Paper 4: The ecology, vegetation and land use of subhumid Nigeria

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Abstract

The subhumid zone of Nigeria covers 455 000 km^2 or approximately half of Nigeria and a third of the zone in West Africa.

Typically low in carbon and nitrogen, the soils have a tendency to form hard crusts. They have a poor capacity for retaining nutrients, poor water penetration and shallow water tables, all of which adversely affect cropping potential.

Rainfall in the zone ranges from 1000 to 1500 mm, with growing season from 180 to 300 days per year. The zone offers a wide variety of cropping options, but the growing season is invariably punctuated by dry spells. There is high runoff. During the growing season the humidity is conducive to pathogen survival and transmission. In the dry season the vegetation is subject to burning.

The zone has five vegetation subzones, but the Guinea and derived savanna subzones account for some 90% of the zone. There is good vegetation cover, although it is dominated by varieties suited to impoverished soil conditions. The feed quality of the grasses rises after the onset of the rains, but declines rapidly after they stop and is low for most of the year. The pattern of vegetation and land use form a mosaic of medium to high levels of cultivation, grassland and woodland. Twenty percent of the zone is cultivated, and cultivation is expanding at 4.8% per annum. It is estimated that by the turn of the century 33% will be cultivated. This estimate is well below the former one of 70%.

Crop yields cannot be sustained on cleared land for more than 3 years without fertilizer or manure. There are opportunities for introducing forage legumes, but such interventions must be in accord with intricate and well established mixed cropping systems. The bigger the contribution of forage legumes to soil fertility and hence to food crop yields, the better the chances of their adoption.

Introduction

The Nigerian subhumid 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 the derived savanna and forest vegetation zones (Nord, 1982). It occupies some 455 000 km^2, amounting to approximately one half of Nigeria's total land area and one third of the zone in West Africa (Jahnke, 1982).

Geology

More than half of the Nigerian subhumid zone is covered by Pre- to Upper Cambrian basement complex. It includes the oldest rocks known in Nigeria, principally composed of metamorphic and igneous material. Over most of the area underlain by basement complex there is a discontinuous mantle of weathered gneiss and granite, but this is generally thin, with a high clay content, and does not serve as an efficient aquifer. The water tables are shallow and adversely affect crops and cropping potentials at the height of the wet season. The soil tends to form a hard crust after the first rains, effectively preventing penetration of water and seedling emergence. It therefore needs tillage for cropping. Areas with excessively coarse materials, a poor capacity for retaining nutrients due to low cation exchange capacity, and topography exceeding 2-3% slope are normally avoided by farmers. Under the traditional production system long fallow periods are necessary for maintaining soil fertility.

Relief

For an area covering half a million square kilometres, the variation in relief within the subhumid zone is limited. Four major relief types can be identified:

The Niger-Benue trough is a Y-shaped lowland area which divides the subhumid zone into three parts. It has been deeply dissected by erosion into tabular hills separated by river valleys. The Niger section is especially rugged.

The upland areas north of the Niger-Benue trough, and west of the Niger river, are generally undulating and strongly marked by inselbergs. The north-central plateau is made up of two different platforms - the high plains of Hausaland, which at an average height of 600 m a.s.l form the first step, and the Jos Plateau at an elevation of between 1000 and 1800 m forming the second step. The latter falls outside the subhumid zone.

The area south of the Benue and east of the Niger, extending eastwards as far as 9º30'E, consists of the lowland Cross River plains, east of Enugu, which show outcrops of limestone and shales whereas the relief in general is gentle; and the scarplands west of Enugu, which are made up of the Udi and Awka-Orlu plateaux.

Sunshine and radiation

The maximum seasonal variation in day length in Nigeria is 1 hour and 45 minutes. This variation is sufficient to cause differences in the performance of crops sensitive to photoperiodism. The mean annual number of hours of sunshine increases progressively to the northeast. The daily mean duration of sunshine in July, at the height of the rainy season, is greater in the north than in the south, where the cloud cover is more constant. The same pattern is observed in January, when there is a general lack of cloud cover in the north, but due to humid air from the Gulf of Guinea cloudiness may be expected in the south. This results in a marked zonal pattern when the whole of Nigeria is considered. The northern part of the subhumid zone stands out as having the highest national values of net radiation. Further to the north, outside the zone, surface albedo is higher, reducing net received radiation.

Rainfall

Most of the Nigerian subhumid zone lies between the 1000 mm and 1500 mm isohyets, offering a wide choice of crop options. Rainfall is governed by the annual passage of the Inter-Tropical Convergence Zone (ITCZ), the meeting point of a dry northeastern low-pressure air mass and a moist southwestern high-pressure air mass. The northeastern movement of the ITCZ and the rain-bearing winds that accompany it mark the onset of the rainy season. Its southwestward movement and the accompanying harmattan winds mark the beginning of the dry season. Annual rainfall and its reliability decrease from the south northwards.

The northern part of the zone has unimodal rainfall distribution in which rains increase in frequency and amount, beginning in May and peaking in August. In the southern part the rainfall pattern is bimodal, the first peak occurring in June-July, and the second in September, with August relatively dry. Variations in annual rainfall make it difficult to draw a strict geographical boundary between these two distribution patterns. Much of the subhumid zone is transitional between unimodal and bimodal rainfall distribution.

The rains are expected to reach the southern boundary of the subhumid zone at the beginning of March, and the northern boundary 2 months later (Walter, 1968). At the northern boundary the rainy season normally ends in early October, and at the southern boundary 6 weeks later. The expected duration of the wet season in the subhumid zone thus ranges from 5 months in the north to more than 8 months in the south. Nevertheless the season (April to October) is invariably punctuated by dry spells, the length of which varies from a few days to a few weeks.

Evapotranspiration exceeds rainfall north of latitude 7°30'N (Kowal and Knabe, 1972), although almost everywhere in the zone there appears to be a period of water surplus in the year when rainfall exceeds evapotranspiration. Rainfall is usually torrential, 25 to 50 mm or more often falling within 1 hour. Measurement of infiltration or rainfall acceptance on a ferruginous soil type using catchment gauges gave an average ultimate infiltration of 24 mm/hour. Rainfall exceeding this rate can cause serious erosion and runoff. High humidity and concentrated rainfall during the growing season are conducive to pathogen survival and transmission. The dry season, on the other hand, is severe and the vegetation becomes parched and easily combustible.

Major soil types

Ferruginous tropical soils cover approximately half the Nigerian subhumid zone. These soils are generally characterized by a sandy surface horizon overlying a weakly structured clay accumulation. Their base-exchange capacity is low, but their base saturation and pH values are relatively high. They have high natural fertility, and FAO (1966) rates them as having good potential. However, under traditional management practices ferruginous tropical soils are of low productivity, are sensitive to erosion and have low water-holding capacity.

The alluvial soils found along the Niger and Benue rivers show light accumulations of organic matter but are often, under traditional management practices, too wet during the rainy season for crops other than rice. Under improved management practices, including irrigation and drainage, these soils have been classified by FAO (1966) as having strong to good potential, depending on their local texture and salt content.

The ferralsols that occupy much of the other half of Nigeria's subhumid zone are deep, strongly weathered soils of friable consistency. They have a low base-exchange capacity, low pH values and generally low nutrient contents. However, their resistance to erosion and good physical properties make these soils suitable for a wide range of crops. The ferralsols within the subhumid zone are categorized by FAO as soils of low present productivity, but as having medium potential if their management can be improved.

The lithosols found in the north-central part of the zone are of local significance only, and have been classified by FAO as being of variable productivity and potential. Under traditional management, they are dry for 6 to 8 months of the year. In addition they are shallow, moderately leached with little organic matter, and have a low base-exchange capacity.

The vertisols found in a small area west of Yola are difficult to work under traditional management practices. They crack deeply when dry, and have a heavy dark texture when moist. They are therefore of only medium productivity, in spite of being generally high in nutrients. Under improved management practices, FAO classifies these soils as having good potential.

The soil properties in ILCA's case study areas are shown in Table 1.

Table 1. General soil properties in two ILCA case study areas.

Location	pH	Organic C (%)	Total N (%)	Available P (ppm)	Ca (Meg/100 g)	Mg (Meg/100 g)	Mn (Meg/100 g)	K (Meg/100 g)	Total acidity
Kurmin Biri	5.2	0.58	0.071	3.9	1.12	0.37	0.02	0.13	0.78
Abet	5.3	0.36	0.086	1.8	1.04	0.49	0.11	0.13	0.46

Vegetation and land use

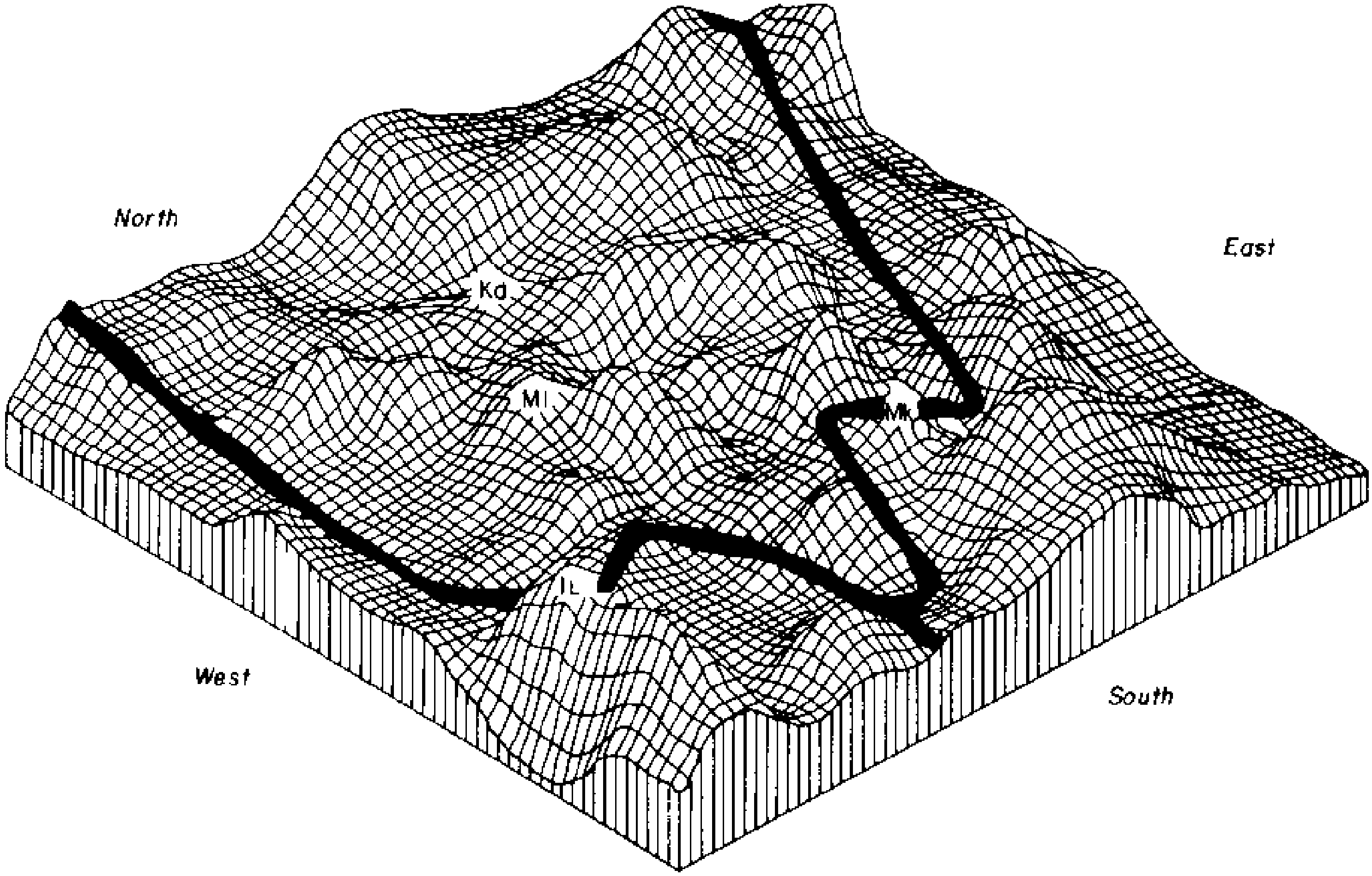
The subhumid zone includes five vegetation subzones, excluding those found at high altitude. The Guinea and derived savanna subzones occupy some 90% of the area. The areas of Nigeria where man's influence on the vegetation is greatest lie to the north and south of the subhumid zone, exemplified by conditions in the Sahel and by the diminishing rain forest. Blair-Rains (1968) stated that the existing vegetation in Nigeria in general may bear little resemblance to the original zonal categories, because of the combined effects of human activity: burning, cultivation, tree felling and cattle grazing.

Extensive areas of medium to high levels of land-use intensity are found on the northern border of the subhumid zone extending northwards, with the highest cultivation density being associated with major towns. The same pattern is found on the southern border, around Enugu, and southwards, where the proportion of land cultivated reaches its highest, at 25%. The land in between these two areas falls within the subhumid zone, where cultivation declines to some 17%. Here the pattern of vegetation and land use can best be described as a mosaic of varying levels of cultivation, grassland and woodland. An interconnecting patchwork of more intense 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. In this belt, cultivation reaches a peak of 35%. To the west and east of it, cultivated areas are generally more scattered (10%) with woodland tending to predominate.

Distribution of cultivation

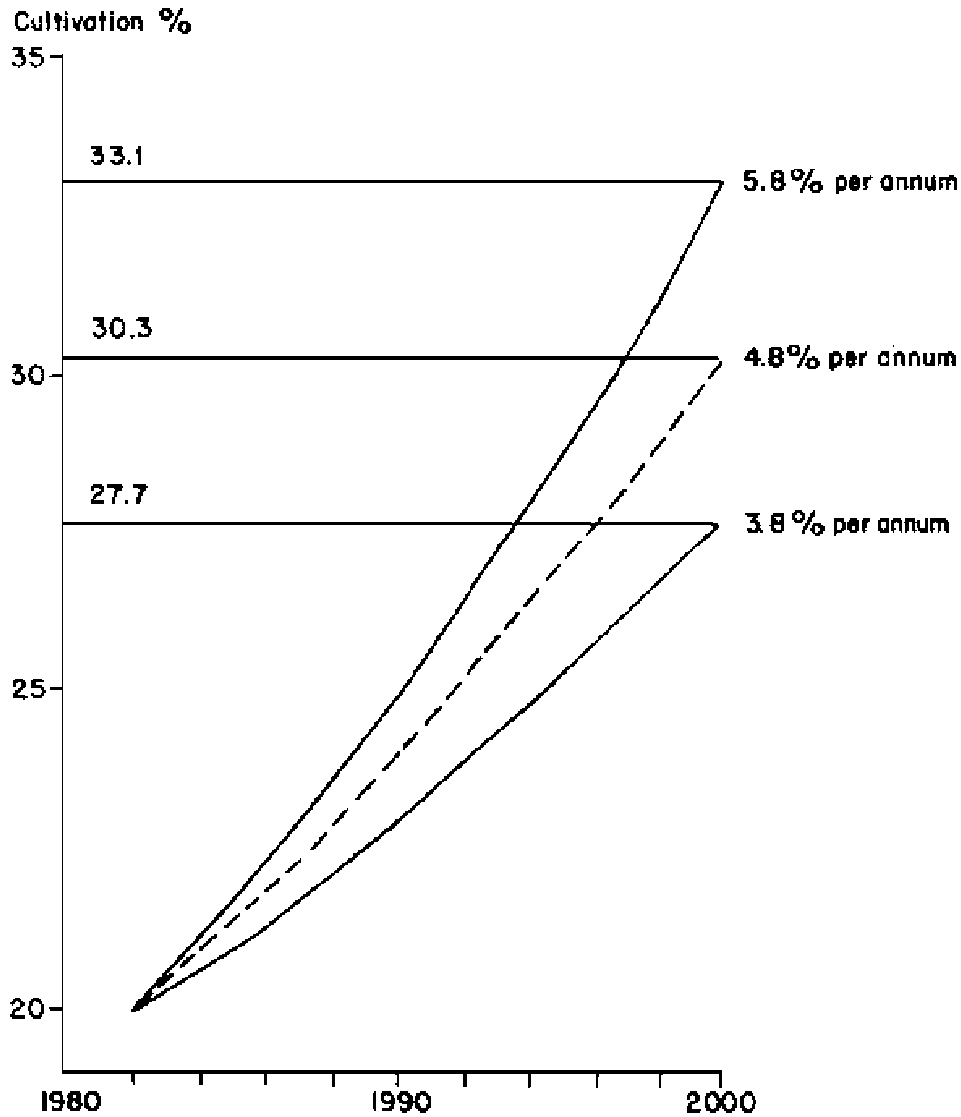
Bourn and Milligan (1983) estimated 20% of the Nigerian subhumid zone to be under cultivation. The overall distribution of this farmland, and hence the intensity of land use, are represented by the three-dimensional surface shown in Figure 1, in which the proportion of land under cultivation is indicated by apparent height. As already suggested by the side-looking airborne radar (SLAR) vegetation and land-use map, cultivation was found to be unevenly distributed within the subhumid zone, being 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 1 but not evident on the SLAR map is that cultivation is taking place throughout the surveyed area, albeit at very low levels in the more western areas and to the southeast.

Figure 1. Distribution of cultivation in the Nigerian subhumid zone.



Putt et al (1980) have demonstrated a rapid rate of agricultural expansion, associated with human population increase, both within and outside the subhumid zone. In the Lafia region, for example, comparative airphoto-interpretation indicated that cultivation was expanding at an annual rate of 4.8%. Assuming continued expansion at that rate (plus or minus 1%) and an estimated 20% of the zone to be cultivated at present, Figure 2 projects the increasing proportion likely to be under cultivation to the turn of the century. Even the higher estimate of 33.1% under cultivation is very much below the previous estimate of 70% for the zone as a whole (ILCA, 1979). Since approximately one third of the West African subhumid zone is in Nigeria, the figure of 70% would appear to be an overestimate.

Figure 2. Projected land area under cultivation within the Nigerian subhumid zone until the turn of the century.



Forage resources

The herbaceous cover of the subhumid zone consists mainly of annual grasses, with a very low percentage of native legumes. Seasonal changes in herbage quality are primarily due more to changes in plant development than to climatic conditions per se. The C_4 photosynthetic pathways in grasses promote a rapid accumulation of structural components, resulting in dilution of nutrients such as N and P in the tissue. Legumes on the other hand, exhibit a less efficient C^3 photosynthetic pathway and are independent of soil N. which is secured through biological fixation in the root nodules. Legumes are therefore usually higher in protein and minerals and have higher dry matter (DM) digestibility and voluntary intake by animals than do grasses at similar stages of growth. Growing forage legumes should thus provide a means of overcoming the protein deficiency of the grasses which dominate natural feed supplies.

Forage productivity

Measurement

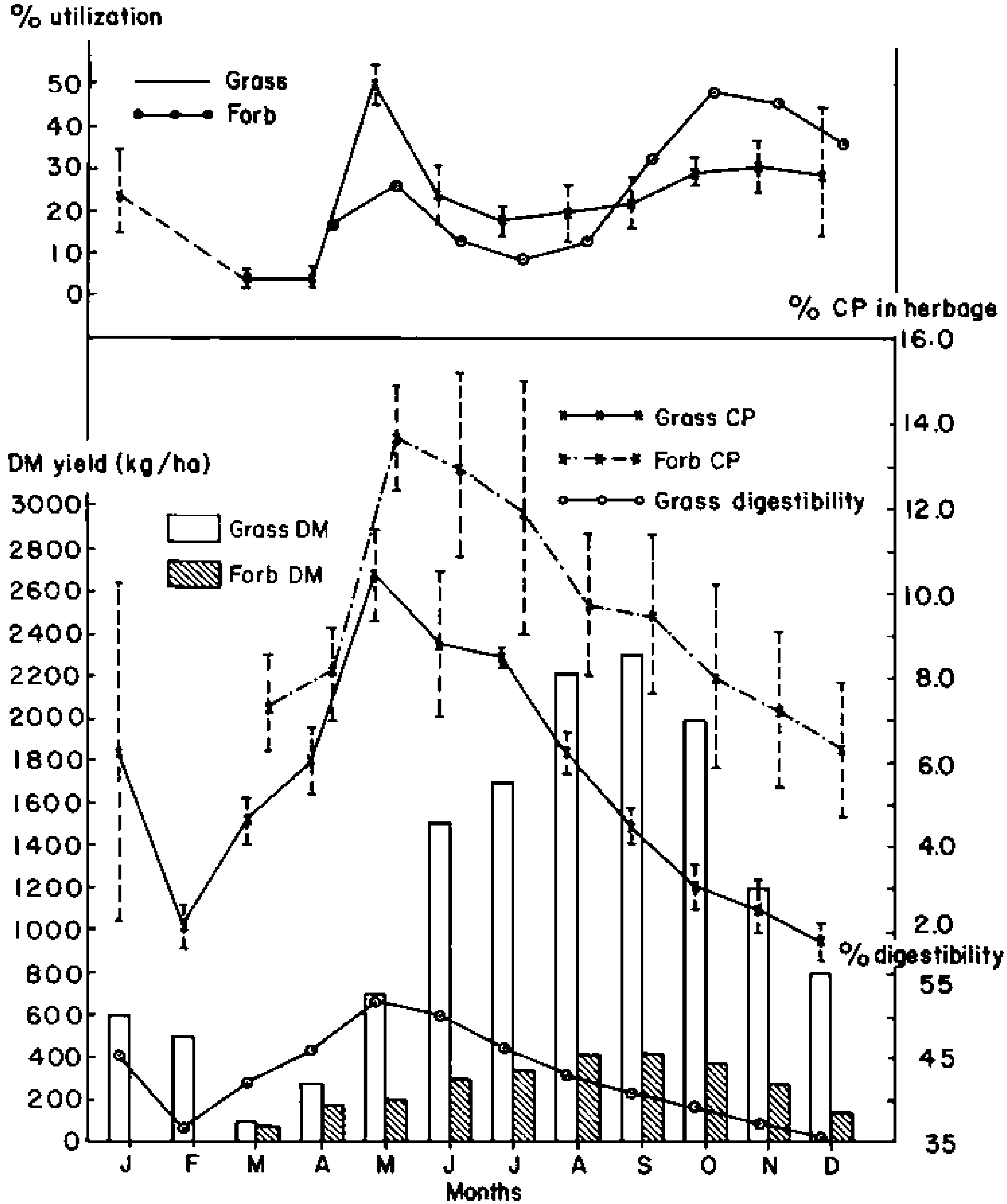
Land-use patterns affect the productivity of natural forage. Because of its favourable rainfall the subhumid zone is also likely to be increasingly utilized for cropping wherever edaphic and other conditions are favourable. Forage productivity measurements were carried out in two environments where pastoralists are settling:

1. An intensive arable farming area (Abet).
2. An area reserved by the state for grazing (Kurmin Biri Kachia).

An inventory, and the frequency, of existing flora in the herbaceous cover were compiled by using line transects. A number of transects were read in three distinct ecological niches in each study area.

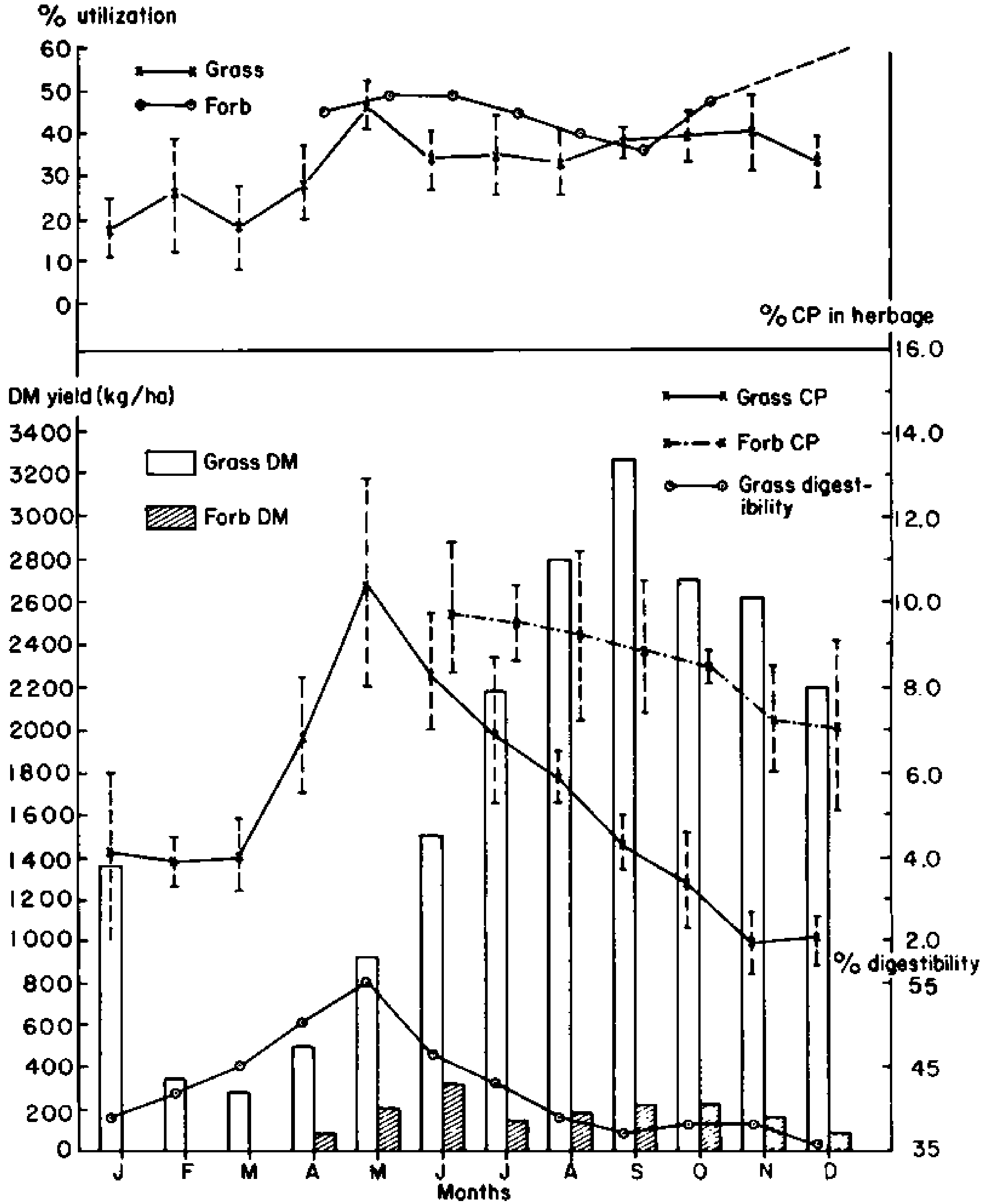
Potential yield of the herbaceous strata of the three ecological subdivisions was estimated from five samples of 1 m^2 each, clipped to ground level at the beginning and end of the rains, within a 5 x 5 m enclosed area protected from livestock throughout the growing season. Monthly forage production and botanical composition were also estimated from 1 m^2 samples, clipped to the ground within similar enclosures as above, but moved randomly after each monthly clipping. Weight difference or DM disappearance between clipped samples from within and outside the enclosures was assumed to have been grazed by livestock during that month. Cut samples, hand-separated into grass and non-grass (forb), were taken, dried and analysed for crude protein (CP) and DM digestibility. Data collected from the three ecological subdivisions were pooled to construct a generalized pattern of forage production in the subhumid zone (Figures 3 and 4).

Figure 3. Generalized productivity and utilization pattern of natural herbage at Kachia Grazing Reserve.



	J	F	M	A	M	J	J	A	S	O	N	D
Grass DM S.D.±	141	33	34	14	64	313	360	125	548	700	264	130
Grass digestibility S.D.±	2.10	3.65	1.90	2.58	0.18	1.82	4.14	8.22	1.30	3.25	2.29	2.28
Forb DM S.D.±	–	-	37	27	98	87	96	197	136	82	107	64

Figure 4. Generalized production and utilization pattern of natural herbage at Abet.



	J	F	M	A	M	J	J	A	S	O	N	D
Grass DM S.D. ±	1026	233	178	170	156	430	796	479	1295	1438	2183	1763
Grass digest S.D. ±	6.8	1.9	4.8	5.7	5.5	4.0	3.4	2.5	3.0	3.9	2.1	0.9
Forb DM S.D. ±	-	-	-	13	68	29	29	70	51	43	44	16

DM productivity

One season of uninterrupted growth of the herbaceous stratum in a burnt area in the subhumid zone produced a DM yield of 2250 kg on shallow, ferruginous soils. Fadama (lowland) soils, with deep hydromorphology, tend to support higher DM productivity - up to 5 tonnes in one growing season (Table 2). On this soil type forage growth is prolonged by residual moisture long after the rains have ceased (Figure 5).

Figure 5. Dry matter production pattern of herbaceous cover in a fadama area at Abet.

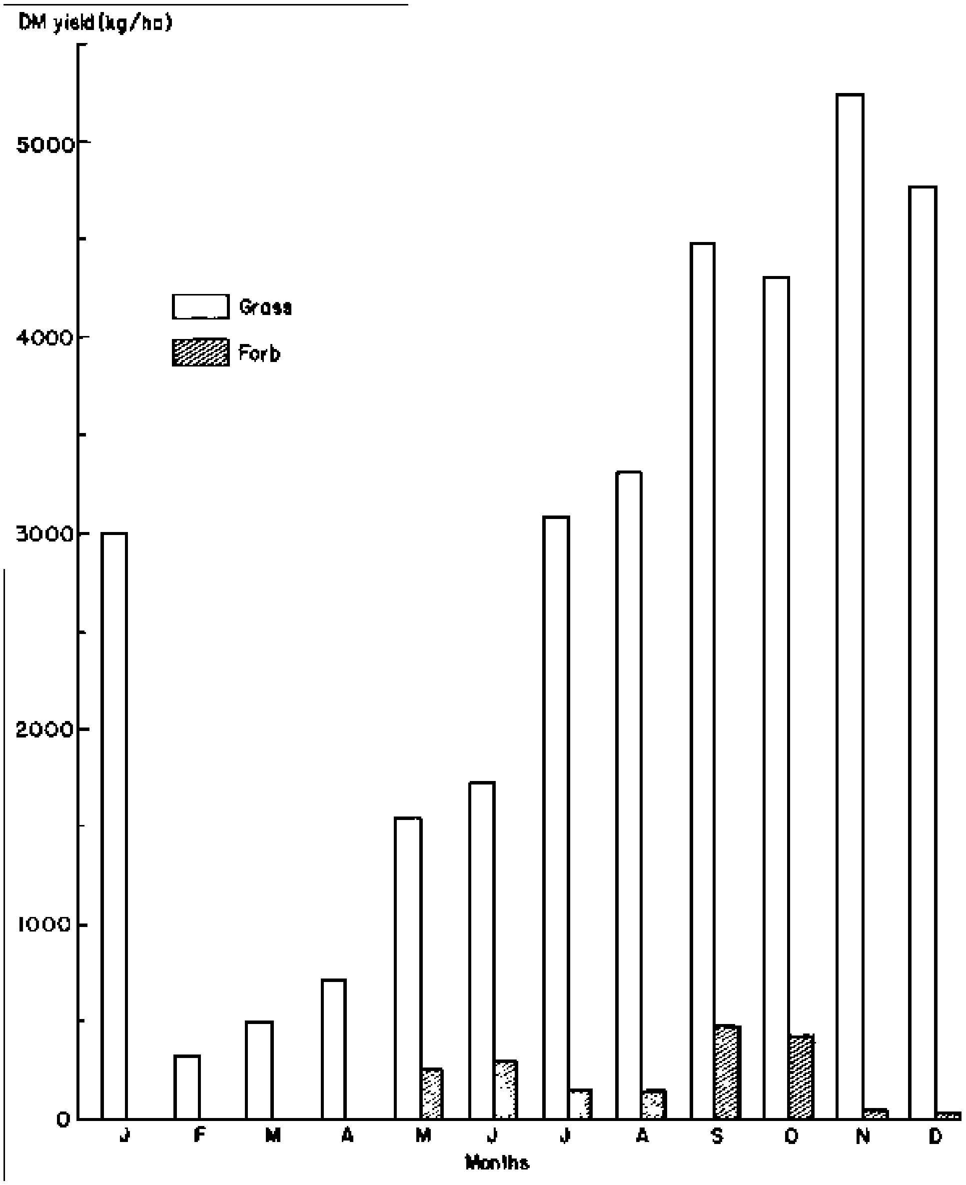


Table 2. One season's DM production (kg/ha)[a/] of the herbaceous layer in different eco-subsystems in two study areas of the subhumid zone of Nigeria.

	Fadama	Woodland	Scrubland	Riverine
Kurmin Biri	3754	1758	2251	2156
Abet	4922	-	2185	1940

[a/] Uninterrupted growth.

Herbage growth and production varies seasonally, and the maximum herbaceous biomass on offer is attained between August-September (Figures 3 and 4). Seasonality of production also affects non-graminoid components, and their proportion in the total biomass is higher at the beginning of the rainy season (Table 3). Non-graminaceous types are insignificant in the herbaceous layer, especially in burnt areas.

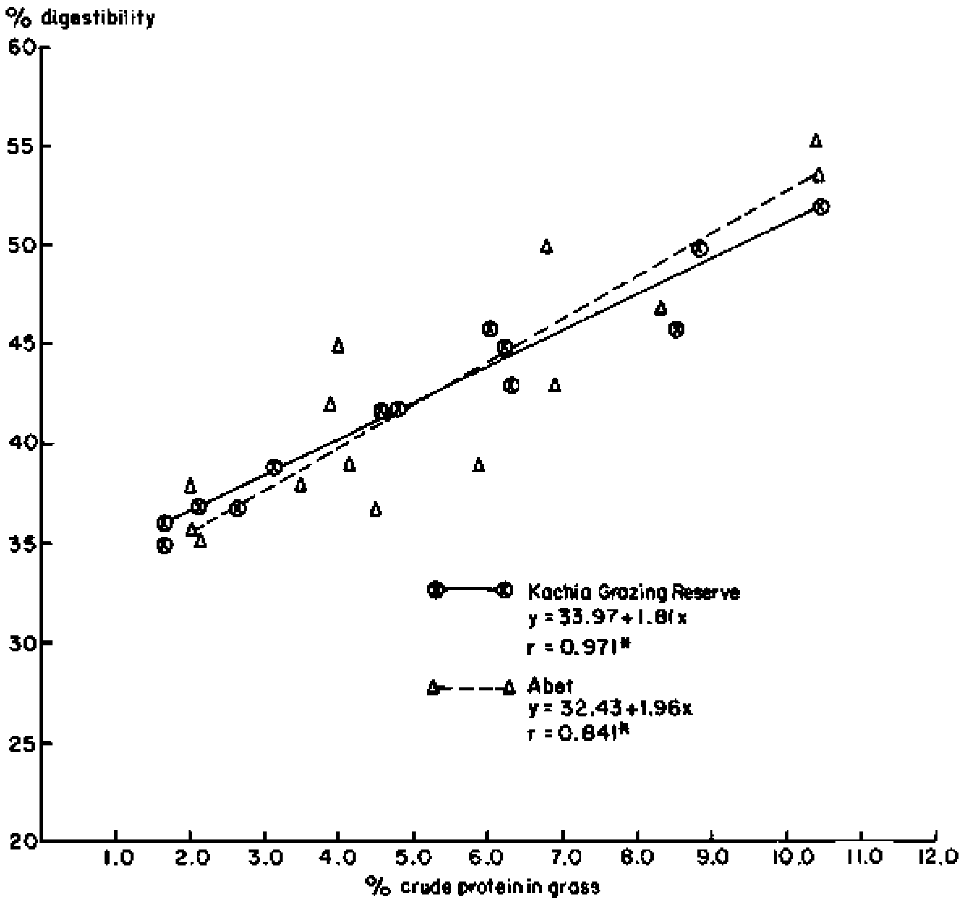
Productivity of the herbaceous cover also varies between years. Herbage produced in the fadama at Abet was about 1 tonne higher in 1981 when the area received 167 mm more rain than the previous year. Both seasonal and species differences contribute to changes in forage quality. During their early development grasses increase in protein content. Where conditions are favourable, the release of soil nitrogen early in the growing season may increase their CP to 9%. But once the rains are over CP content declines rapidly, and since the main bulk of forage on offer is grass, the overall nutritive value of the herbaceous cover in terms of protein is low for most of the year.

Table 3. Botanical composition of the herbaceous layer of two ILCA case study areas in the subhumid zone of Nigeria (kg/ha).

Study area/Months	Grass	Forb	Total	% Forb
Kurmin Biri				
January	612	-	612	-
February	504	-	504	-
March	144	76	220	34
April	288	172	460	37
May	714	206	920	22
June	1573	301	1874	16
July	1799	368	2162	17
August	2298	431	2729	16
September	2380	437	2817	18
October	1980	386	2366	16
November	1200	285	1485	19
December	826	165	991	20
Abet				
January	1382	-	1382	-
February	322	-	322	-
March	290	-	290	-
April	518	93	611	15
May	910	203	1113	18
June	1502	328	1830	18
July	2193	166	2359	7
August	2811	189	3000	6
September	3094	226	3320	7
October	2729	218	2947	7
November	2688	163	2851	6
December	2212	94	2306	4

The digestibility of grass is low throughout the year (Figures 3 and 4). It exceeds 40% for only 4 months during the growing season, when the tissues are tender. Digestibility changes closely follow the level of protein in the tissue (Figure 6). This correlation highlights the importance of increasing protein levels in the forage.

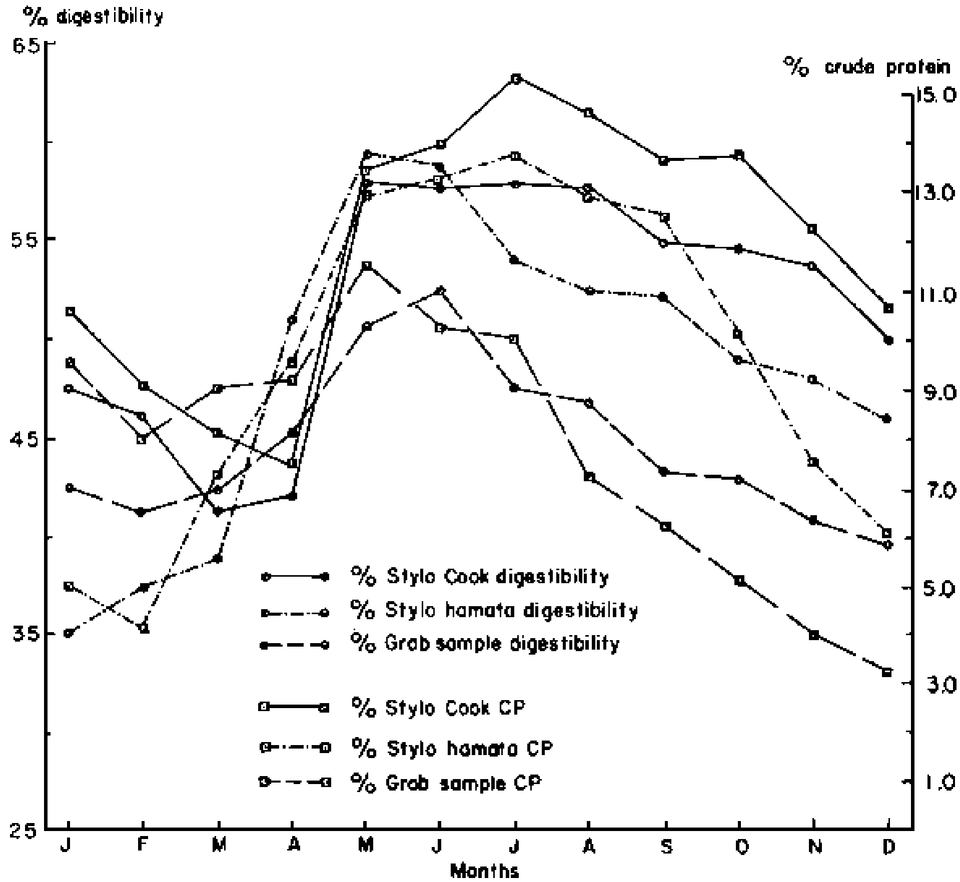
Figure 6. Relationship between herbage crude protein and digestibility of graminoid forms in the herbaceous cover of the Nigerian subhumid zone.



* Significant at P<0.01

Livestock, through selective grazing, tend to consume a better quality diet than average protein and digestibility levels would suggest. Analyses of grab samples collected by following animals showed higher protein content and digestibility throughout the year (Figure 7). The overall quality of forage from a burnt area was also higher. Burning as early as October-November increased the quality of regrown forage, but the bulk left at the end of the growing season was very low in quality and therefore less utilized by livestock, which prefer the new flush of shoots induced by burning (Figures 3 and 4).

Figure 7. Digestibility and crude protein (%) of forage legumes and grab samples at Kurmin Biri.



Indications are that forage utilization in more intensively farmed areas is higher than in other areas, possibly because of the tendency of pastoralists to settle near arable farmers.

Forage composition and availability

The subhumid zone has good ground vegetative cover. Empty spaces in any area account for 8 to 17%, depending on the type of soil, available moisture and the level of land use. Grasses make up about 62 to 82% of the total herbaceous forage. Leguminous species are very low. Other short-growing dicots, associated with grass, make up about 10 to 20% of herbaceous cover (Table 4).

Table 4. Composition of the herbaceous cover of three eco-subsystems of the subhumid zone (%).

	Eco-subsystem		
Plant cover	**Fadama**	**Scrubland**	**Riverine**
Total plant cover	92.1	83.7	83.2
Grass	82.0	64.2	62.3
Legumes	0.7	4.4	1.4
Others	9.4	15.1	19.5

On the basis of percentage frequency, Rattray (1960) used a given grass genus that emerged as the dominating type to designate a particular climatic zone. Accordingly, the subhumid zone of West Africa could be divided into three belts that cross the south-north axis: the Pennisetum, Hyparrhenia and Andropogon belts. These dominant species have given way to others over the years, doubtless as a result of human influence. The graminoid types in both the ILCA study areas are dominated by Loudetia simplex, which is a tufted perennial, suggesting impoverished soil conditions (Table 5).

Table 5. Frequency distribution of the major grasses in the herbaceous cover of the Kachia Grazing Reserve.

Grasses	Occurrence (%)
Andropogon spp.	6.2
Brachiaria spp.	8.3
Digitaria spp.	0.8
Hyparrhenia spp.	11.4
Loudetia spp.	40.7

Panicum spp.	0.8
Paspalum spp.	1.4
Setaria spp.	0.6

Forage constraints and interventions

Cropland

Land cleared and prepared for cropping has an unprotected surface and therefore deteriorates rapidly under the impact of the torrential rains typical of the subhumid zone. Clearing increases surface runoff and leaching of nutrients. Moreover, the temperature of an unprotected soil surface tends to be higher, which encourages more rapid decomposition of organic matter than in a soil with a natural vegetative cover. Soil undergoing degradation at such a rate cannot support continuous cropping unless its lost properties are restored in some way. When such a soil is cropped repeatedly, crop yields decline and the capacity of the land to support human life diminishes with time (Table 6). Experienced farmers are able to predict the time limit for profitable cropping once an area is cleared, which generally ranges from 1 to 3 years unless manure or fertilizer is applied.

Table 6. Productivity of sorghum (kg/ha) when cropped for 3 years continuously with or without manure additions (Kurmin Biri, 1981-1983)[a/].

		Year		
		1981	1982	1983[b/]
Without animal manure				
	Grain yield	858	690	267
	Crop residue	4330	3740	2133
With animal manure				
	Grain yield	-	1352	933
	Crop residue	-	5710	4000

[a/] Each replicate in the trial was divided into two, and 20 to 30 animals were confined for 5 days on one half, prior to land preparation in 1982 and 1983.
[b/] In 1983 there was a very short wet season compared with previous years.

Soil fertility is traditionally restored by fallowing. The length of time the soil is rested after cropping is generally a function of population pressure. Where population is low, rest periods between cultivated phases may be prolonged, resulting in a low cropping index. In this system a farmer has to clear a new area for cultivation each time he abandons the old one. Soil restoration is left to take a natural but prolonged course with no inputs from the farmer. Areas with a low cropping index can provide reasonably well regenerated land whenever this is required by farmers,

Higher population levels make prolonged fallow periods less feasible. Farmers are obliged to return to a previously cropped area much sooner. Incomplete recovery then has to be compensated by additional inputs to make the soil productive. The return of ash, household sweepings, night soil and, of course, fertilizers to the land are some of the measures used.

For the farmers in parts of Nigeria's subhumid zone, access to manure plays a very significant role in the maintenance of soil fertility with or without short rest periods. Manure allows intensive cropping and hence higher human support capacity per unit area of land. Crop and livestock production are commonly carried out by ethnically separate communities, although mixed farming is increasing in Nigeria. Fulani pastoralists prefer to settle in the vicinity of cereal farmers, who thus have access to manure even if they do not own livestock themselves. Animals can also be used for traction and transport, besides being a source of much needed protein.

For all the contributions of livestock, the crop sector at the moment tends to offer only crop residues and unimproved fallows in return. Although valuable to livestock early in the dry season (Paper 14), crop residues alone are inadequate to meet the nutritional demands of animals.

Growing cereal crops and forage legumes in a mixture is a recent concept in African agriculture. Both components in the mixture require a different production emphasis (grain from cereals and hence emphasis on the reproductive phase, but herbage from legumes, and hence emphasis on the vegetative stage). The agronomic requirements of a cereal/forage crop mixture differ from those of other conventional crop mixtures.

Research carried out by ILCA in the past 3 years indicates that forage legumes can be incorporated into existing cropping systems by simple adjustments of sowing time, plant densities or planting sequences. These adjustments improve the nutritive value of crop residues and hence the economic returns per unit area of land.

Mixed cropping is the basic farming practice in the subhumid zone of Nigeria. Sorghum is the principal crop and predominates in the different crop mixtures. Most commonly, it is intercropped with soybean and/or maize, but various other crops, such as groundnut, cowpea, millet, and okra, also feature.

Farmers' reasons for growing a mixture of crops are to minimize risk, spread labour inputs, and reduce disease problems (Evans, 1960; Norman, 1974). These advantages outweigh the benefits of sole cropping, and mixed cropping will doubtlessly remain the standard practice in the subhumid zone for the foreseeable future. Yield advantages in mixed as compared to sole cropping are also common when the component crops complement each other. This happens when their growth patterns differ in time, so that each crop makes its major demands on resources at different times (Wiley, 1979). It will be possible to incorporate forage legumes into crop mixtures only if appropriate adjustments can be made to cropping patterns. These adjustments should not be too far removed from the existing practices if they are to be adopted easily by the farmers.

Rangeland

Natural forage provides the cheapest source of nutrients for ruminants, but the land on which it grows does not often have a high capacity for biomass production. The deflected or disclimax vegetations typical of such land are also likely to increase with the spread of human activity into areas which are as yet underutilized. These areas will not revert back to climax floral associations whilst under continued pressure from man and stock.

Livestock grazing natural rangeland derive most of their feed from grasses, with browse becoming increasingly important (but never dominant) as the dry season progresses.

High costs and the communal ownership of rangeland preclude large-scale pasture development in Nigeria's subhumid zone. Unrestricted access and widespread burning have so far frustrated conventional range management strategies. Small units of sown forage might nevertheless be respected on private property just as cereal crops are. The Fulani in the ILCA case study areas have traditionally sown fonio (Digitaria exilis) on areas grazed and trodden by cattle. This technique can be adapted to provide the labour required for legume establishment. Small units are probably a safer investment than large ones, owing to the risk of fire.

Conclusions

The land and ecology of subhumid Nigeria are not as hospitable to change as may at first appear. The soil presents difficulties because of its structure, high water table, poor drainage, low fertility, high surface temperatures and fragility. The rainfall is adequate in total quantity but likely to be erratic in the critical early growing season and overabundant at other times, leading to soil erosion and plant disease.

The zone is not highly cultivated but the distribution of cultivation is uneven, tending to be high in the north and south. Mixed crap-livestock systems are expanding.

There are opportunities for introducing forage legumes, but these must be considered in conjunction with existing cropping systems.

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