cattle.			
In Area Surveyed.	3,654,200	3,365,500	3,509,900
In Sub-Humid Zone.	4,668,900	4,299,900	4,484,400
Herd Density* 100km .	18	14	16
Mean Herd Size*.	55	68	62
Estimated Number of Herds.			
In Area Surveyed	66,440	49,490	57,970
In Sub-Humid Zone	84,890	63,230	74,060

*Figures in parenthesis are percentage standard error.

Assuming eventual overall 40-49% cultivation with average cattle density of 15.8 km² in dry season and 16.0 in wet season.

	Dry	Wet
In survey area (356,510 km²)	5,633,000	5,704,000
In SHZ (455,500 km²)	7,19,708	7,287,900

Comparison of the two surfaces clearly illustrates the dynamic nature of seasonal cattle distribution. Although cattle were found throughout the zone, their overall distribution was far from uniform, and shows a generally clumped pattern, which was most pronounced during the wet season. In the dry season cattle distribution was more widespread, with higher densities occurring to the east and north-east, and lower densities to the south-east and along the southern, western and most of the northern boundaries. In contrast, wet season cattle distribution appeared to be generally more restricted and concentrated within a broad central band, running north-south, with highest densities occurring on the northern boundary, and decreasing densities towards the south-west, south and south-east.

3.2.1 Cattle Density Gradients.

The south-north and west-east components of the geographical gradients in cattle density represented in figure 7 are illustrated in figure 8. Clearly in both seasons there was a marked increase in cattle density from south to north (upper graph); there being an almost linear four fold increase during the wet season. Interestingly, the dry season density curve followed a semi-sinusoidal pattern which cut the wet season line. Below the cross-over point, that is in more southerly latitudes of the sub-humid zone, dry season cattle density exceeded that found in the wet season, whilst in more northerly parts of the zone the reverse was true.

The west to east component (lower graph) also showed a general eastward increase in cattle density. Both wet and dry season curves followed a generally similar pattern, except to the extreme east in Gongola state where the two curves diverged markedly, with the dry season curve rising to reach a peak density value and the wet season curve declining towards minimum density. This would indicate that only in the extreme east of the sub-humid zone was there any substantial immigration of cattle during the dry season.

3.2.2 Herd Density Gradients.

The geographical gradients of seasonal herd density (figure 9) follow approximately similar courses to those of cattle density. In the south herd densities were greatest in the dry season, whilst in the north wet season herd densities were greatest. This might indicate a dry season influx of cattle herds directly into southern parts of the zone from outside, but is considered more likely to reflect a seasonal, cyclical movement of cattle herds from north to south within the sub-humid zone itself. To the west there was little difference between wet and dry season herd density trends, but further to the east herd densities began to diverge, with the dry season having the highest, and the wet season the lowest values. This would indicate little seasonal change in herd density to the west, but an increased number of dry season herds to the east, either reflecting an increased tendency for herds to be split, or resulting from an influx of herds from outside the zone.

3.2.3 Herd Size Gradients.

Mean herd size (figure 10) decreased both to the north and the west. Wet season herd size was relatively low in the south, rose to reach a maximum in the mid latitudes, and declined again further to the north. On the west-east axis the wet season herd size generally exceeded that found in the dry season, except in the extreme west and east.

3.3 Cattle and Predominant Vegetation-Land Use.

Table 3 gives the seasonal mean cattle densities and mean herd sizes in each of the predominant vegetation and land use types within the surveyed area of the sub-humid zone. The estimated area of the major vegetation and land use types is also shown, as is the proportion estimated to be under cultivation within each.

Greatest cattle densities were found during the dry season in regions where Aquatic Grassland and Riparian vegetation predominated. Mean densities of more than 30 head per square kilometer were encountered and reflected a concentration of cattle in riverine flood plains and in proximity to perennial water sources, represented by riparian forest. However, because of the limited extent of these vegetation types, amounting to only 3% of the surveyed area, the proportion of the overall cattle population they contained was relatively small - around 10% in the dry season and 3% in the wet season.

Transitional Woodland, by far the largest vegetation and land use category amounting to some 40% of the surveyed area, showed little seasonal change in cattle density, which, at 6-7 head per square kilometer, was one of the lowest. As a consequence, this category contained only 24% of the estimated overall cattle population in the dry season, and 30% in the wet season.

Cattle density in Woodland vegetation was somewhat higher than Transitional Woodland, but showed little seasonal change and remained constant at about 10 animals per square kilometer. However as this vegetation type only occupied some 7% of the surveyed area it contained a relatively small proportion of the total cattle population.

The four remaining vegetation and land use types, occupying some 46% of the surveyed area, contained approximately 60% of the estimated overall cattle population in both the wet and dry seasons. A feature common to each of these vegetation and land use categories was that more than 20% of their land area was under cultivation. In the two Farmland categories cattle density increased from around 11-12 animals per square kilometer during the dry season to 16-17 per square kilometer during the wet season. The other two categories Wooded-Shrub-Grassland and Farmland/Woodland Mosaic showed the opposite trend in cattle density, with a decline from about 13 animals per square kilometer in the dry season, to between 8-11 in the wet season.

Table 3 : SEASONAL CATTLE DENSITY AND MEAN HERD SIZE IN THE PREDOMINANT VEGETATION AND LAND USE TYPES OF THE NIGERIAN SUB-HUMID ZONE.

Vegetation and Land Use Types	Area Surveyed km	%	% Cult- ivation**	Cattle Density* Dry	Cattle Density* Wet	Mean Herd Size Dry	Mean Herd Size Wet
Woodland	25,900	7	10	9.77 (31%)	9.97 (86%)	65	111
Transition***	141,690	40	12	5.94 (18%)	7.20 (25%)	50	65
Wooded-Shrub -Grassland	20,820	6	21	13.44 (30%)	8.37 (18%)	46	52
Mosaic****	85,320	24	30	12.95 (16%)	10.76 (19%)	62	77
Farmland 30 - 60%	28,950	8	26	11.89 (15%)	17.23 (25%)	50	64
Farmland > 60%	28,950	8	50	11.17 (46%)	15.98 (26%)	49	61
Aquatic Grassland	6,600	2	7	31.22 (21%)	4.08 (64%)	78	51
Riparian	5,080	1	12	30.02 (39%)	12.92 (89%)	83	92
Minor Types	13,200	4	8	-	-	-	-
Total/Mean	356,510	100	20	10.25 (11%)	9.44 (16%)	55	68

* Figures in parenthesis are percentage standard errors.
** Visually estimated during aerial survey.
*** Transitional between Woodland and Wooded-Shrub-Grassland.
**** Mosaic of Wooded-Shrub-Grassland and Farmland.

3.4 Distribution of Cultivation.

Some 20% of the Nigerian sub-humid zone was estimated to be under cultivation. The overall distribution of this farmland and the intensity of land use is represented by the three dimensional surface shown in figure 11, in which the proportion of land under cultivation is indicated by apparent height. As expected from the SLAR vegetation and land use map (figure 4), cultivation was found to be unevenly distributed within the sub-humid zone, and concentrated in a series of semi-isolated peaks of high intensity land use, surrounded by areas of relatively low cultivation. However an important feature indicated in figure 11, but not evident on the SLAR map, is that cultivation was taking place throughout the surveyed area, albeit at very low levels in the more western areas and to the south-east.

As previously mentioned, Putt el al. (1980) have demonstrated a rapid rate of agricultural expansion, associated with human population increase, both within and outside the sub-humid zone. In the Lafia region, for example, comparative airphoto interpretation indicated that cultivation was expanding at an annual compound rate of 4.8%. With an estimated 20% of the sub-humid zone currently under cultivation, and on the basis of such a rate of agricultural expansion, plus or minus one per cent., figure 12 projects the increasing proportion of the sub-humid zone likely to be under cultivation to the turn of the century.

3.4.1 Land Use Intensity Gradients.

The south-north and west-east components of the geographical gradients in land use intensity are shown in figure 13. On the south-north axis the proportion of land under cultivation was highest in the south where some 25% of land was cultivated. In the mid latitudes cultivation declined to a minimum of some 17%, and then began to rise towards the northern boundary of the zone. On the west-east axis cultivation increased steadily from a low of some 10% in the far west, to peak at a level of 35% of land under cultivation in the mid east, and then declined rapidly towards the far east.

3.5 Cattle and Land Use Intensity.

Figure 14 shows the variations in mean cattle density, mean herd density and mean herd size that were found at different levels of land use intensity. Very few cattle were found in areas where cultivation was absent, in either the wet or dry season. In both wet and dry seasons mean cattle density rose progressively to reach a peak of approximately 16 animals per square kilometer at between 20 - 40 cultivation. At higher levels of cultivation, cattle density decreased in both seasons, but fell more steeply in the wet season.

Mean herd density followed a similar pattern to that of cattle density, but it was evident that dry season herd densities were consistently higher that in the wet season.

A maximum mean herd size of some 80 animals was found during the wet season at land use intensities of between 10 - 20%. At higher levels of cultivation mean herd size progressively declined. In contrast, during the dry season mean herd size appeared to be relatively stable, fluctuating between 50 - 60 animals per herd, over a wide range of land use intensity.

4 A MODEL OF CATTLE DISTRIBUTION DYNAMICS IN THE SUB-HUMID ZONE.

Referring to the typical seasonal movement of cattle in Nigeria, Glover (1960) commented that: "The annual migration of Fulani takes two forms in the dry season. In one the movement is local; the herds only go short distances into neighbouring river valleys which are often infested by tsetse flies where grass and water can be found. This form of local migration also includes the movement of cattle from high ground, like the Jos plateau, into the surrounding foothills. The other form, which applies to most of the Fulani cattle, consists of a journey southwards, covering hundreds of miles in search of food and water. The herds often traverse large fly belts on the way and may well spend the whole dry season in tsetse infested country."

Nearly a quarter of century has elapsed since that description was written, and during that time the Nigerian environment has been modified substantially; the pattern and extent of seasonal cattle movement has altered significantly; and the proportion of nomadic cattle owners has declined. Van Raay (1975) considered that only 12% of Nigerian Fulani were fully nomadic, while he regarded 38% to be semi-settled, and the remaining 50% to be fully settled.

For many years the prime mover bringing about profound and widespread changes in the Nigerian environment has been the rapid increase in human population, which has led to an ever increasing demand for more food, and more land to cultivate. As a result there has been a greater competition for land in areas of high human population density, and consequently a progressive expansion of agriculture into areas of lower human population density. The latter process has been both encouraged and channeled by the expansion of Nigeria's major road network, particularly into the moderately high rainfall areas of the sub-humid zone.

In the past both the northern and southern regions of Nigeria were recognised as areas of high human population density, with the central "middle belt" being characterised by relatively low human population levels and little cultivation (Buchannan and Pugh, 1955). However, as reflected in the SLAR vegetation and land use map (figure 4), circumstances have changed and these characteristics can no longer be considered valid for the zone as a whole. Not only are local populations increasing in size, but also, because of increased land pressure, both to the north and to the south people are leaving their traditional areas and are moving into and settling within the sub-humid zone.

It is apparent that the main thrust of this agricultural expansion within the sub-humid zone has been experienced in a central bridging band, from Kano state in the north, southwards to the west of and including the Jos plateau, through Abuja, across the Niger and Benue fork, towards Benin and Enugu.

The increasing extent and intensity of both farming and hunting within this central bridging belt has greatly changed the pattern of vegetation and land use, and inevitably led to an overall reduction in wildlife species, and in many places brought about their local extinction. Thus both natural habitats and hosts of tsetse, the vectors of trypanosomiasis, have declined, which in turn has brought about a widespread reduction in the distribution of tsetse. The two savanna species of tsetse, G. morsitans and G. longipalpis , which typically have high trypanosome infection rates, have been most severely effected by the changes taking place within the sub-humid zone, and their overall distribution has contracted. This, together with the general decline in the wildlife reservoir of trypanosmiasis has resulted in a marked reduction in the silvatic cycle of disease transmission.

In contrast, the riverine species of tsetse G. palpalis and G. tachinoides, which have comparatively low infection rates, have tended to persist despite widespread environmental changes brought about by agricultural expansion. In part their continued survival has depended on their close association with riverine forest and thicket vegetation, and the greater human effort required to convert this type of vegetation into farmland. The continued survival of riverine species of tsetse has also depended on their more catholic feeding habits; in particular, their ability to adapt to the alternative hosts provided by the frequent, regular passage of cattle and people at forest crossing and watering points.

Nevertheless, because of the very restricted distribution of riverine tsetse, their relatively limited abundance, and their low infection rates, typically with trypanosomes of non-silvatic origin, the trypanosomiasis challenge they represent is likely to be relatively low.

The distribution of cattle within the sub-humid zone and the seasonal changes described in this paper are considered to represent a transitional stage in a continuing southward spread of Fulani cattle owners and their Zebu stock. This southward drift is inextricably bound up with a long term process of agricultural expansion resulting from human population increase and greater competition for land resources, which is generally opening up and changing the environment of the sub-humid zone, and at the same time leading to a proliferation of local markets for the sale of dairy and meat products.

A conceptual view of the possible overall dynamics of cattle distribution within the Nigerian sub-humid zone is illustrated in the form of a three phase model shown in figure 15, in which past, present and future conditions within the zone are represented.

In the past (upper model), Zebu distribution was transient and limited largely to a dry season influx of nomadic cattle from the north, indicated by the broad pathways entering and exiting the zone. Cultivation, represented by stipple is shown encroaching the zone centrally from both the north and the south.

Associated with the expansion of agriculture into the sub-humid zone, there has been an increasing degree of sedenterisation amongst Fulani cattle owners. This has involved both a reduction in the scale of their seasonal transhumance, represented in figure 15 by the "eddies" spiralling of the schematic pathways of cattle movement; and an increased proportion of permanent settlement, symbolised by stars.

As time passed and population increased, agricultural expansion was focused on the central bridging band across the sub-humid zone, but because of generally increased competition for limited land resources to the north, seasonal cattle movements extended progressively further south into the sub-humid zone. This southward dispersal of cattle, which has occurred across the entire zone, may also have been encouraged by a trend of increasing aridity further north, and by a general decline in the distribution and abundance of tsetse and a consequent reduction in the significance of trypanosomiasis.

This situation is illustrated in the central model of figure 15 representing conditions at present, in which substantially reduced seasonal transhumance and increased settlement of Fulani and their cattle is indicated within the central bridging band of cultivation stretching across the sub-humid zone. To the east and the west a southward dispersal of cattle has also taken place; to such an extent that much of the seasonal movement of cattle, even of long distance transhumance (represented by the large oval pathways), is now believed to take place with the sub-humid zone itself. The proportion of nomadic entrants from further north is now considered to be low in comparison with year round residents of the sub-humid zone.

In the future, as land pressure in the central bridging zone, as well as to the north and south, continues to increase, as it must do as long as human population increases and remains substantially rural, it seems inevitable that agricultural expansion will increasingly be directed outwards to the west and east.

However, because of the siting of the new Federal Capital at Abuja and the major commercial/communication axis linking Lagos. Ibadan, Abuja, Kaduna and Kano, preferential agricultural expansion and land development are likely to take place to the south and west. Thus, as indicated in the future model of the sub-humid zone illustrated at the bottom of figure 15, a south-westward spread of arable agriculture and rural populations can be anticipated, along with a closely associated dispersal of cattle and Fulani, who can be expected to settle and gradually establish a system of mixed farming.

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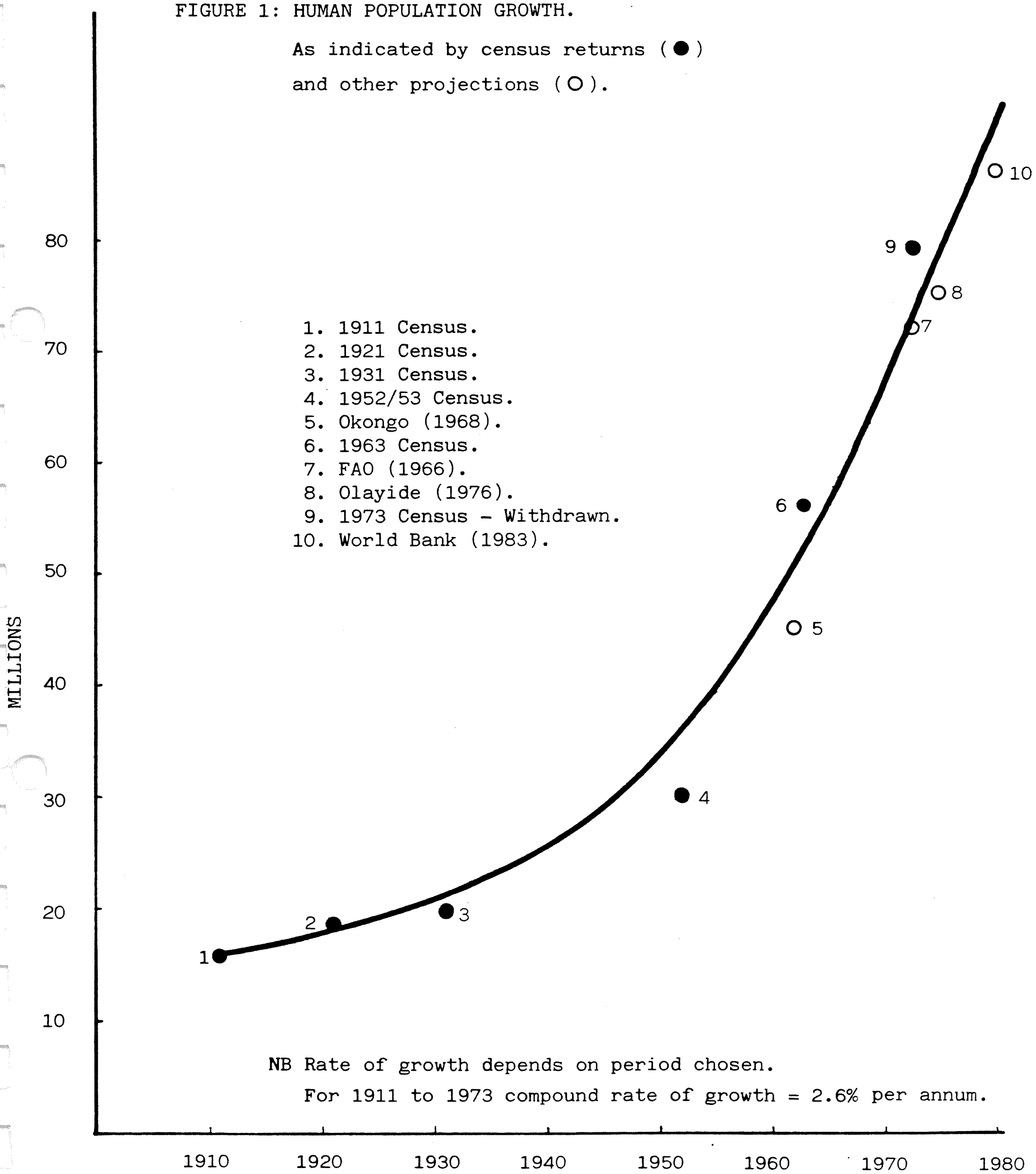


FIGURE 1: HUMAN POPULATION GROWTH.

As indicated by census returns (●) and other projections (○).

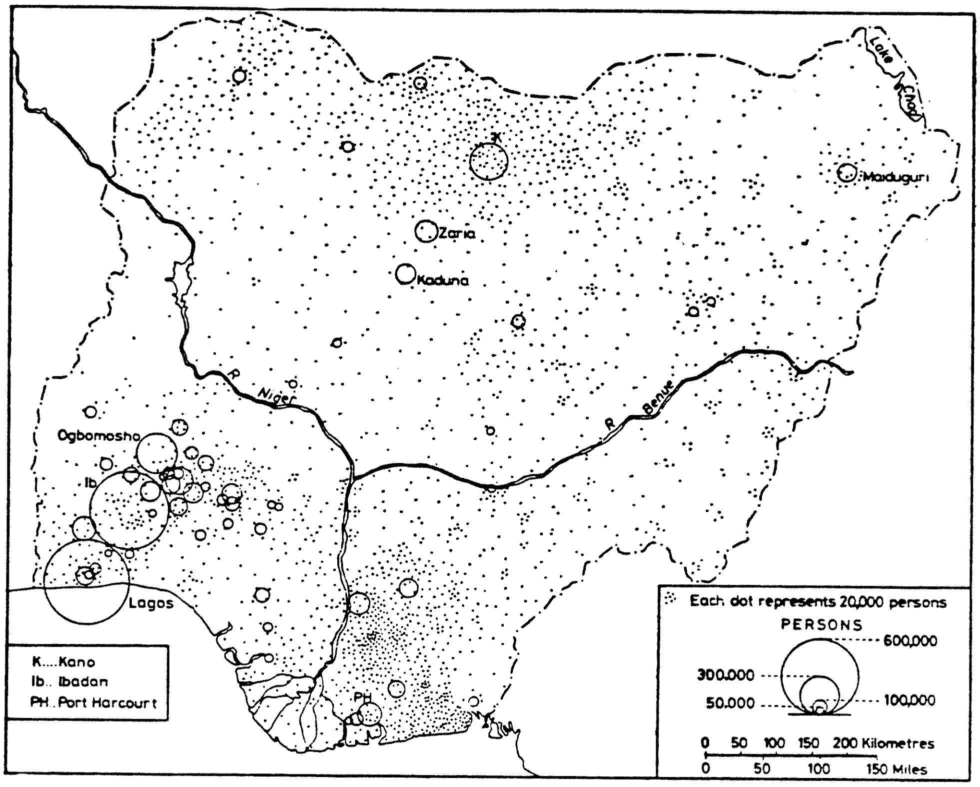


FIGURE 2 : HUMAN POPULATION DISTRIBUTION AND DENSITY - 1963 CENSUS
(AFTER AFOLAYAN, 1978)

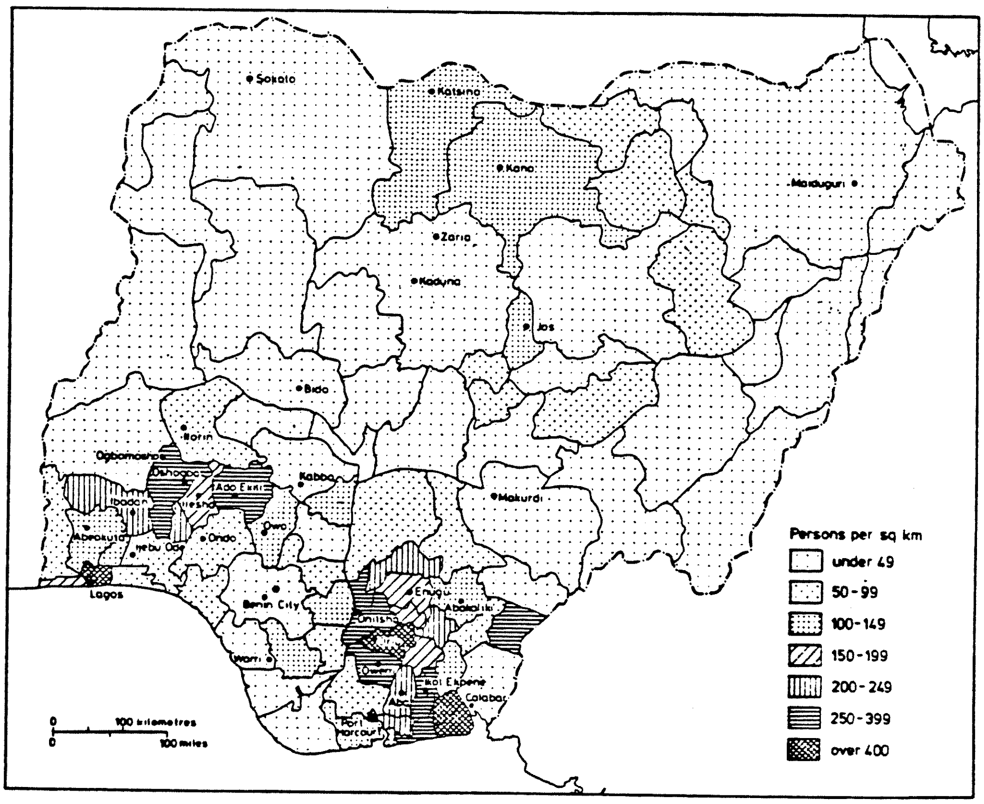
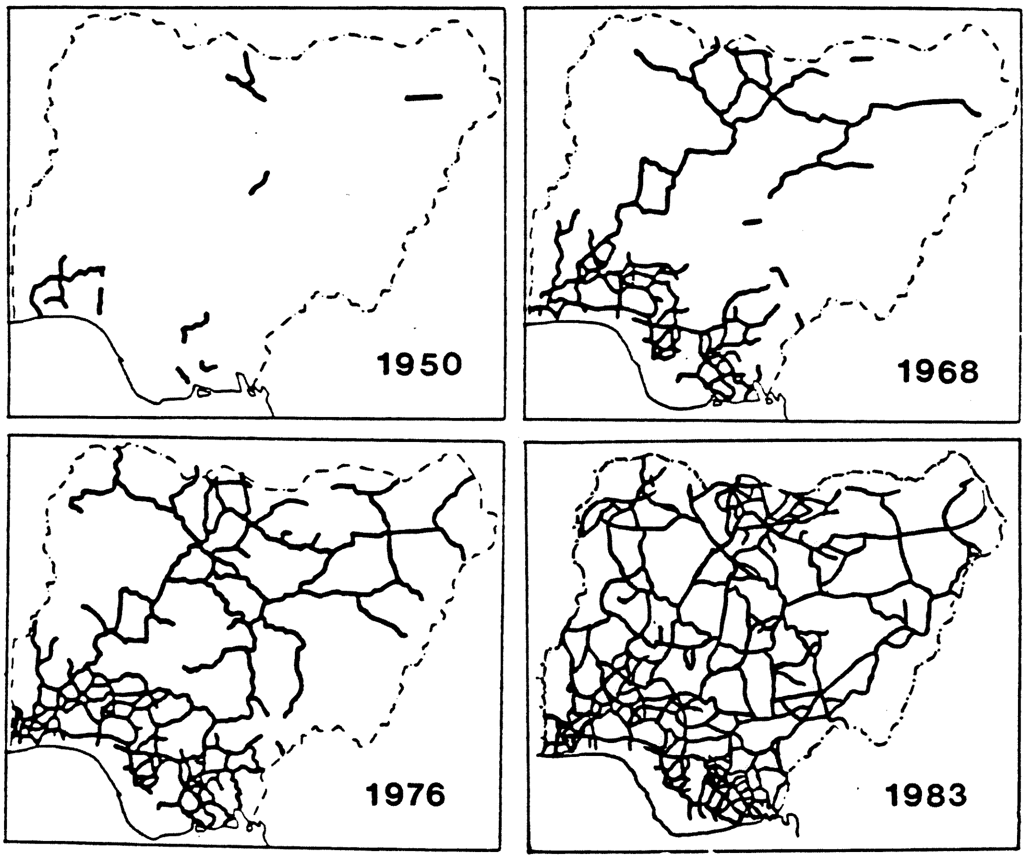


FIGURE 3: EXPANSION OF NIGERIA'S MAJOR ROAD NETWORK, 1950 - 1983.



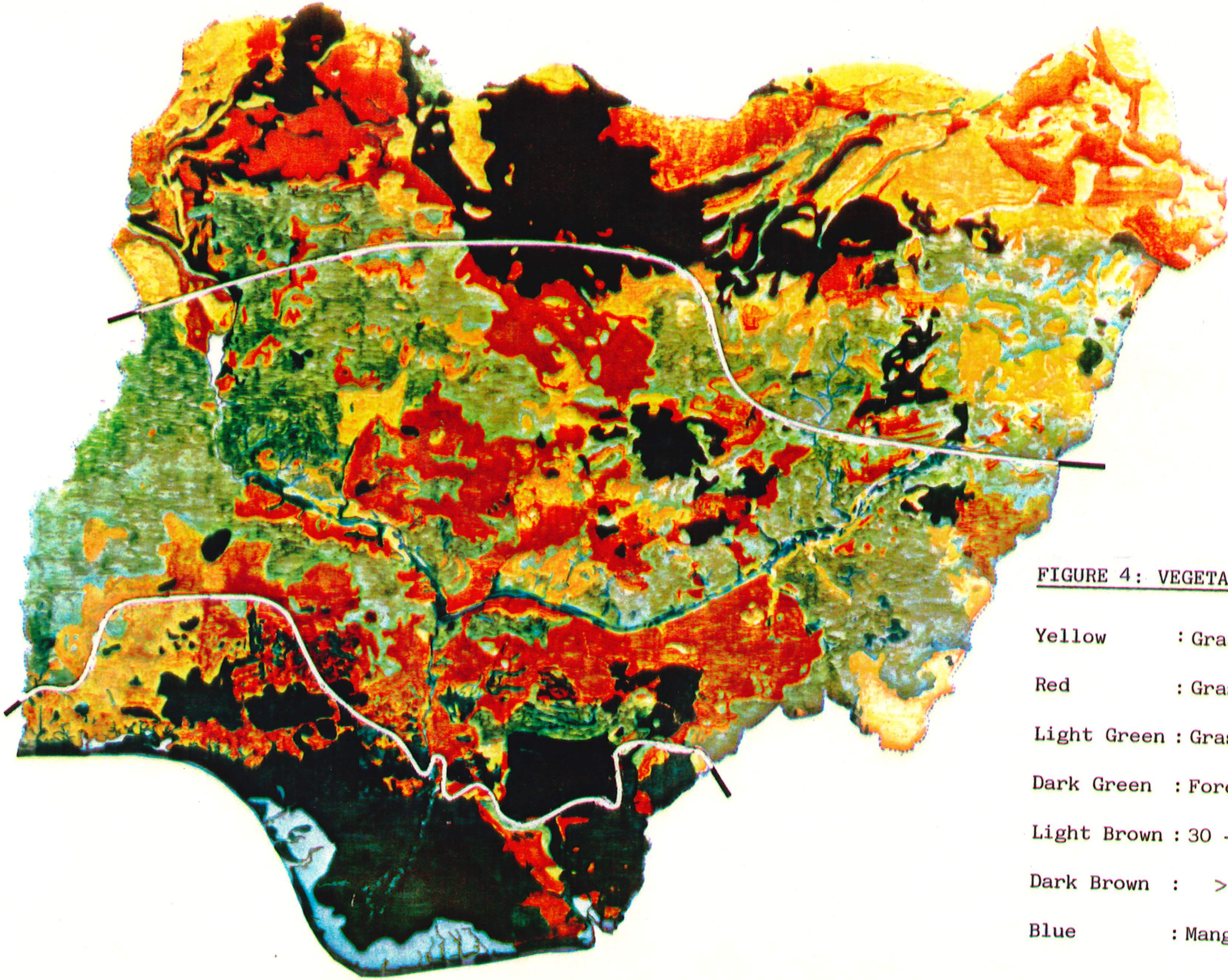
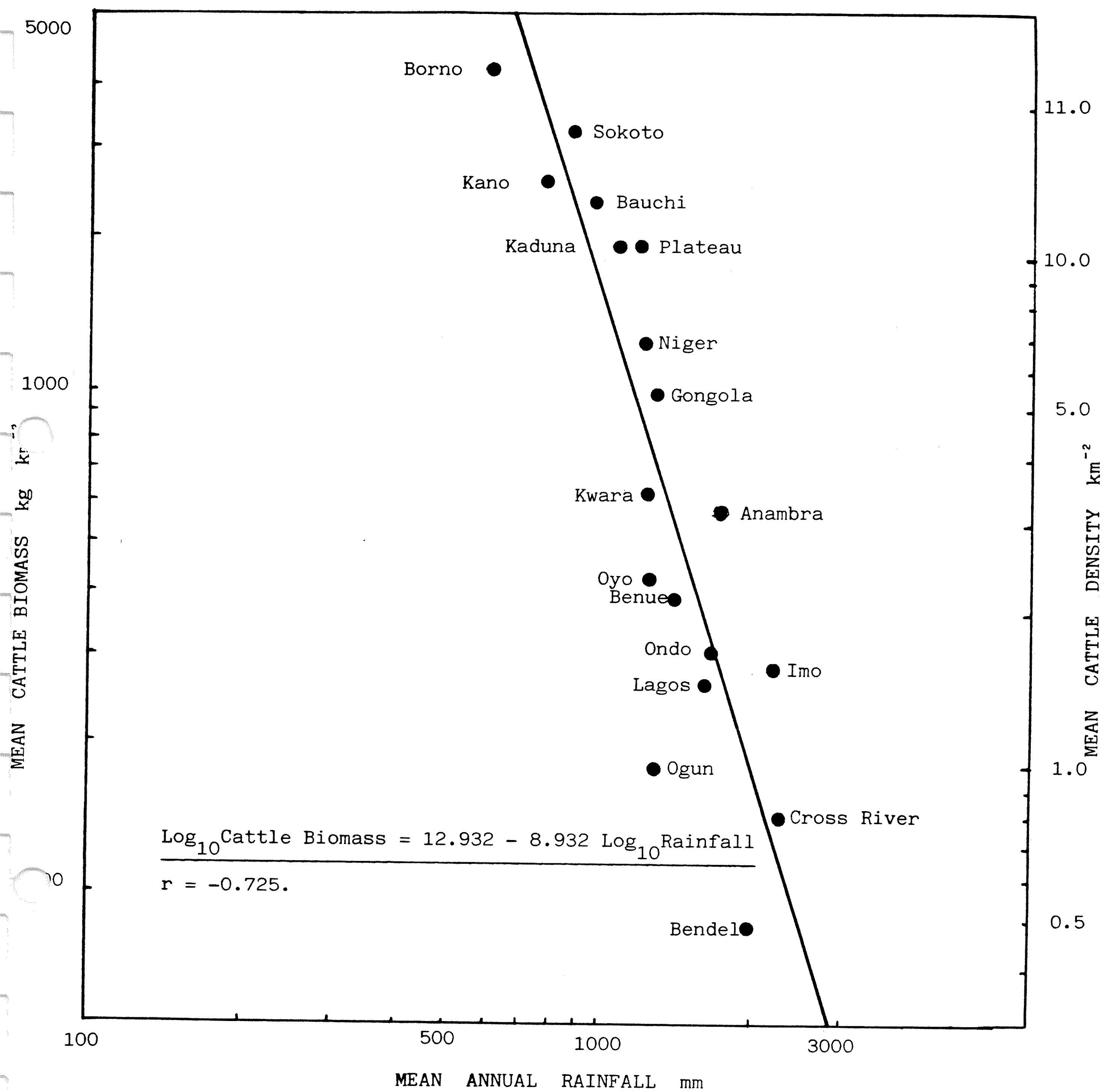


FIGURE 4: VEGETATION AND LAND USE.

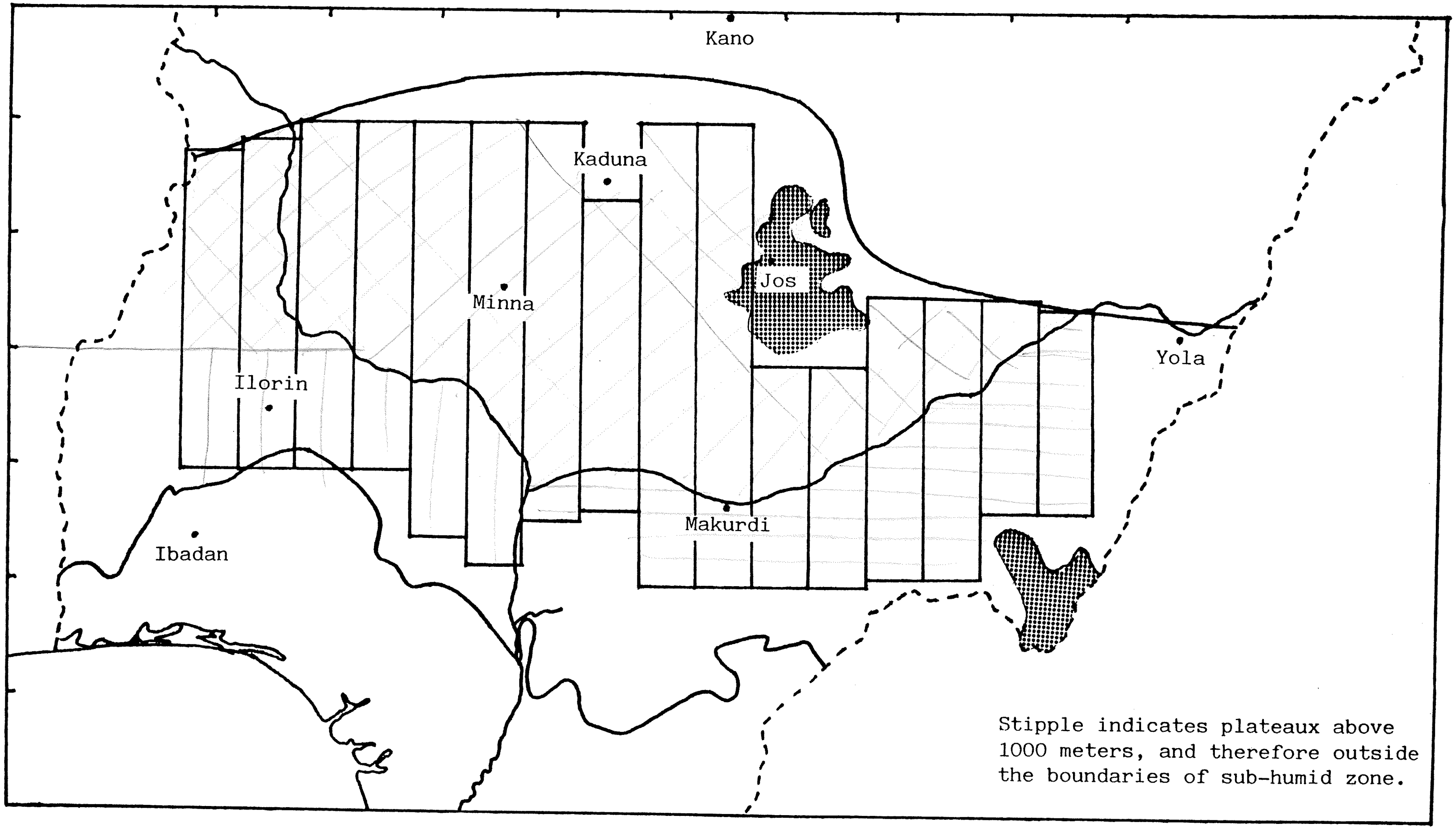
Yellow	: Grassland
Red	: Grass-Shrub-Land
Light Green	: Grass-Shrub-Wood-Land
Dark Green	: Forest
Light Brown	: 30 - 60% Farmland.
Dark Brown	: > 60% Farmland
Blue	: Mangrove

FIGURE 5: INVERSE RELATIONSHIP BETWEEN ESTIMATED CATTLE BIOMASS/DENSITY AND MEAN ANNUAL RAINFALL FOR EACH STATE IN NIGERIA.



Notes: Cattle numbers from FLD (1978).
Rainfall from Putt et al. (1980),
Biomass based on unit weight of 180 kg., Watson (1972).
Rivers state falls off scale, bottom right.

FIGURE 6: LONGITUDINAL BLOCKS SAMPLED DURING LOW ALTITUDE, LOW INTENSITY AERIAL SURVEY OF THE NIGERIAN SUB-HUMID ZONE



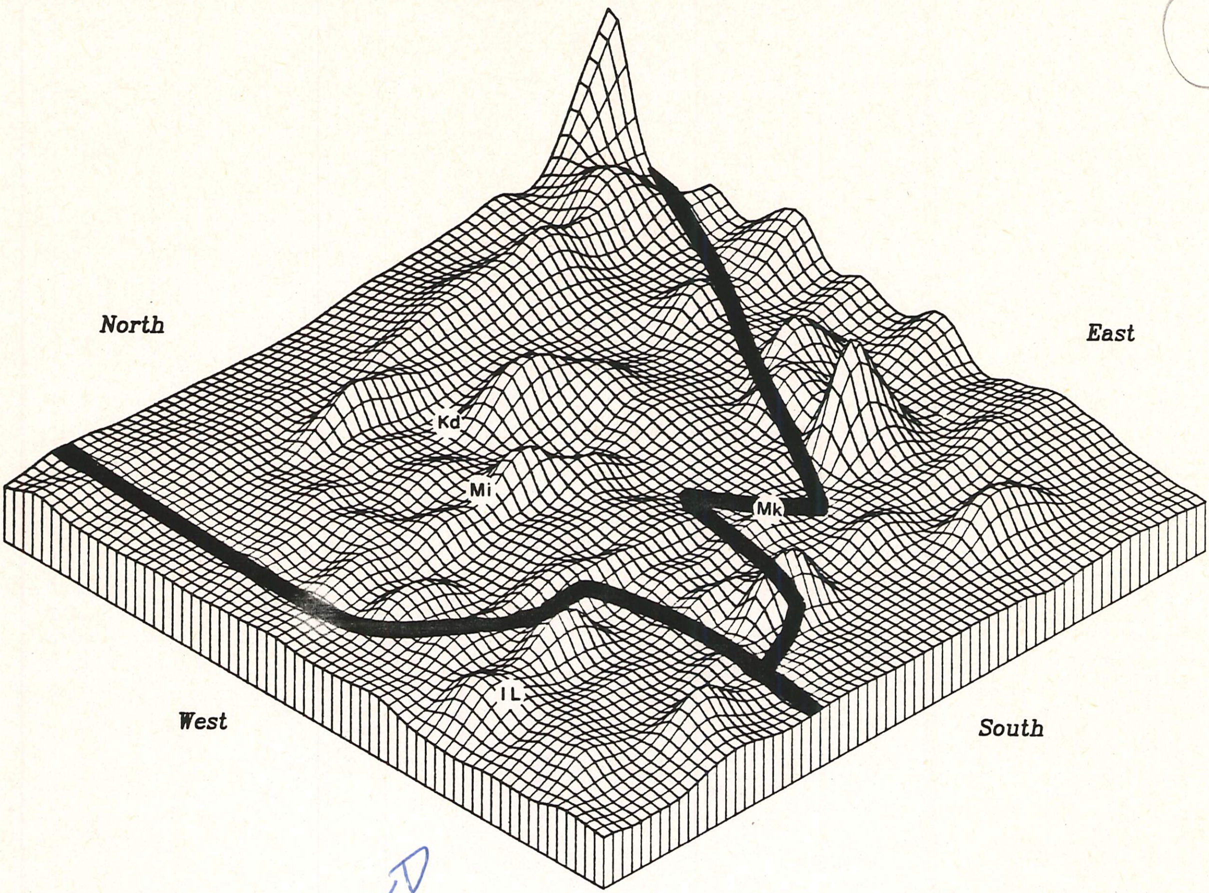


FIGURE 7: WET AND DRY SEASON SUB-HUMID ZONE CATTLE DISTRIBUTION.

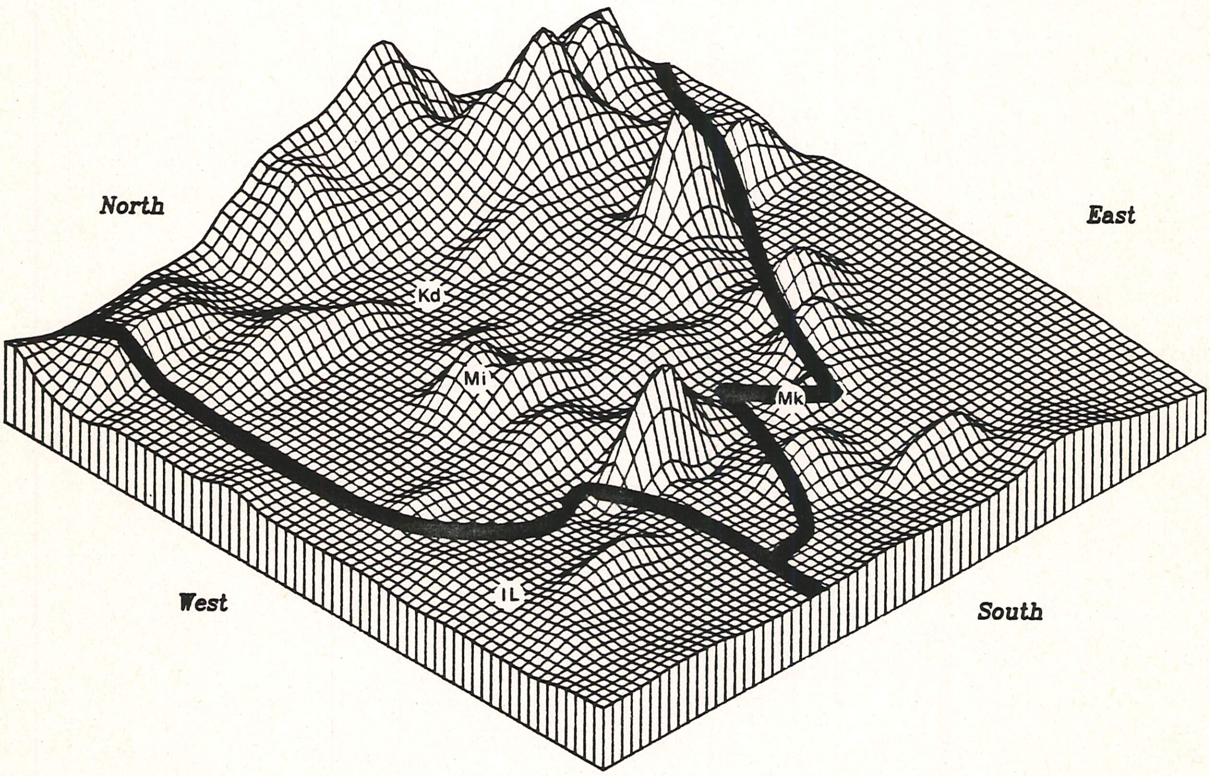


FIGURE 8: GEOGRAPHICAL COMPONENTS OF CATTLE DENSITY GRADIENTS IN THE NIGERIAN SUB-HUMID ZONE.

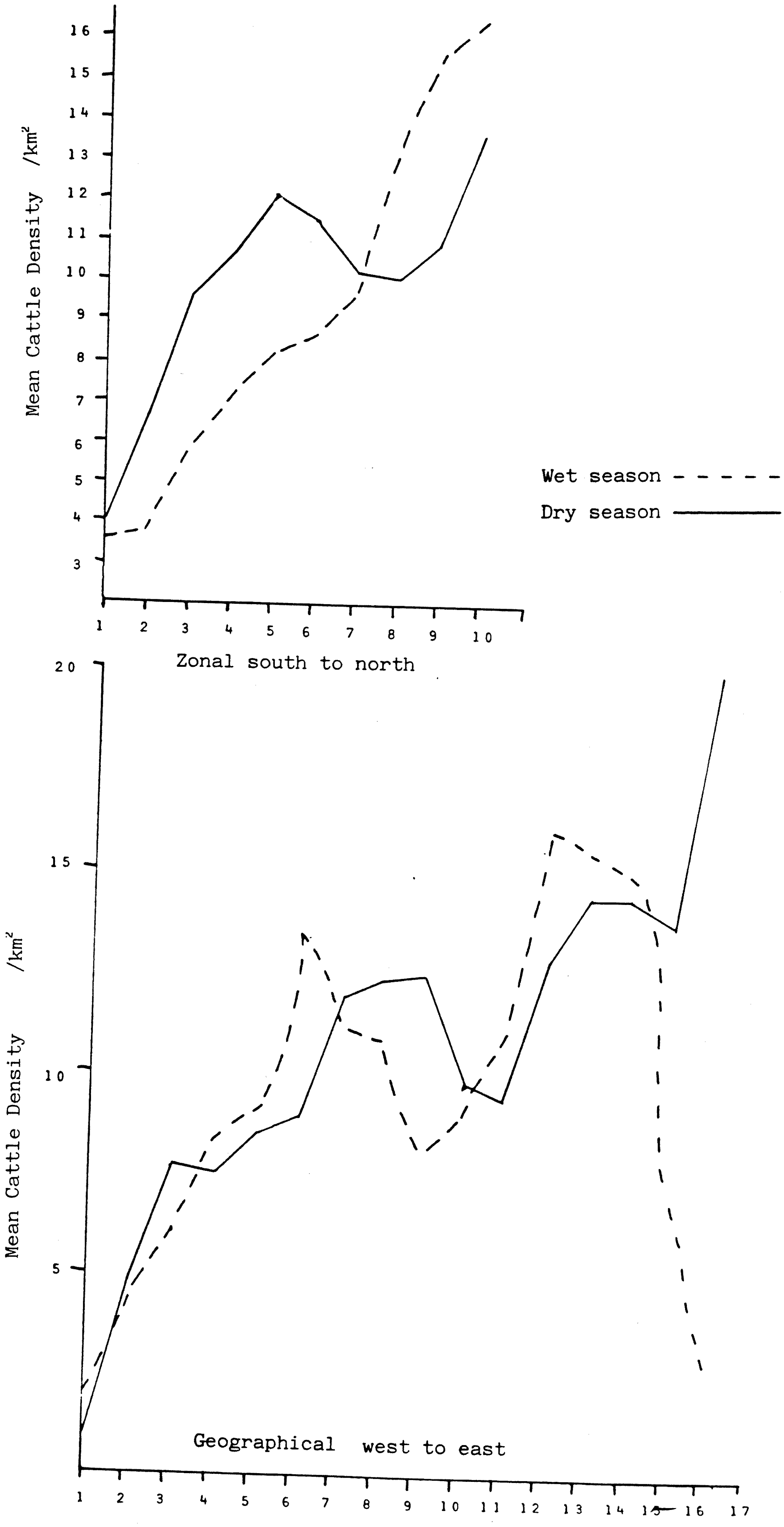
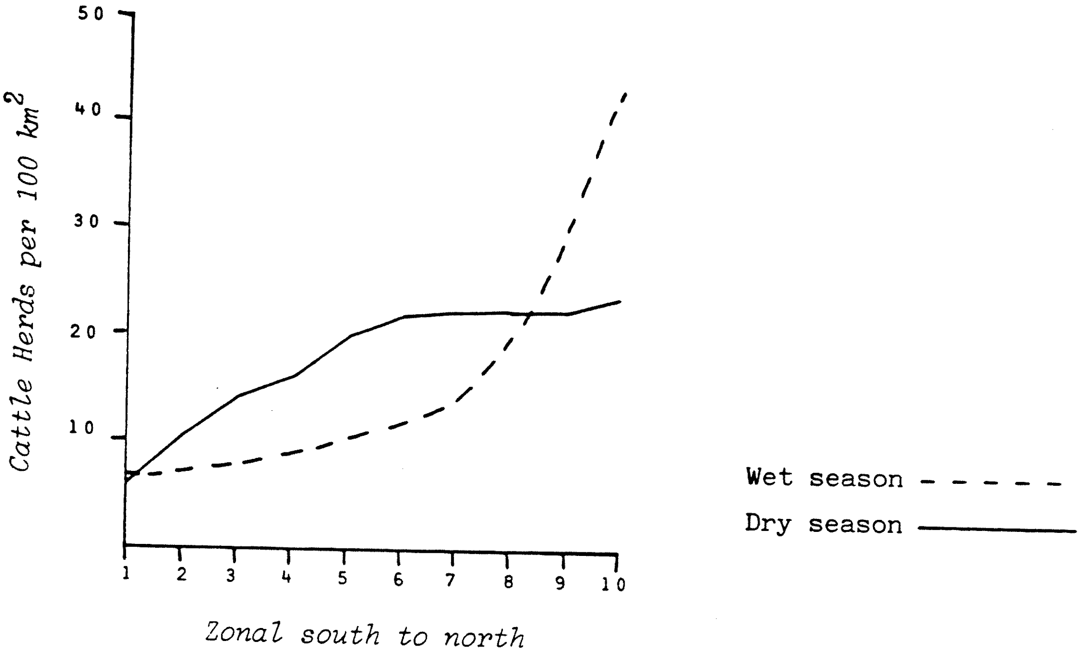


FIGURE 9; GEOGRAPHICAL COMPONENTS OF HERD DENSITY GRADIENTS IN THE NIGERIAN SUB-HUMID ZONE.



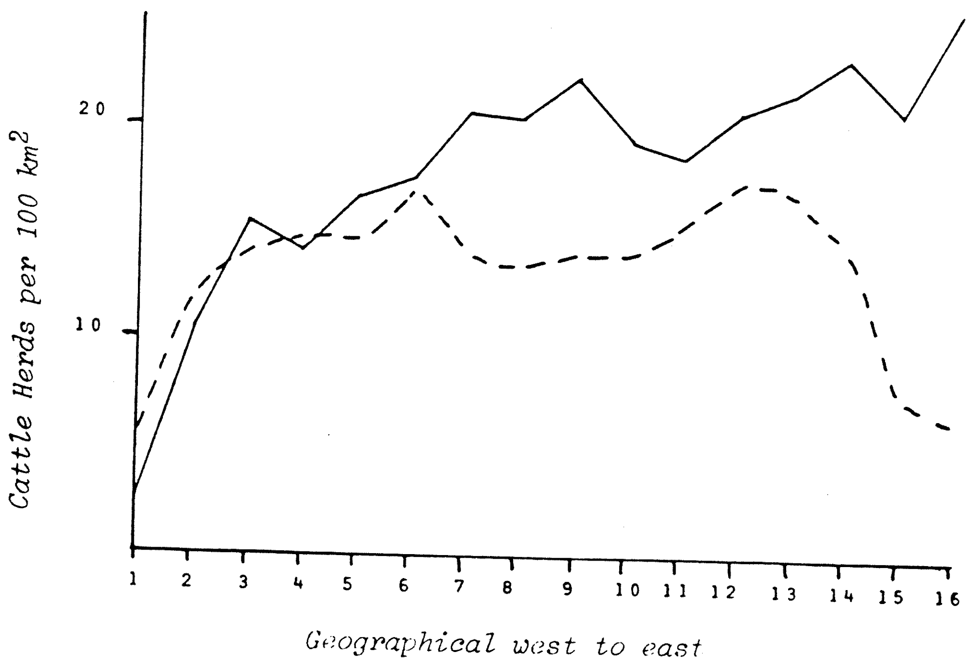
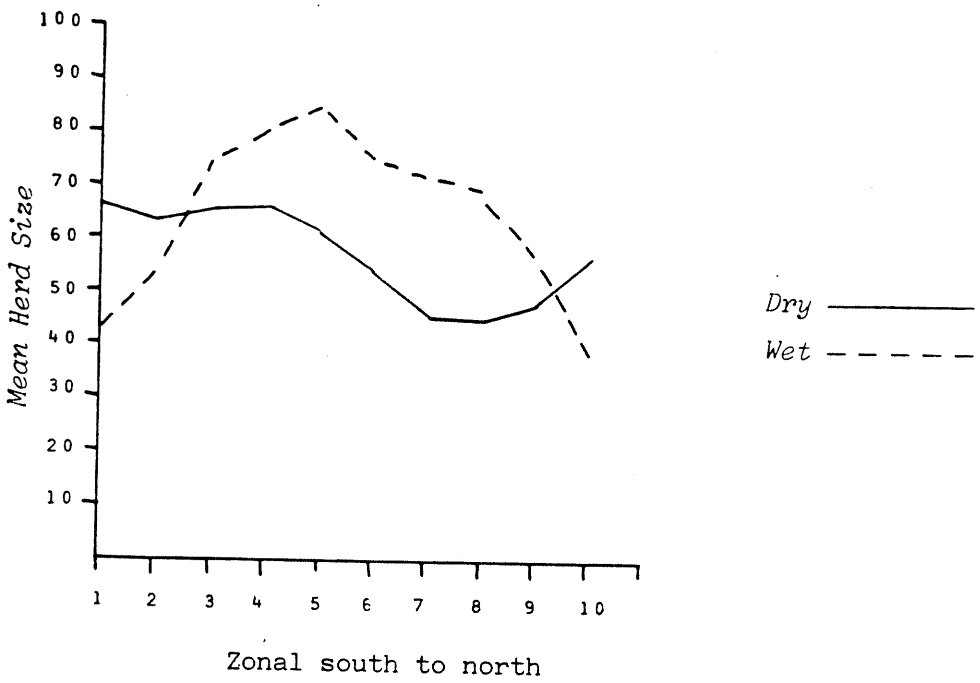
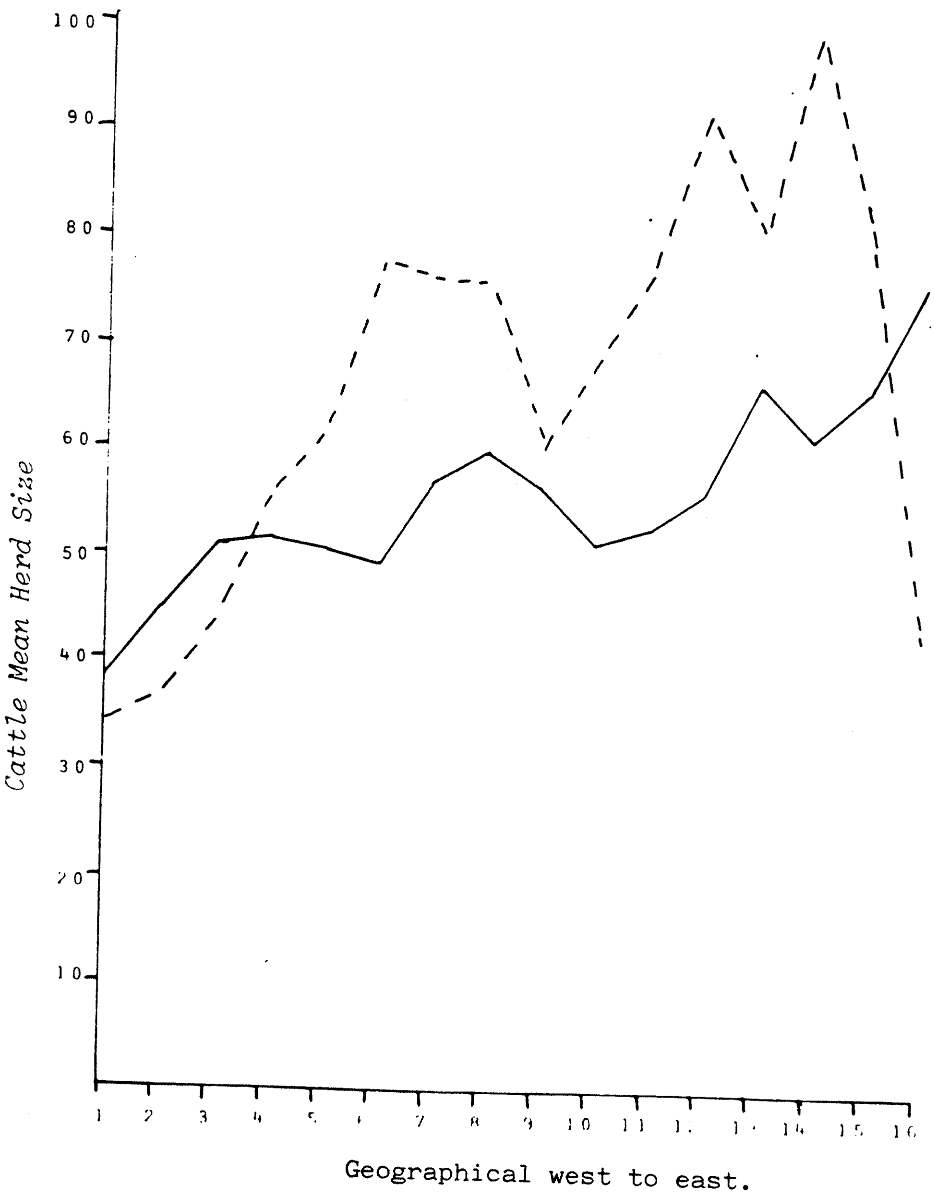


FIGURE 10: GEOGRAPHICAL COMPONENTS OF HERD SIZE GRADIENTS IN THE NIGERIAN SUB-HUMID ZONE.





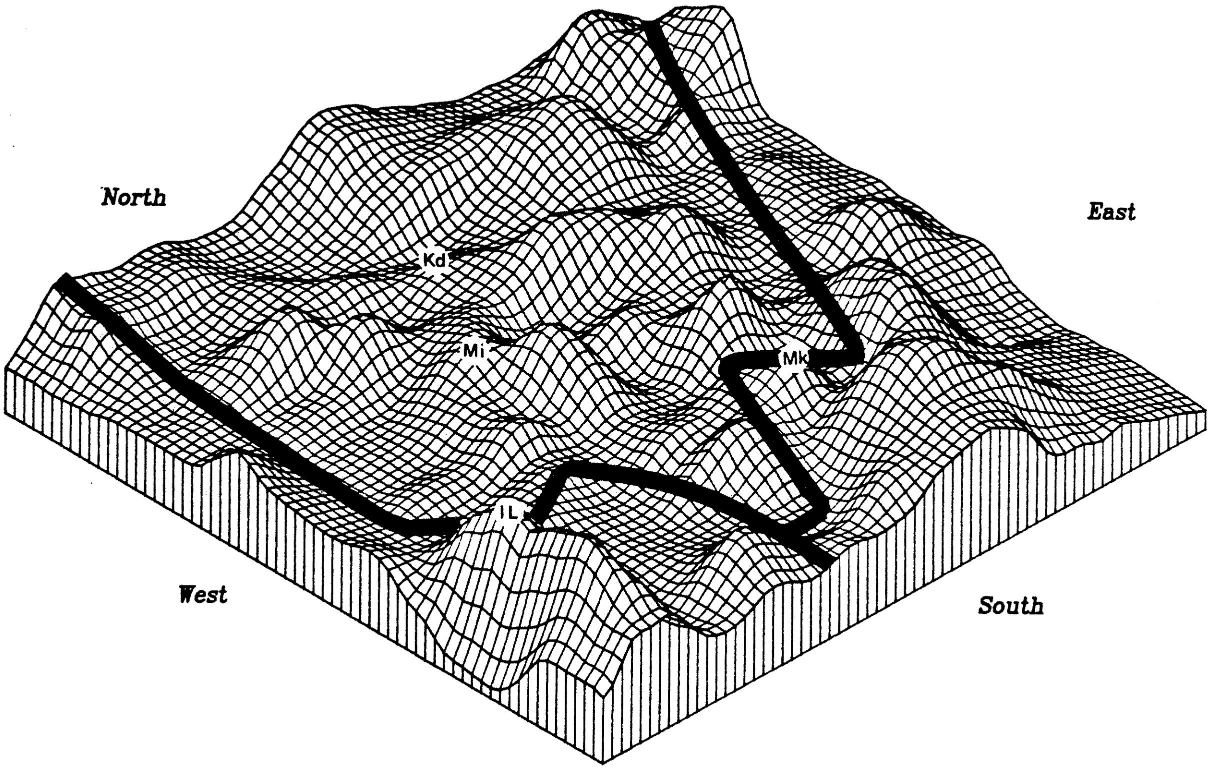


FIGURE 11: DISTRIBUTION OF CULTIVATION IN THE SUB HUMID ZONE.

FIGURE 12: PROJECTED LAND AREA UNDER CULTIVATION WITHIN SUB-HUMID ZONE UNTIL THE TURN OF THE CENTURY.

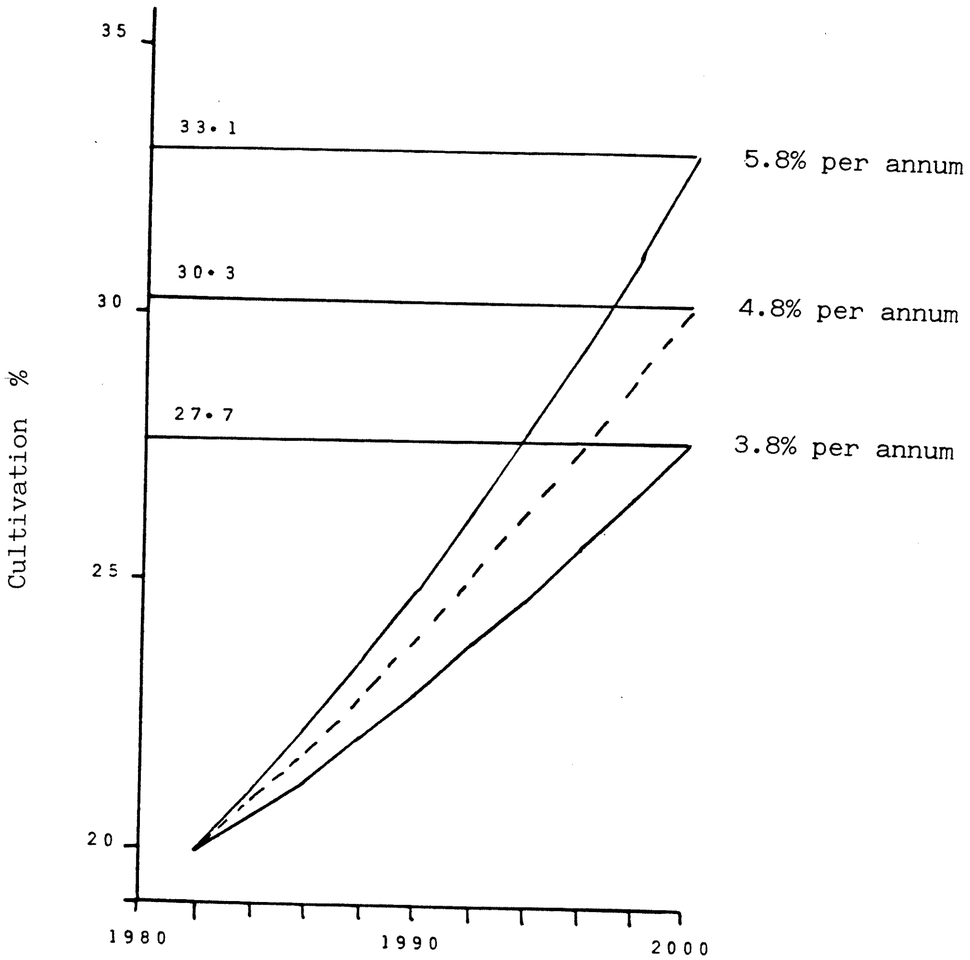


FIGURE 13: GEOGRAPHICAL COMPONENTS OF LAND USE INTENSITY GRADIENTS IN THE NIGERIAN SUB-HUMID ZONE.

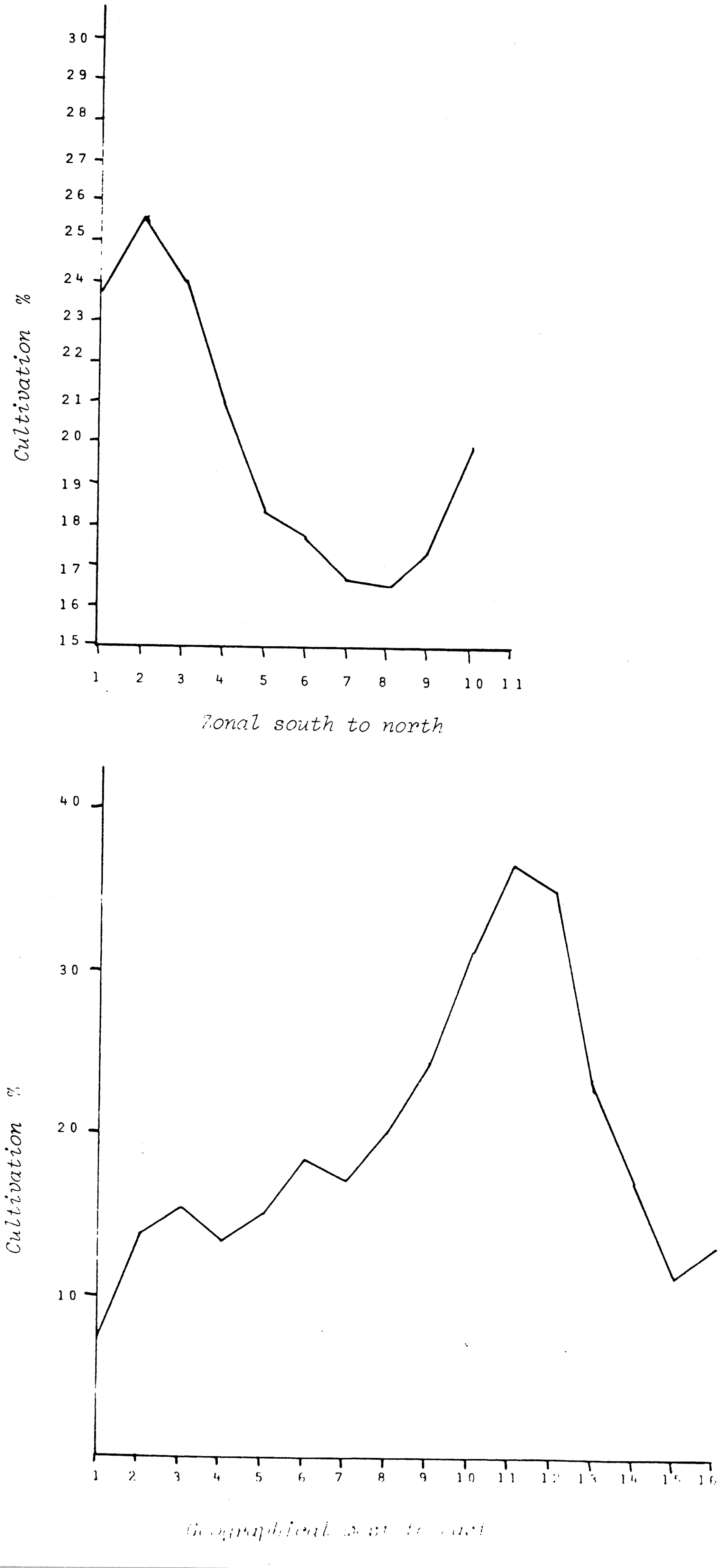


FIGURE 4: VARIATION IN CATTLE DENSITY, HERD DENSITY AND HERD SIZE WITH LAND USE INTENSITY IN THE NIGERIAN SUB-HUMID ZONE.

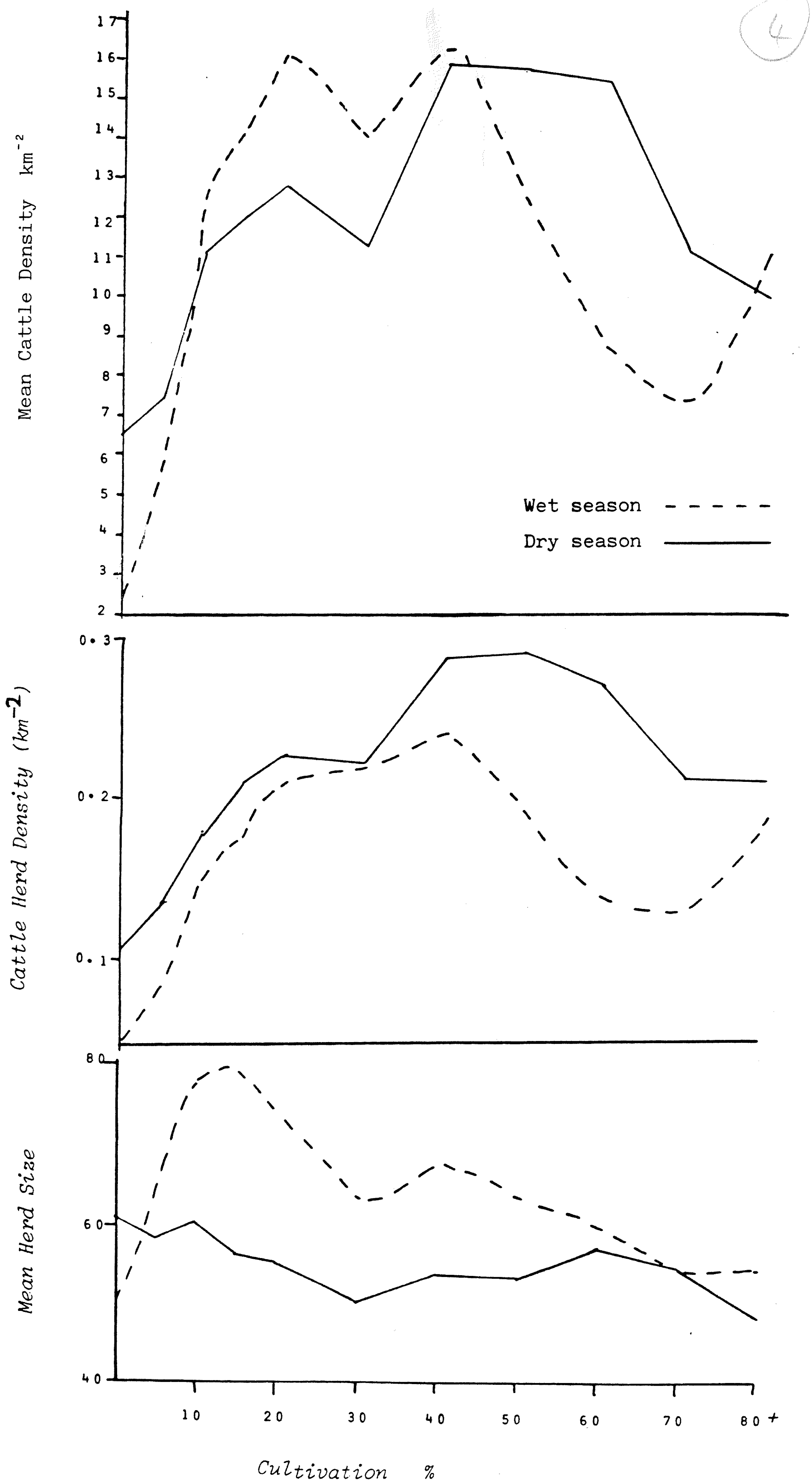
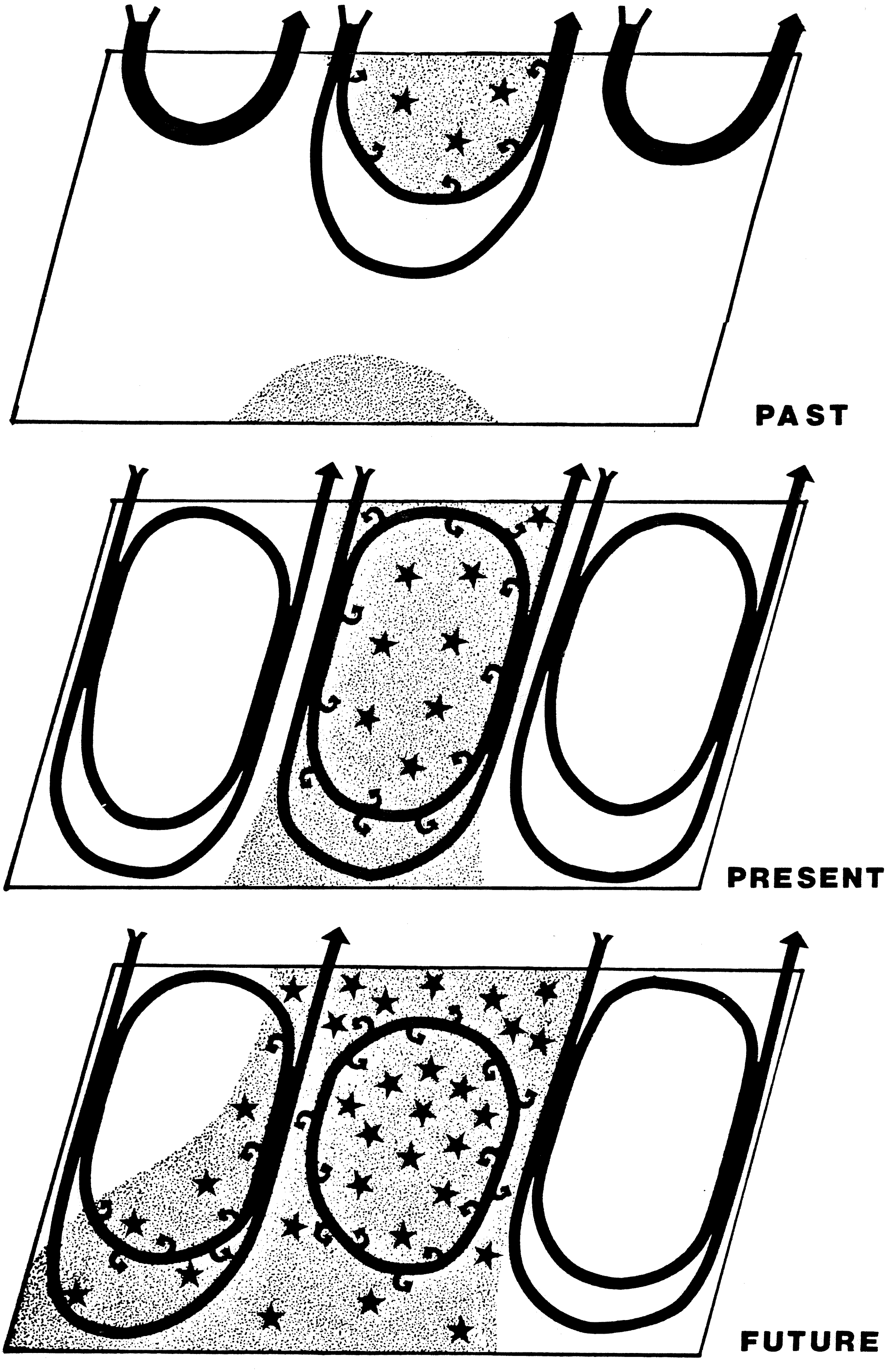


FIGURE 5: SCHEMATIC MODEL OF THE DYNAMICS OF CATTLE DISTRIBUTION IN THE NIGERIAN SUB-HUMID ZONE.



INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA.
AERIAL SURVEY UNIT.

THE DYNAMICS OF CATTLE DISTRIBUTION IN THE NIGERIAN SUB-HUMID ZONE.

An assessment based on environmental analysis and low intensity, low altitude aerial surveys.

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