THE CENTRAL WESTERN SUDAN

AND ITS VEGETATION.

With Supplementary Papers on

Forestry Research in Northern Nigeria

and

The Identification and Examination

of Forest Types

From Aerial Photographs.

by

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For D. Sc.

PREFACE

Increased interest in the wise use of land has focussed attention in recent years on the study of the vegetation of the Western Sudan and the question of progressive desiccation and accelerated soil erosion in Northern Nigeria and in French West Africa has received serious investigation. It is now appreciated that soil deterioration has occurred over large areas of arable land which has been unwisely over-exploited and that accelerated soil erosion does not occur to any extent, (although there is normal soil erosion), in the southern portion of the French Niger Colony and in Northern Nigeria; this is largely because the region is for the most part, an undulating if somewhat elevated plain.

The writer was engaged on the investigation of possible desiccation in the Kano and Katsina Provinces and part of Bornu Province in Northern Nigeria and also travelled extensively in Sokoto Province. He has been fortunate in spending several years of service in Northern Nigeria and in having been able to carry out a number of vegetational surveys throughout French West Africa; these included journeys in 1933 from Gao across the Sahara to North Africa, in 1935 from Lagos via Niamey to Dakar, in 1939 from Katsina to Agades and the Bagzan Mountains, in 1943 to the Matamaye area and in January of 1944 from Kano to Zinder and Maradi. The writing of this paper was interrupted for three years during the period of hostilities; the interruption was fortunate, for the writer was able to obtain a wider knowledge of French West Africa with over/

over two years of constant study of it in connexion with his Military duties. French Niger Colony was visited during that period at a number of points on the frontier.

The journeys in French West Africa were made specific-:ally to study the vegetation and ecology of the area, of which so much is yet to be learned, so that it might be compared with the vegetation, the land-utilization and the ecology of Northern Nigeria with its much denser population. The vegetation was plotted continuously on the journeys to Agades and Birnin Konni and to Zinder and Maradi: These with the Gao and Dakar journeys form the basis of the vegetational classification included in this paper. A number of aerial photographs which were taken over Northern Nigeria and Niger Colony are included so as better to illustrate the vegetation types; ground photographs of some of the actual points recorded in the aerial photographs were taken afterwards by the writer for the purpose of comparison.

Two supplementary papers are included in the thesis, one on the identification and examination of forest types from aerial photographs, the second on silvicultural and ecological research from which definite data have been obtained.

The author gratefully acknowledges his indebtedness to Professor E.P. Stebbing, M.A., F.L.S., F.R.G.S., F.R.S.E., for advice in connexion with the problems and controversies on the Sahara Desert and the Western Sudan. He is grateful to Mr. J.L.S. Smith, M.C., M.A., B.Sc., of the University of Edinburgh, and to Mr. Orr of the Royal Botanic Gardens, Edinburgh for helpful discussions regarding the vegetational classification; to Mr. A.H.W. Weir, B.Sc., F.R.G.S., for kindly assistance over a long number of years; to Professor H.G. Champion, C.I.E., M.A., and Mr. A.C. Hoyle, M.A., of the Imperial Forestry Institute, Oxford, for their willing help, criticism and advice; to Mr. F.S. Collier, M.A., of the Nigerian Forest Service for useful discussions/

discussions and arguments; and finally to African Forest Assistants Mohamadu Adelodun and Musa Daggash, and to Forester Musa Sara, for their untiring co-operation in the field.

It should be noted that when examining aerial photographs they should be turned so that the shadows fall on the opposite side to the actual source of light; this gives a better indication of the relief on the ground. The aerial photographs in this paper have been mounted on the assumption that the source of light is from the top of each page. The use of a magnifying glass is recommended.

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[I.W.G. CAMERON].

A WELL AT ADERBISSINAT.

THE CENTRAL WESTERN SUDAN AND ITS VEGETATION.

INTRODUCTION

The science of ecology is now beginning to receive the appreciation and attention it deserves, and while it is a subject of great interest and widespread importance in land utilization in temperate regions, ecological research is now recognised as being of vital consequence in tropical regions, where advancing civilization and science have rapidly been introduced in recent years. Tansley has written: "A know:ledge of what nature produces when she is left to herself is one of the indispensable requisites for wise exploitation". Nowhere is this more true than in tropical Africa. It is in fact, obvious, although it is not generally appreciated, that progress in Africa and in other tropical countries is dependent upon the wise utilization of the land, just as it is in diverse ways, but perhaps in less striking fashion, in the temperate regions.

The advent of man in ever-increasing numbers and work:ing with ever-increasing intensity has upset the balance of nature over a large part of the earth's surface. Man has revol:utionized energy and production in recent decades, only too often with the unwise exploitation of nature herself who has reacted in some cases seemingly in a spirit of revenge. Thus while man has accelerated production from the soil he has done so frequently at the cost of its natural fertility, for although this may be retained or inflated artifically, the gain can generally/

generally only be temporary. Soil fertility in the tropics may be maintained or improved by artificial methods, but it is more likely eventually to be regained by nature insisting upon her period of rest and allowing the natural vegetation again to reproduce the normal soil fertility.

In recent times very great damage has been done to the soil at the hands of man in his endeavour, in a multitude of ways, to obtain wealth from the land as quickly as possible by crop production, cattle raising, the surface mining of metals and other products, the digging of oil-shafts and a host of other enterprises. Most damage has probably been done in the rapid and unwise exploitation of the soil for crop-production of all kinds whether for luxuries or necessities for peoples throughout the world. This is proved by the fact that recent accelerated soil erosion is found throughout the five continents in the temperate and tropical regions alike and it is perhaps only in Scandinavia, as Jacks and Whyte (1) have pointed out, that there is little or no soil erosion. Even a young country like New Zealand is alert to the danger of accelerated soil erosion.

A correct appreciation of the use of the land can be determined by the study of the ecology of the area, although science in many of its branches should be brought into the field and set the task of guiding the policy of wise land utilization in the tropics and especially in the Colonies in which economic welfare and development is about to play such an important part.

Vegetational/

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(1) The Rape of the Earth. A World Survey of Soil Erosion. G.V. Jacks and R.O. Whyte.

Vegetational growth in tropical countries is often accelerated when the combined conditions of heat, moisture and richness of soil obtain, but in many areas excessive exploitation of the soil has resulted in its debility and even exhaustion. A period of rest may often allow Nature to regain the former soil fertility and this is appreciated by the shifting cultivator and the rotational-fallow farmers. Tragedy appears when the soil is severely or wholly denuded of its natural vegetation and is carried away in the process which is now recognised as accelerated soil erosion.

Examples of the destruction of the fertility of the soil and of accelerated soil erosion are only too common and we have only to think of the tragedies of the Middle West of America, the floods of the Mississippi, the accelerated soil erosion in Europe, Africa, India and even the Antipodes to realize how much correct land utilization has become a world problem. The proper appreciation of the vegetation, the soil and its correct use and the ecology, in its widest sense, of any area, therefore, are amongst the main issues in the policy of any sound Colonial Administration. Fortunately this is realized more fully to-day than in the recent past, and should lead to a wise policy of rural economy and social welfare.

The results obtained in the examination of the vegetation, land utilization and rural economy and the results obtained from personal ecological research has enabled the writer to prepare the following paper on the Central Western Sudan.


AFRICA
SHOWING THE AREA UNDER REVIEW.
Natural Scale 1:35,480,000
Miles
Railways
Orthographic Projection.
Reference to Colours.
British
French
Portuguese
Spanish
Italian
MEDITERRANEAN SEA
ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
ARABIAN SEA
Gulf of Guinea
Tropic of Cancer
Equator
WESTERN SUDAN
FRENCH WEST AFRICA
SAHARA
LIBYA
EGYPT
SUDAN
ABYSSINIA
KENYA
UGANDA
TANGANYIKA TERRITORY
BELGIAN CONGO
ANGOLA
NIGERIA
LIBERIA
GOLD COAST
IVORY COAST
FRENCH GUINEA
MAURITANIA
ALGERIA
TUNISIA
ARABIA
PERSIA
AFGHANISTAN
INDIA
ASIA MINOR

CHAPTER 1

GENERAL HISTORY OF RECENT INVESTIGATIONS.

The occurrence of sand-dune formations in Nigeria was first recorded in recent years in the Nigerian Forestry Annual Report for 1916, wherein their possible afforestration was suggested.

The disturbance of the light sandy surface soil in the 'tornado' seasons in Sokoto Province of Nigeria was mentioned some years later and the question of desiccation and desert encroachment was introduced by the late Emir of Katsina at the meeting of the Advisory Council of Emirs in 1930. The subject of possible desiccation, desert encroachment and loss of soil fertility was examined in Katsina by Mr. F.T. Brand of the Nigerian Forest Department between 1932 and 1935.

Real stimulus was applied to the subject of possible desiccation in Northern Nigeria and the adjacent Niger colony of French West Africa, with a visit to that area by Professor Stebbing, of the Chair of Forestry at Edinburgh University, after co-operation in Paris with the French Department Des Eaux et Forêts, and the results of his visit in 1934, have been described in his Forests of West Africa and the Sahara. Professor Stebbing has also written a series of scientific papers (1) in this connexion.

Thereafter a number of articles were written on the/

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(1) The Encroaching Sahara: The Threat to the West African Colonies. Geog. Journal, June 1935.
The Threat of the Sahara. Journal of the Royal African Society, May 1937.
The Man-made Desert in Africa, Erosion and Drought, Journal of the Royal African Society, Jan. 1938.
Africa and its Intermittent Rainfall. Journal of the Royal African Society, 1938.

the subject of possible desiccation and at the same time a great deal of interest was aroused and literature produced in connexion with accelerated soil erosion and soil conservation

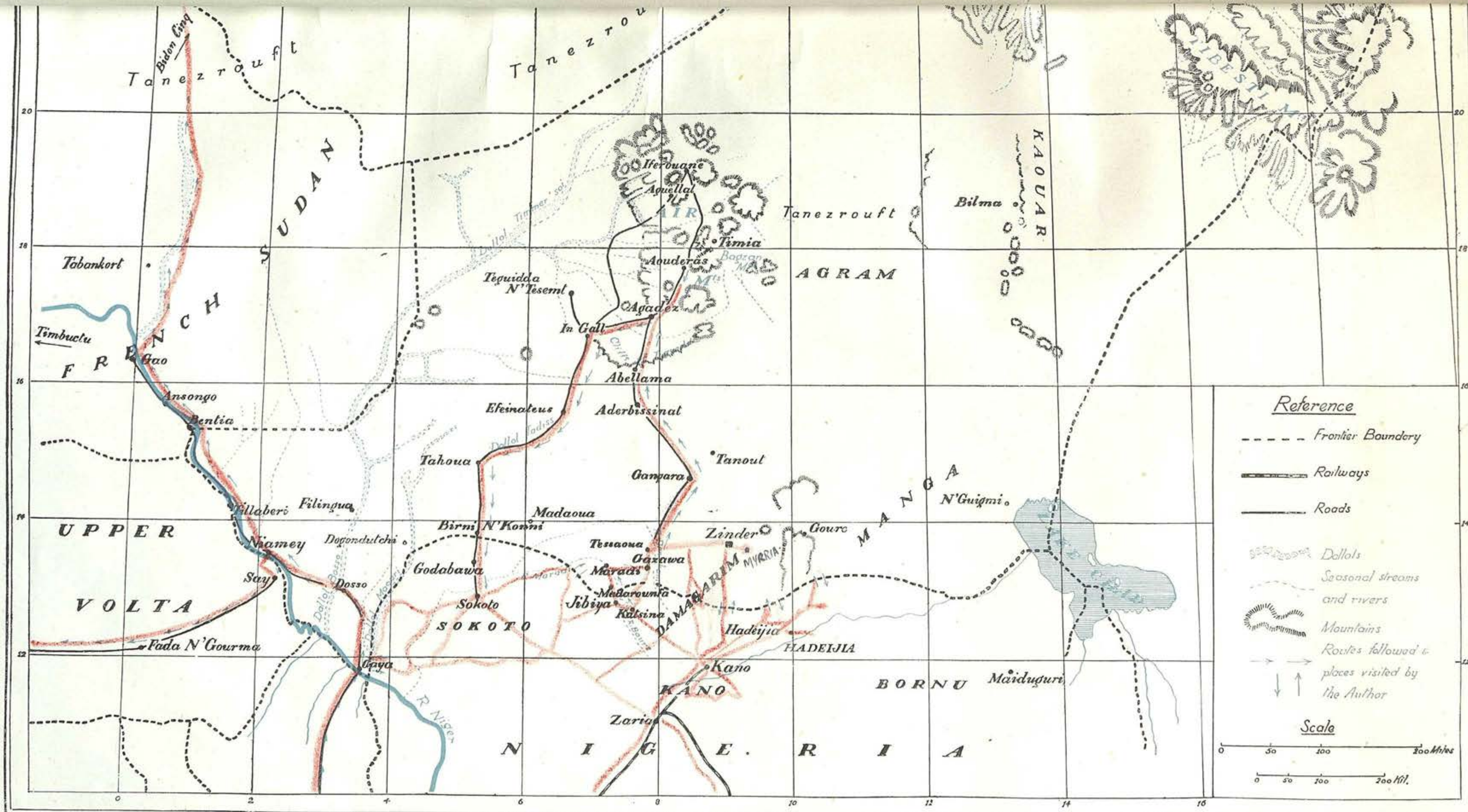
In 1935 M. Aubréville, Inspecteur Principal des Eaux et Forêts of the Ivory coast, visited Nigeria and discussed the question of forest policy in the French Niger Colony and forestry in Nigeria; a report (1) was published in due course.

In 1936 it was decided that an Anglo-French Forestry Commission should be formed to examine the question of desicca:tion within the Northern Emirates of Nigeria and in the neigh:bouring French Niger Colony. The Commission consisted of a Senior Resident of the Administrative Service, two forest officers and one geological officer from Nigeria, one French forest officer and two administrative officers from French West Africa. It examined the question of desiccation, soil deterioration, vegetational retrogression, sand movement and encroachment, water availability and a number of relevant factors in the area between Niamey on the River Niger and Lake Chad.

A report (2) on that Commission was published in 1937; a separate forestry report (3) was written by Mr. F.S. Collier and a paper (4) was written by the same author in co-operation with Mr. J. Dundas, (Nigerian Forest Service), who was also on that Commission and who also wrote a paper (5) on the vegetation of Niger Colony; the late Mr. Brynmor Jones who was the geological officer, also contributed a scientific article (6) on the results of his observations.

In/

1. The Niger Colony, Forestry Expedition, September to December 1935. Aubréville.
2. Nigerian Sessional Paper No. 37 of 1937. Report on the Anglo-French Forestry Commission 1936-37.
3. Report on Conditions in Northern Nigeria and the Niger Colony. F;S. Collier.
4. The Arid Regions of Northern Nigeria and the Niger Colony. F.S. Collier, J. Dundas. Empire Forestry Journal Volume 16 No. 2. 1937.
5. Vegetation Types of the Colonie Du Niger. J.Dundas. Imperial Forestry Institute Paper No. 15.
6. Desiccation in the West African Colonies. Brynmor Jones. Royal Geographical Journal, May, 1938.



ROUTES FOLLOWED AND PLACES VISITED BY THE AUTHOR.

Routes followed.

Places visited.

8A.

In 1936 it had been decided that two desiccation investigations, consisting of two forest officers each, should be made in Sokoto, in Katsina and Kano and later in Bornu Provinces; the first was begun in that year in Sokoto. In mid-1937 it was decided the second party should be formed to examine Katsina and Kano Provinces; the writer had the privilege of leading this investigation and the area north of latitude 12° 30' was examined. The findings of this investigation were published in departmental reports in 1938[1] and in 1940.[2] The investigation included a vegetational survey, a study of plant ecology, the collecting of extensive data on ecological succession, soil deterioration, land utilization and soil conservation, and the choosing of areas for reservation. It may be of interest to record that sixty six reserves covering an area of 393 square miles were proposed by 1940 in Kano and Katsina Provinces and in April of 1944 only nine remained to be legally gazetted, although they had been agreed to and signed by the Emir concerned.

As a result of these investigations in Northern Nigeria and Southern French Niger Colony it was decided that while there was no sand encroachment or desiccation that there was evidence of serious vegetational and soil deterioration and that a wise policy of land utilization which must include forest reservation, should be followed. As far as it has been possible to do so that policy has been followed. The writer, as a result of his investigations in Northern Nigeria/

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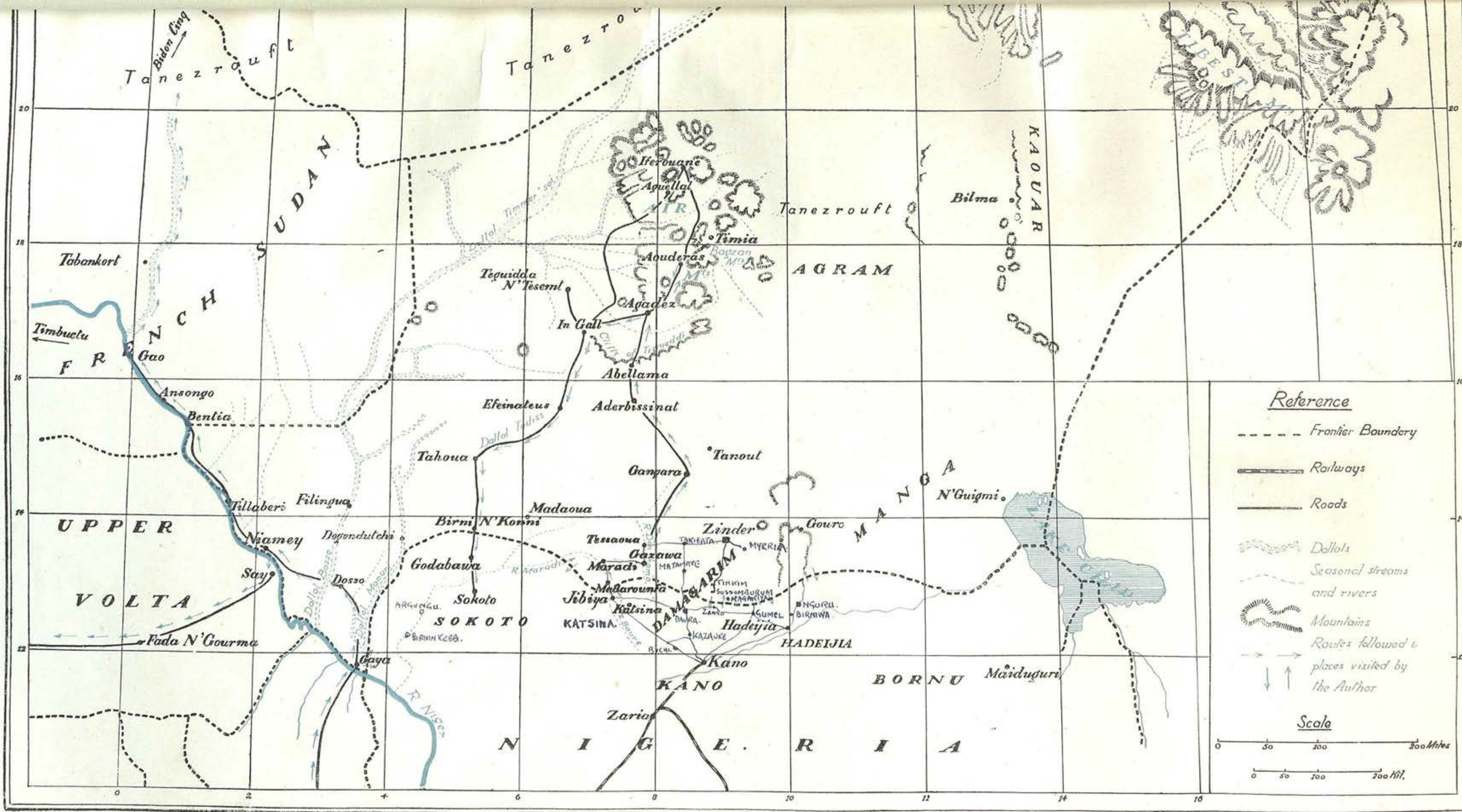
1. The Vegetation and Land use in Katsina Province. Part I. W.A. Fairbairn. (1938)

2. The Vegetation and Land use in Katsina Province. Part II. W.A. Fairbairn. (1940)



MAP OF PLACE NAMES.

9A.

Nigeria and journeys in French Niger Colony published two[(1)] Imperial Forestry Institute Papers, on Ecological Succession in Kano and Katsina Provinces in 1939 and on the Classification and Description of Vegetation Types in French Niger Colony in 1943.

A more general description of the history of the Central Western Sudan and of the scientific investigations and records therein may now be of interest. The area under review includes from the latitude of Kano on the south to north of Agades and from the region of Gao near the Niger bend to east of Kano.

The present vegetation of the Central Western Sudan is a result of the history of its peoples. Heavily populated in the last three hundred years, the natural vegetation has been vastly altered from its natural form and, in Nigeria, comparatively few areas have been left untouched.

Northern Nigeria, Dahomey and Niger Colony have been influenced by the sway of power of the various ruling communities and their wars and resulting conquests have materially affected the utilization of the land. The Songhai from the Gao region, the Sokoto and the Bornu factions all ruled after fierce wars at various times, and these events contributed to the resulting vegetation at the beginning of this century. With the advent of British and French Administration peace was brought to the area, the population increased rapidly, farming became more widespread and intensive and a fraction only of the former climax vegetation now remains in the populated regions. Formerly, waterless areas prevented settlement and destruction of the vegetation and the fear of local/

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1. Ecological Succession due to Biotic Factors in Northern Kano and Katsina Provinces of Northern Nigeria. Im-:perial Forestry Institute Paper No. 22, 1939.
Classification and Description of the Vegetation Types of the Niger Colony, French West Africa. Imperial Forestry Institute Paper No. 23, 1943.

local raids and larger attacks by invaders stopped anything but restricted farming relatively close to the centre of defence. Man was in the area in pre-historic times, but our knowledge of the area goes back approximately to the 11th Century. Written records on Kano go back for some six centuries; unfortunately written records of the Songhai were destroyed at Timbuctu and at Katsina at sackings of these centres of learning.

Leo Africanus visited the Western Sudan in the 15th Century and mentioned (1) the flourishing garden centre of Kano but his visit to Kano itself is doubtful; he made no mention of Katsina and the translation by John Pory gives little guide to the vegetation of the area at that time.

Mungo Park (2) with his two journeys to West Africa gave an indication of the conditions at the beginning of the 19th Century, but he was largely limited to the vicinity of the River Niger whose immediate vegetation differs from that of the surrounding country. He described some of the farming activities of the peoples and also some of the more important economic tree species.

Our first true picture of the vegetation of the Western Sudan is given by that untiring and meticulous observer Dr. Barth, who between 1850 and 1855 covered very large areas in the course of his travels. (3)

He/

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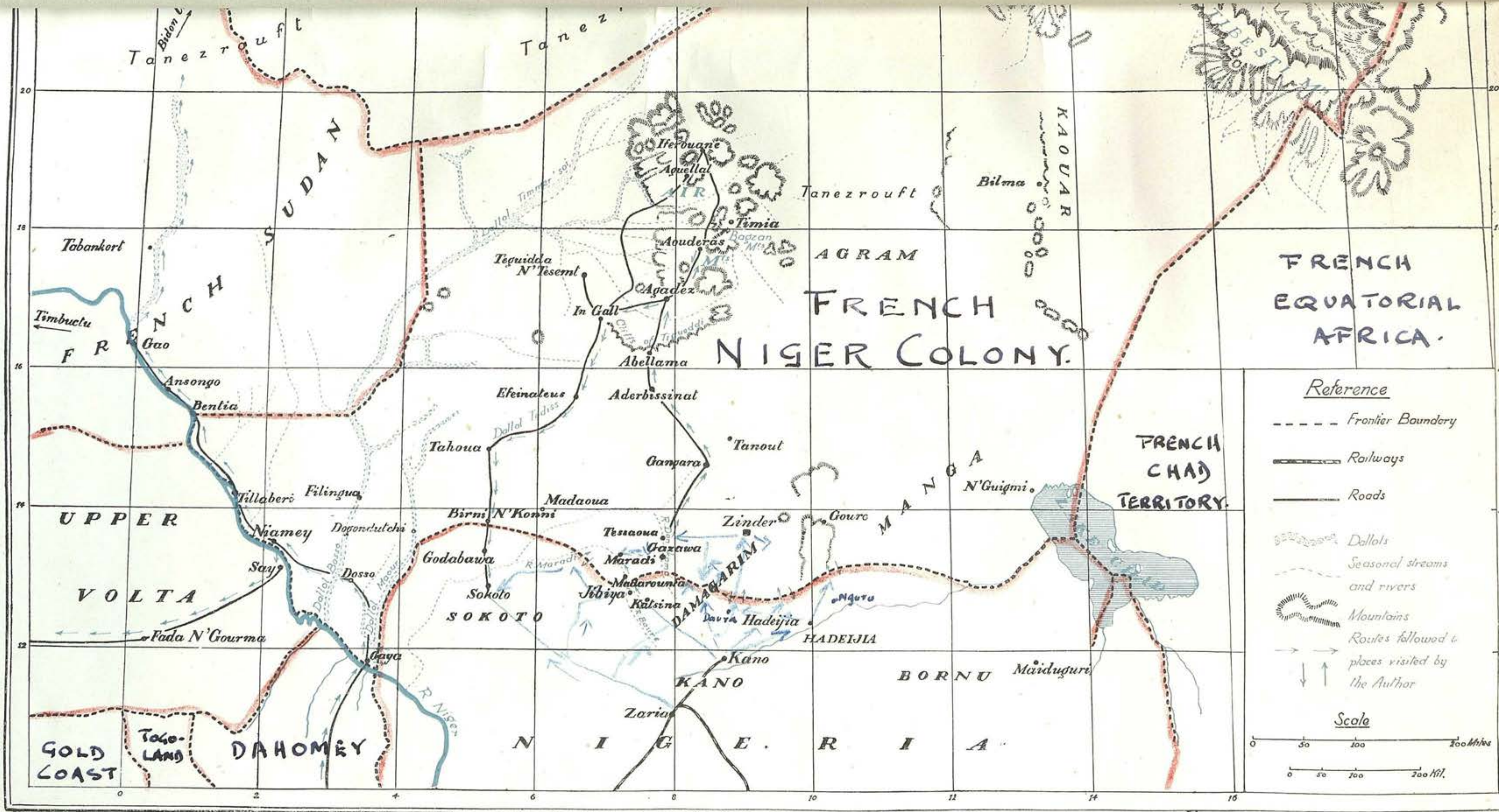
1. A Geographical History of Africa (translated by John Pory), London, 1600. Leo, John (Africanus)

2. Travels in Africa
Travels in the Interior Districts of Africa } Mungo Park.

3. Travels in Central Africa. Travels in North and Central Africa, Vols. 1 to 5 (1857) London, 1857-8.



POLITICAL MAP.

II A.

He visited, amongst other places, Timbuctu, Agades, Sokoto, Katsina, Kano and Dikwa; he recorded, in very great detail, observations on his marches, on the people, their mode of life, their history and their laws and gave general but useful descriptions of the vegetation. It is obvious from his records that there were greater areas of forest and closed woodland in the Western Sudan than there is to-day, and from his descriptions of the vegetation and the farming methods round the larger towns we are able to recognise that vegetational retrogression has occurred in specific areas in the last ninety years.

The Frenchman M. Abadie produced an able volume (1) in which he describes the area, the people, land utilization and the vegetation in Niger Colony in recent years.

In 1934, as already recorded, Professor Stebbing visited West Africa and carried out a wide survey of the forest conditions in British and French West Africa, returning to Europe by the Saharan route. The discussions which followed led the Nigerian Government seriously to consider the problem of land protection in Northern Nigeria and as already mentioned one international and two Nigerian desiccation investigations followed. These activities, the resulting scientific papers and the action taken by the two Governments might not, in the writer's opinion, have taken place but for Professor Stebbing's visit and there is no doubt that he emphasized the problem of land utilization in the dangerous areas of Northern Nigera and the Niger Colony to the two Governments and thereby rendered invaluable service.

The Flora of West Tropical Africa by Hutchinson and Dalziel/

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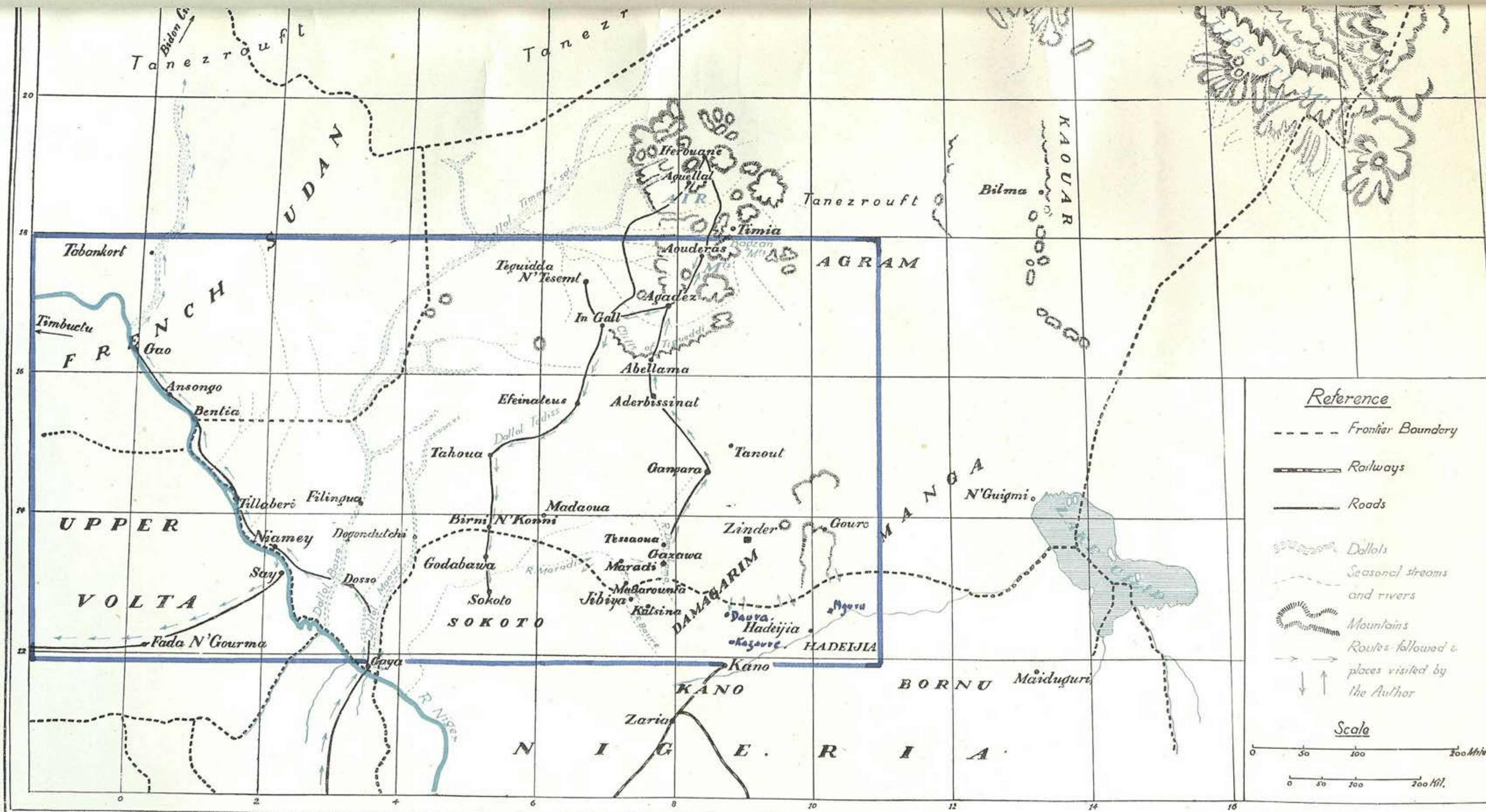
1. La Colonie du Niger. Paris 1927. M. Abadie.

Dalziel and The Useful Plants of West Tropical Africa by Dr. J.M. Dalziel, very materially helped in the study of West African vegetation. A valuable contribution to the literature on Africa was provided by Lord Hailey's "An African Survey", which was produced in 1938.

It will therefore be seen that much interest and activity has been shown in the study of the vegetation and general conditions in West Africa in the last decade. There remained the rôle of the departmental officers, especially the forest officers, intensively to investigate and study the conditions, after extensive reconnaissance in the field, so that a wise policy of land utilization can be formed with a view to improving the social welfare and economic development of the people.

An intensive study of the ecology and vegetation of the Central Western Sudan has enabled the writer to produce the present paper which he hopes may be of some value in connexion with the formation of a wise land policy.



The Central Western Sudan.

Indicating the Region under Review.

CHAPTER 2

SITUATION, AREA AND PHYSIOGRAPHY, AND HYDROGRAPHY.

SITUATION

The portion of the Central Western Sudan under re:view in the present paper includes from longitude 2° West to 11° East and from latitude 12° North to 18° North, approximately from the longitude of Ouagadougou on the west to that of Nguru, in Nigeria on the east, and from the latitude of Kano on the south to that of Iferouane in the north.

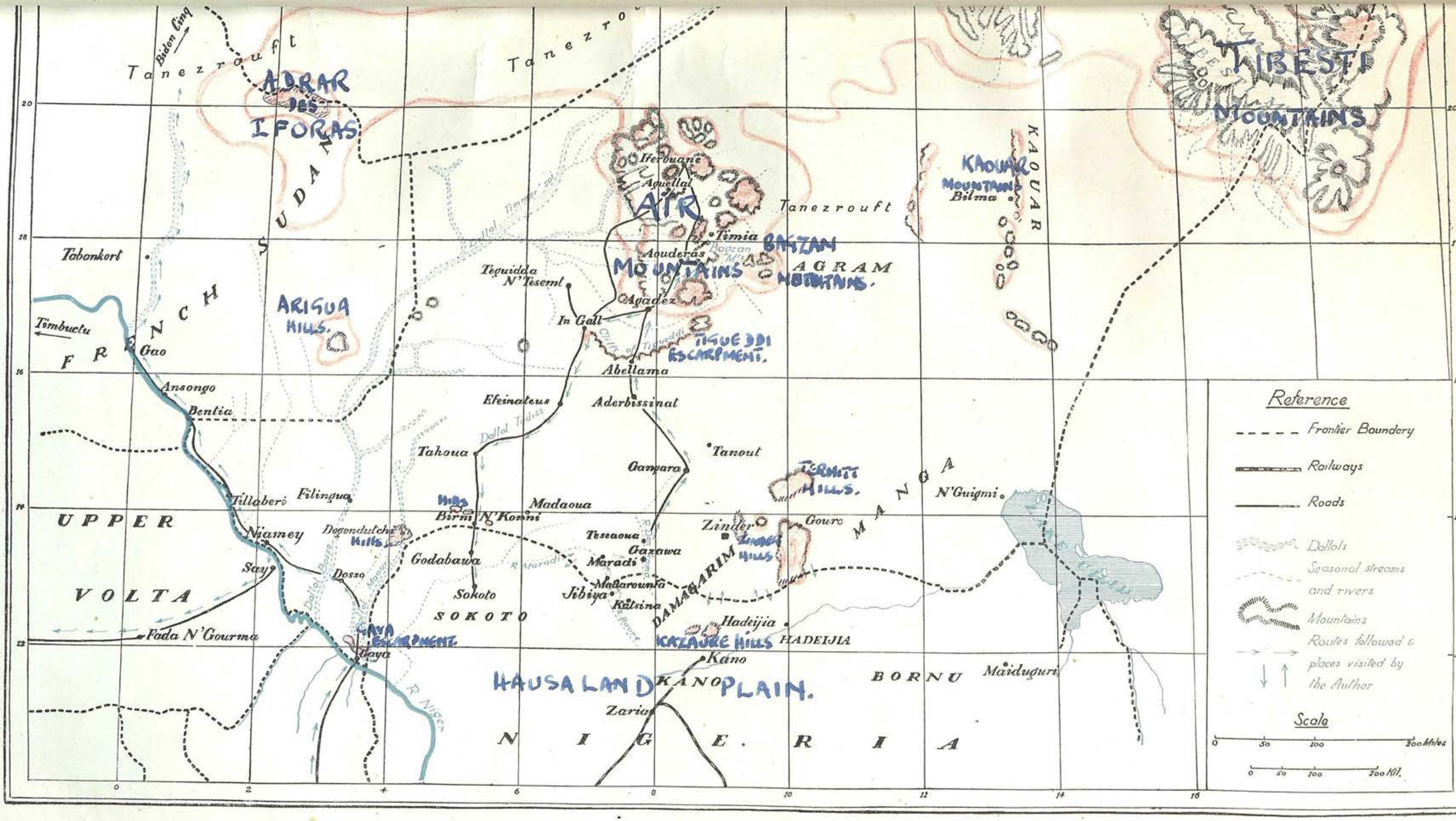
AREA

The area included in this paper is approximately 320,000 square miles which the author makes no claim to have covered, but a large number of representative portions and the more important areas have been visited. The general map shows the routes covered and the points visited by the writer.

PHYSIOGRAPHY

In an area covering over 300,000 square miles the configuration is bound to be somewhat diverse although part of it lies within the Sahara Desert which popular opinion is still inclined to consider as a large flat sandy waste.
In actual fact the region is divided into river and ancient river valleys by far the greater number of which drain towards the River Niger. Only a few rivers, the catchment areas of which are relatively small, do not supply the Niger, but flow in the south-east portion of the area, towards Lake Chad.

There/



PHYSIOGRAPHICAL MAP.

14A

There are two main mountain regions only, that of the Adrar des Iforhas north-east of Tabankort and just appearing in the area described, and the southern portion of the Aïr Mountains near Agades. Both are outstanding in an area of upland plain and they have, with the River Niger, a decided influence over the climate, the vegetation and the peoples. The western desert route, over which the writer travelled, from Gao to Oran, passes close to the foothills of the Adrar des Iforas and the writer regrets he was unable to examine the area, for comparison with the Bagzan Mountains of the Aïr massif.

There is also a relatively small mountain range approximately 150 miles to the east of Gao. This is the Arigua range and is interesting in that it divides the Niger 'dàllols' running from the north-west, from the Adrar des Iforhas range, and those from the Hoggar Massif and the Aïr Mountains to the north-east.

By far the most striking area in the region is the Aïr Mountains, the southern foothills of the Hoggar Massif of the Central Sahara. The two areas are joined, but for all practical purposes the Aïr area is a massif in itself. The writer visited the southern portion of the Bagzan Mountains from Agades. They are interesting geologic-:ally and are important from the vegetational point of view for they exhibit by no means total desert conditions, and have a vegetation which is interesting floristically and which deserves careful examination. The Bagzan Mountains rise to some 5,000 feet and make a striking change in the desert area. One of the most interesting areas in the Agades region is the plain between the Cliffs of/

of Tigueddi and Agades; this represents the bed of a sea of Quaternary times and the present day escarpments repres:ents the cliffs of the former sea which occupied that area. They are about one hundred feet high and are most important in that they represent, at this point, the southern boundary of the desert. This area which now supports scattered thorn-scrub once carried tree vegetation of some size and fossilized pieces of tree trunk about one foot in diameter can still be found on and near the cliffs.

There is a small range of hills running north and south to the east of Zinder, and they are also of geological interest. The huge granite outcrops which form large hills in the southern area are important features of the region; they are granitic and form the oldest rock in Africa. The outcrops rise in places to two and three hundred feet above the plain and they too affect the soil and the vegetation. They are found principally in the south-central area from Dogon Dutsi,(the Hausa words for tall hill) in the west, through the Birnin Konni and Katsina areas to Zinder on the east. They are subjected to disintegration by weather:ing and exfoliation occurs fairly rapidly. They produce a good soil so that they are by no means unimportant. These granitic masses emerge from the level of the plain, either by having been elevated or uncovered by erosion.

Flat-topped lateritic-rock covered plateaux are also a feature of the south-central area and they occur from the Niger between Tillaberi and Gaya, eastwards through Tahoua, Sokoto, Katsina and Kano in Nigeria eastwards to the region north of Nguru in French territory. They are frequently found in close proximity and their common altitude indicates a former plain level.

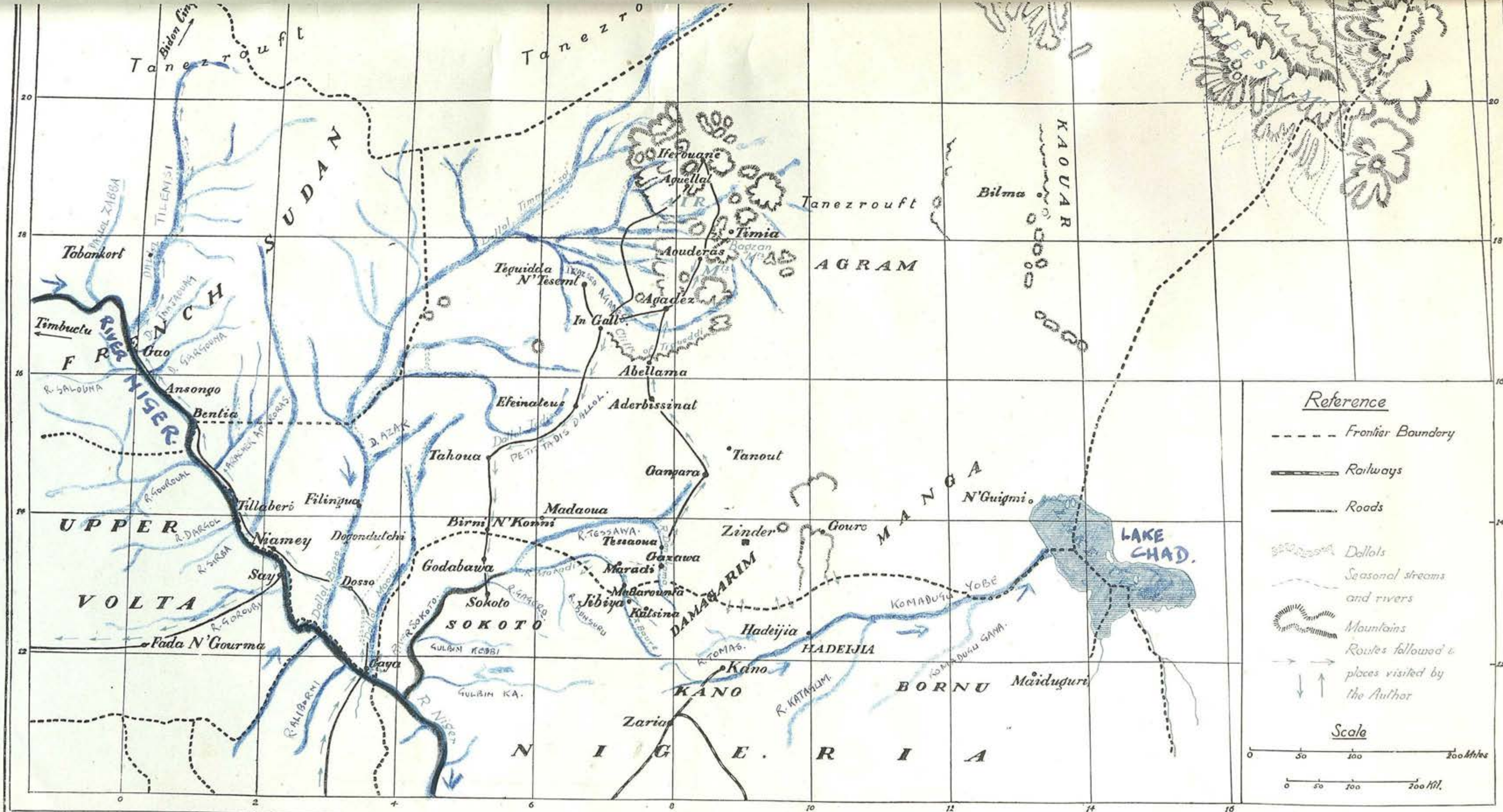
On/

On the southern boundary occurs the plain which is a continuation of the Hausaland tableland of Northern Nigeria; this is a gently undulating elevated plain with a height of about 1,200 feet above sea level. In the south-east occurs the flat plain of the Chad series, a sandy plain entirely different geologically from the remainder of the area.

In the southern region sand-dunes also occur; in this area they are now fixed but were formed in pre-Quaternary times when the area now known as Northern Nigeria endured true desert conditions. To the north-east, but outside the area under consideration, movement can be observed to-day in some of the sand-dune formations.

The valleys of the former rivers of Quaternary times are, apart from the mountain regions of Aïr, among the most striking features of the configuration of the area under re-:view. Their history is interesting; their soil is, as one would expect, rich, since it contains much of the good soil from the slightly more elevated ground of the catchment area; the vegetation of these valleys is much richer than that of the surrounding country; tall trees, wooded glades and thickets occur and they also form good farmland areas. The banks are frequently some hundreds of yards wide and they have either flowing river-water in the rains, or at least from a series of swamps from which the water table of the surrounding country is raised. This benefits the natural vegetation, the farmlands, the water supply for the local natives and their stock which, in the dry season, are often woefully short of water, the greatest need in the improvement of this area.

HYDROGRAPHY/



MAP OF HYDROGRAPHICAL SYSTEM.

Permanent Rivers Seasonal Rivers

17A

HYDROGRAPHY

Although a description of the river systems might have been included in the physiographical description of the area, the two subjects are treated separately in order to emphasise the rivers which have a very important bearing on the vegetation.

The historic River Niger with its host of tributaries and the lesser known River Komadugu Yobe flowing into Lake Chad constitute the main river systems in this region and the former is one of the few perennial rivers amongst all the rivers and streams occurring in this vast region. The Niger, flowing for a distance of about 600 miles through the area, rising a little to the east of the British Colony of Sierra Leone, enters the region under review in the French Sudan, where there are few tributaries; once it enters French Niger Colony there are a number of rivers and streams, the greater number of which are on the right bank. The Niger is the main feature of the area, but only a few rivers in the region under discussion help to swell its large volume.

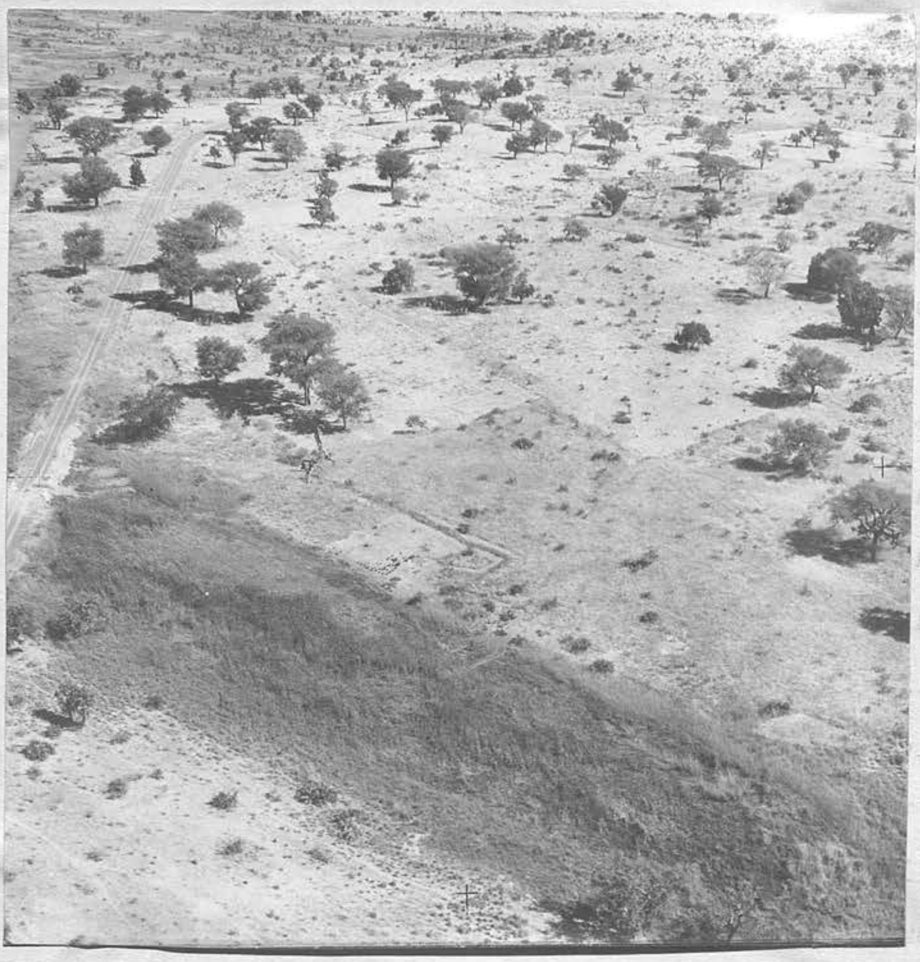
On the right bank of the Niger the River Gorouol joins it to the north, and the river Dargol to the south of Tillaberi; the River Goroubi meets it south of Say and the Tapoa between Say and Gaya; the Aibory joins it north of Gaya and the River Sara at Gaya.

On the left bank of the Niger there is a series of former river valleys or 'dallols' of Quaternary times and in which water may flow for only a short time during the wet season; they help to drain the area and have, at the same time, a definite effect on the vegetation.

Geologists state that in some cases there is a sub-surface/

sub-surface flow of river water in these ancient valleys, but this is probably still open to doubt.

One of the largest of these former river valleys is the Tilemsi valley which reaches the Niger immediately to the north of Gao. This valley is some miles wide in its lower reaches and a large number of contributary valleys, and drainage channels run into it north of Tabankort, having risen in the mountain region of the Adrar des Iforas and the foothills near Kidal. The motor route from Gao northwards follows this valley for over a hundred miles and photographs of the valley near Gao and Tabankort are included. Small river valleys also reach the Niger at Ansongo and near the old town of Bentia. The valley of the Oued Exgeret helps to drain the south-eastern portion of the Adrar des Iforas and the ancient rivers flowing from the central Hoggar Massif also drained into this valley which meets the Niger south of Tillaberi. The well marked Dallol Bosso joins the Niger near Boumba and it also served to drain the southern portion of the Hoggar Mountains and the mountain area of Air. The Dallol Maouri reaches the Niger just south of Gaya and drains the large area between Dosso, Dogon Dutsi, Tahoua and Birnin Konni. It is easily traced as a shallow depression along the north-west portion of Nigeria and in the dry season it consists of a number of dried swamps, with a vegetation entirely different from that of the surrounding area. A number of rivers rising in the Sokoto, Katsina and Kano areas in Nigeria flow first northwards then in a north-westerly direction, later in a westerly direction and finally in a southerly direction to form the large perennial River Sokoto which joins the Niger near Dakingare in Sokoto Province./



The west bank of the valley north of Matamaye.

Part of the long dallol running from south of Tessawa to Gazawa, thence towards Maradi.

Province. Aerial photographs of this river valley at Maradi and Madaoua are included.

The former river valleys in the region of Dauara, Zinder, Tessawa and Gangara drained the area in Quaternary times and the 'dallol' joins the River Sokoto west of Sabon Birni in Sokoto Province. The accompanying photo-:graphs show portions of this drainage system near Tessawa and Matamaye.

The river valleys in the Agades region also ran in a south-westerly direction to join the Tahoua valleys which finally debouched into the Niger. A ground photograph of the valley of the Petit Tadiss Dallol north-east of Tahoua is included later in this paper.

The lower portions of these ancient valleys have a comparatively rich soil, which the farmer has not been slow to exploit and some of the richest farming areas occur in the valleys and depressions.

These former river valleys constitute an interesting geological study and they still await intensive examination. It is obvious they are of not little importance in the study of the vegetation and are important botanically, in that they support in their rich soil a number of relict species which are not found in the surrounding vegetation.

The Hadejia river system flowing into Lake Chad is important although it is much smaller than that of the River Niger, for it drains a large area of country from south and west of Kano to Lake Chad. Its tributaries are the Rivers Katagum, Jamaari and Komadougu Gana which join to form the Komadougu Yobe flowing into Lake Chad. All these rivers are seasonal but even in March, at the end of the long dry season, water is available in pools or near the surface, in the lower portion of the rivers.

There/

There are traces on the left bank of the River Hadejia of valleys of former tributaries in Quaternary times, but these are merely shallow depressions to-day in which there are areas of swamp during the wet season, but in which there is no longer any appreciable flow of water. The swamps near Nguru in Nigeria form part of a 'dallol', a former tributary of the Hadejia. The River Tomas is interesting, rising to the south-west of Kano, it flows to the north of Kano for a distance of some sixty miles and then disappears into a series of swamps in Gumel Emirate; it is without doubt a former tributary of the Hadejia, although some geologists are inclined to the view that there may be an underground flow of water for some distance after its disappearance. It is certain however, that it does not cross Gumel and Hadejia Emirates to reach the Hadejia river.

Some of the rivers in this area have dried up in the memory of man and an instance of this is shown in a dry valley in the region of Birniwa on the railway from Kano to Nguru, in which the older inhabitants, in 1938, stated they could remember flowing water in the valley during the wet seasons in the days of their child:hood, some seventy years before. Although critical of such descriptions, the writer sees no reason to doubt the veracity of this statement; he would not however, adjudge that the river systems have materially altered or that the water table has fallen seriously in recent times, for wetter conditions might again obtain in the area; but he would record that great seasonal variations continue to occur throughout the area, with obvious changes in the wealth of the vegetation during living memory.

CHAPTER 3

GEOLOGY

The Central Western Sudan is part of that tract of Central Africa which consists of a large stretch of ancient crystalline rocks, covered by wide areas of sedimentary rocks deposited by a succession of seas which penetrated far into the continent. Traces of these seas of Cretaceous times are seen in the flats round Timbuctu, the extensive plain between Ansongo, Tahoua and the Chad basin and in the depression thirty five miles wide between the Cliffs of Tigueddi and Agades. These seas covered a great part of Niger Colony and a consider:able area of northern Nigeria, wherein marine fossils occur in certain areas. The plain north of the Cliffs of Tigueddi, formerly a sea bed, consists of an infertile argillaceous soil, supporting a very poor vegetation.

Large granite masses rise from the level of the plain in various regions and have been elevated or uncovered by erosion. They can be seen at Dogon Dutsi, Birnin Konni, Katsina, Kano, and at Zinder; M. Abadie realistically writes of the granite outcrops at Zinder: "Certaines se trouvent dans une position d'equilibre invraisemblable".

Surface and sub-surface ironstone cover very large areas of the region; it occurs as a lateritic crust or as a capping on rocks and may stretch for many square miles. It occurs in the region of Niamey, Dosso, Tahoua, Gangara (north of Tessawa), Sokoto, Katsina, Kano, north of Matamaye and near Zinder.

The Air Massif was subject to intense volcanic activity in the Tertiary period, shown by the volcanic débris overlying the more ancient rock formations. The mountain/

mountain region of Aïr covers some 17,000 square miles; it is an area of uninviting aspect & appearance, but is full of interest to the scientist. Volcanic rocks have also thrust their way through the ancient rock, and granites, gneisses, basalt, quartz and schists are found. It is an area which still awaits intensive scientific study.

The Western Sudan previously enjoyed a period of much greater humidity than to-day; the 'dallols' and wide river valleys show how numerous and how large the rivers were. The rainfall must have been heavy and the area must have supported a fairly rich vegetation. Fossils, already mentioned, of large trees can still be found on the Cliffs of Tigueddi and they show that trees of a foot and more in diameter occurred.

Sand-dunes occur in the southern portion of the area; they are fixed dunes for the most part, and they appear to have been formed when the region known as Southern Niger Colony and Northern Nigeria supported very arid conditions. No moving dunes appear to occur in this area although they are found to the east of Nguru in the Manga region and to the north thereof in south-east Niger Colony. Obvious sand-dunes which are now fixed and which have some vegetation occur in the Maradi area and the neighbourhood of Jibiya in Northern Katsina province. In Hadejia Emirate of Kano Province long narrow fixed sand-dunes occur which may stretch for a distance of five or six miles; they carry a sparse vegetation of grass and no recent movement appears to have occurred.

In that part of Northern Nigeria lying in the area under discussion the following distinct geological groups occur.

1/

1. Undifferentiated gneisses of the Pre-Cambrian era, occurring in the central and part of the western portion, the rocks consist of gneisses, schists and older granite.

2. Undifferentiated Tertiary formation in the central portion.

3. The Chad Sands series, occurring in the eastern areas and which belong to the Post-Middle Eocene period; they consist of a series of sands and clays.

The crystalline rocks of the first formation occupy a great stretch of the central portion of the northern provinces of Nigeria; there are various intrusions of granites, schists, quarzites, gabbros and quartz porphyries. They occupy large areas of Sokoto, Katsina and Kano Provinces.

The second group - the Tertiary formation, has an interesting geological history. The Tertiary period was one of instability when there were depressions below sea level and elevated areas above sea level. Extensive areas in Sokoto Province and restricted areas in Northern Katsina Province are occupied by rocks of Tertiary age. Superficially however, there appears to be little difference between the soils produced by these two groups, the soil is a sandy one for the most part, except in the river valleys and in the depressions caused by the rivers in Quaternary times; the changes in the vegetation are a result of the decrease in rainfall as one proceeds northwards.

The last section, the Chad group contains a large series of sands and clays which belong to the close of the Pliocene or even to the Pleistocene era; the group has affinities with the Benin Sands, in Southern Nigeria, the northern limits of which represent the former coast line of the Gulf of Guinea. The western boundary of the Chad sands/

Sands runs in a north and south direction near the road from Kano to Daura and the group extends eastwards to Lake Chad. The surface soil is a sandy one and the clays are found in the region of the seasonal and perennial swamps and in the vicinity of the river valleys.

The soil analysis included later shows the differences between the soils of the undifferentiated gneisses (No. 1164,-Kafin Sole), the undifferentiated Tertiary formation (No. 4508,-Bumbum) and the Chad Group (Nos. 4509 and 4514 inclusive,-Gumel and Hadejia, and 1681 from near Lake Chad).

Surface and sub-surface ironstone (1) is found over considerable areas in Niger Colony and in Northern Nigeria. Contrary to the belief of a few years ago, it is now realized that lateritic concretions are formed and are in the process of being formed rapidly, and they are no longer regarded as having been produced only in the last pluvial age. Recently formed laterite ironstone can be seen having been created in the space of a few years in borrow pits and in compost pits. Laterite ironstone occurs, as a crust of varying thickness or in drift as ferruginous concretions, to form platforms. The ironstone which is found <u>in situ</u> as a result of rock weathering is usually thicker than that formed in drift.

These concretions in one form or another are found intermittently in Northern Dahomey, in Northern Nigeria from western Sokoto province to north of Nguru in Bornu province and in Niger Colony from the Niamey-Tillaberi area eastwards to near Zinder. In other areas it has formed almost exclusively on the sedimentary rocks as opposed to crystalline rocks.

The lateritic-capped plateaux show where lateritic concretions/

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1. Jones, Brynmor. Lateritic Ironstone in Sokoto Province Geol. Inst. No. 1 Vol. 4 Feb. 1943

concretions have formed in situ over sedimentary rocks and they show in each region a former level of the plain at one time.

'Laterite' varies in appearance and hardness and where it has been exposed it forms a hard rock which may be used for building or for road-making. At lower levels, as Brynmor Jones points out, it is softer, then grades to a clay-like substance.

The ironstone forms an iron ore of good quality and it has, in the past, been widely exploited by the native. Kano is said to have sprung from a small iron-smelting village at the base of one of its two ironstone-capped hills.

The lateritic plateaux are frequently in the process of being destroyed by the undercutting of the softer sediments. Since 'laterite' is always found as a crust on rocks and is never interbedded with them, it is clearly demonstrated that it is a product of superficial alteration and not a sediment-:ary deposit.

Reformatsky (1) studied the ironstones in western Niger Colony (1925-26) and he pointed out that the ironstones are found during the decomposition of the rocks and that he regards them as true laterites.

Lambert (1938) examined the southern portion of Niger Colony round Tahoua immediately to the north of Sokoto province, and he mentioned the 'laterite' crust in the Gwandu and Calcareous groups. His unpublished paper "Note explicative du la feuille Tahoua-East' has been read by the writer. Lambert, unfortunately does not discuss the mode of formation of laterite.

Hubert/

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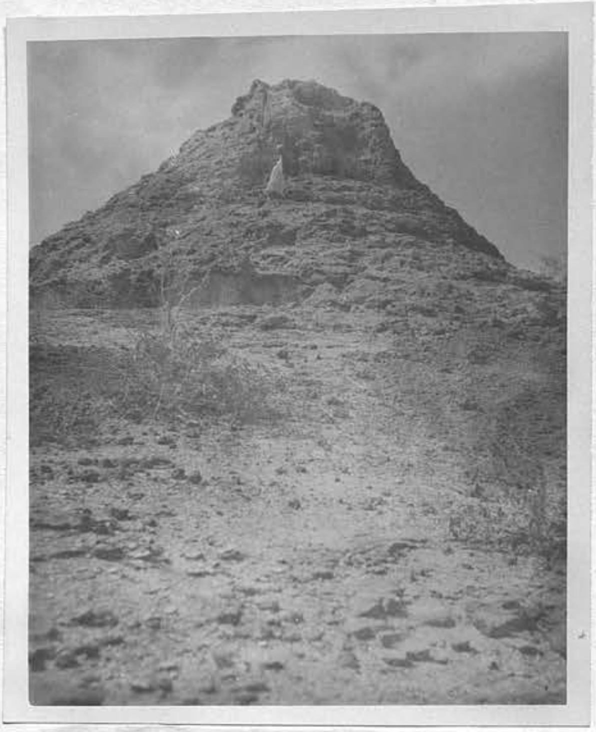
1. Reformatsky No. 195. Quelques observations sur les laterites et les roches ferruginesès de l'ouest de la Colonie du Niger. Bull. Geol. France Ser., v.p. 575.



Degarded low scrub on a disintegrating lateritic hill south of Takieta, and consisting mostly of Combretum micranthum.

Hubert (1908) published the 'Mission scientific au Dahomey', but there is little information with relation to the Central Sudan although this volume provides a large number of data of great interest.

Brynmor Jones suggests that the fact that ironstone occurs in this Calcareous Group plain close to the foot of outlying hills of the Gwandu Group suggests that the material is still in the process of formation. The writer has proved from observations at Daura that lateritic soil can be formed, given suitable conditions, in five years, and this will be described at a later stage. Brynmor Jones also suggests as another factor that it is the seasonal rise and fall of the water table that has promoted the formation of lateritic iron-:stone in Sokoto province since this material does not form in water-logged ground. He points out that the flat-topped hills are now well drained so that the formation of ironstone on them has practically ceased. The lateritic capping on these hills originated as an ironstone sheet in a plain as it was undergoing dissection. Thus a series of lateritic-topped hills in one area are very nearly at the same height and are striking features of the plain. They are particularly notice-:able in Northern Dahomey, round Birin Kebbi and Sokoto, near Niamey, at Tahoua and also in Katsina province in Nigeria.

Brynmor Jones describes yet another process in the formation of ironstone with the mechanical removal of unaltered clay by descending water. The sesquioxides deposited in the upper part of the crust have the form of a hard skeleton, the holes being occupied by softer, earthy material. Rainwater percolating through the crust removes the soft material, leaving a cellular mass comprised principally of limonite, which is the normal form in which the ironstone occurs. It is probably this process/

process which occurs in Daura, where the writer has observed the very rapid formation of ironstone.

Scaetta (1) considers that the laterization process in the sub-equatorial zone is slowed down by three factors. Firstly, by the decomposing organic waste from the woodlands which sustains an active micro-flora and furnishes bases to the soil. Secondly, that woodland area arrests the sand and clay dust which is carried from the desert area by the seasonal wind of the dry season, and that the dust becomes incorporated in the soil, thus mineralizing it. Thirdly, that the superficial run-off of rain and soil water is re-:tarded by woodland.

The writer agrees with these suggestions and proof has already been obtained of how quickly lateritic concretions appear even on sandy soils which are denuded of vegetal covering. It is in fact a common phenomenon in the northern Emirates of Nigeria but its significance has not been recorded until recent years. The writer has recorded elsewhere (2) that the large areas of lateritic soils in Kano and Katsina, carrying a degraded combretaceous scrub or devoid of vegetation, are of recent formation and occur in areas which, within living memory, were valuable farmland. There appears to have been no evidence of laterite, of which there is much to-day, round the native towns of Katsina and Kano when Barth visited the area between 1850 and 1855. The present Emir of Daura has recorded that the area of 'laterite' round Daura town to-day consisted of good farmland seventy years ago.

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(1) Scaetta. Reviews of various papers. (Geog. Rev. April, 1942 and extracts from Soils and Fertilizers)

(2) Anti-Desiccation Investigation Reports. Kano and Katsina 1938 and 1940.

It is quite obvious that it is necessary to maintain a vegetal covering capable of retaining a sufficient depth of soil to prevent the formation of 'laterite'. The problem of how to render laterite soils once again fertile is no easy one and it is possible it can only be done by the careful retention of the vegetation which remains, by protection and allowing it to improve in type until the vegetation is capable of forming a new soil. Soil research on these lines alone is urgently required. Observations by the writer in connection with the rate of formation of lateritic concretions are de-:scribed under the chapter on soils.

The plains of Northern Nigeria and Southern Niger Colony are almost universally covered by drift deposits, consisting mainly of alluvium with some admixture of wind-blown fine sand and clay. The fine dust carried by the Harmattan wind is an alkaline clay richer in plant foods than some of the soils on which it falls; its chemical analysis is also described in the chapter on soils.

CHAPTER 4

SOIL

It is difficult to give a detailed and comprehensive description of the soil of the Western Sudan until very much more study and analysis are made; the present description must err somewhat on the superficial. Some soil samples from the Colony du Niger and from Northern Nigeria have been collected and the writer is grateful for the analysis by Agricultural Chemists, of a number of samples he himself collected, and for a series of analysis of soils collected by Agricultural Officers and others; he is also grateful for some valuable information on the Northern Nigerian soils from the paper Soil Types and Manurial Experiments in Nigeria by Messrs Doyne, Hartley and Watson.

It is obvious that there must be very great differences in the kinds of soil, in the area being described, since it covers the region from the latitude of Kano to some 400 miles north thereof, a considerable distance into the Sahara Desert in which there is a certain diversity of soils. Yet as will be shown there is less difference between the semi-desert soils and those of Northern Nigeria than between the latter and those of Central and Southern Nigeria.

The most fertile soils naturally occur in the river valleys and in the ancient river valleys of Quaternary times, and it is in the area of the Niger and its tributaries and in the Komadugu Yobe river system that the best agricultural soils occur. Generally speaking the soils in the valleys and depressions are heavier and produce better crops than the light sandy soils of the elevated plains such as the Hausaland plain of central Northern Nigeria. The soil over the greater part of/

of the area is sandy, yet contrary to expectation it is a relatively fertile one and good crop yields are usually ob-:tained, given a normal supply of rainfall in the year.

There are considerable areas of lateritic soils which will also be described more fully in due course. There are a number of lateritic capped plateaux already mentioned under Geology, from the Niamey-Tilliberi region on the west through the Tahoua-Sokoto area to Katsina, Kano, Takieta and to north of Nguru near the Nigerian frontier. These are, in some cases, being gradually broken down to produce a good type of soil on the plains below.

The granitic outcrops which occur from Dogon Dutsi on the west through Sokoto, Katsina and Kano and across parts of Niger Colony to Zinder also produce a good type of soil.

The Aïr Massif was subjected, in the Tertiary period to intense volcanic activity which is shown by the volcanic débris overlying the more ancient rock formations and the soil is consequently very different from that of the plain between Angongo, Tahoua and the Chad basin which was covered by seas in the Cretaceous period. The Aïr region consists of the ancient rock through which volcanic rocks have been thrust and granites, gneisses, basalt, quartz and schists occur, making the soil a diverse one.

Between the Cliff of Tigueddi and Agades an infertile agrillaceous soil occurs on which however there is a fair growth of grass and scattered thorn scrub.

Niger Colony as a whole in fact, and the northern part of Nigeria appears to be part of that tract of central Africa which consists of a wide stretch of ancient crystalline rock, covered with extensive areas of sedimentary rocks de-:posited by a succession of seas which penetrated far into the continent and over part of which sea fossils are found.

Sand/

Sand-dunes also occur in the southern portion of Niger Colony and in northern Nigeria but as opposed to the shifting dunes of the area north-west of Lake Chad they are fixed dunes with a binding of grass and a very scanty vegetation.

Sufficient has been said therefore to show the numbers of different kinds of soils which occur in the Western Sudan, although it must be borne in mind that although a number of the sandy soils appear physically to resemble each other they do very often differ in their chemical composition and therefore in their fertility. The chemical aspect must therefore also be studied.

It has been stated (1) by soil chemists that in general, soils in this area on which natural vegetation is growing are much less acid than soil under cultivation and that in many instances, particularly with immature soils derived from igneous rocks, there is a continuous increase in acidity with depth, extending into the uppermost horizons of the decaying rock. It is reasonable to assume that the increase of acidity with depth is caused by the removal of bases from the depths and their deposition on the surface. It is also possible to assume that owing to intense evaporation the rise of water in the soil exceeds the action of leaching and the exchangeable bases tend to move towards the surface.

The presence of concretions is often evident either on the surface or at varying depths and they are probably the/

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1. Soil Types and Manurial Experiments in Nigeria. H.C. Doyne, K.T. Hartley and W.A. Watson.

the result of a temporary waterlogging which occurs in the rains and tend to form above the water-table. It has been suggested that the dehydration of sesquioxides to form concretions is an irreversible change and thus they tend to accumulate and finally to form impenetrable masses of conglomerate. It has however been pointed out (1) that instances have occurred of lateritic soils evolving to a better type of soil, but this may have been due to artificial conditions.

The least acid soils in Nigeria are those derived from igneous rocks where the pH is about 5·5 to 6·5 at the surface and gradually decreases to 4·5 to 5·0 in the depths.

It is interesting to note that nitrification increases enormously over the area after the first rains have broken.

The Northern Drift Type of soil occurs in the northern areas of Nigeria, and in Southern Niger Colony. The 'drift' becomes the predominant feature and the soils contain less clay and organic matter and more coarse sand than do the soils further south. Concretions may occur at considerable depth but only where the underlying formation is granite as in Kano and Katsina Provinces. The profile consists of a grey or buff surface soil overlying a redder subsoil, below which the horizons become lighter coloured again. In depressions where drainage is restricted sodium carbonate and sodium chloride are present, and may seriously interfere with fertility. Salt is indeed worked on a commercial basis in various areas in Nigeria and in Niger Colony. Doyne, Hartley and Watson/

1. Rosevear, R.D. Soil changes in the Enugu plantations. Farm and Forest Vol. 3 No. 1. 1942.

Watson point out that the nitrogen content rarely exceeds 6·015%, that the available phosphorous is about two to three parts per million and that it is surprising with less than 10% of salt and clay, the soil can grow crops. The main crops are millet and ground-nuts whose success largely depend on their quick maturing in an area with a rainfall of about 25 inches falling in six months of the year.

The swamp type of soil occurs in the basin-like depressions where the drainage is poor and where eroded fine material has collected. They are usually water-logged during the rains and retain water below the surface during the dry season. The soils are dark grey with a bluish tinge and vary considerably in their texture; they often contain 60 to 70% of clay but where nearby erosion is pronounced, there is a mixture of fine sand.

Vageler[1] records that these are frequently fertile soils if they can be broken up and drained. This is not economically possible in this area. That they are fertile is proved by the luxuriant close-woodland or forest vegetation which they support in areas where, with a low rainfall, the surrounding vegetation is poor savanna-woodland or poor orchard-woodland. The areas of exposed swamp soil are subject to such physical conditions as to render their use for crops impossible and the natural regeneration of the tree vegetation rare.

The dust carried by the Harmattan wind which originates from the north-east of the area and is experienced during part of the dry season, is another agency in soil formation. The wind is now believed to occur/

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1. Vageler, P. Introduction to Tropical Soils.

occur throughout the year, but it is only over the winter months that its presence is felt. It is a hot dry wind and as one would expect from its desert origin, large volumes of the dust deposited on the soil over long periods, have a decided effect on the soil. Its mechanical analysis proves that there is 10·8% fine sand, 24·5% silt and 64·7% clay.

A sample sent to the Imperial Institute for Chemical analysis, produced the following figures:-

	%
SiO_2	49·34
AL_2O_3	10·34
Fe_2O_3	4·14
TiO_2	0·66
CaO	5·28
MgO	2·07
K_2O	1·62
Na_2O	0·80
P_2O_5	Nil
Loss on ignition	24·81%

Microscopical examination showed that a consider-:able portion of the dust is composed of diatoms of many different species, some entire but most of them fragmentary, together with particles of quartz most of which are less than 0·025 mm. in diameter. Fragments of biotite and what appear to be riebeckite were also present with a considerable quantity of very fine dust and vegetable tissues.

A series of chemical analysis was made from soils in French Niger Colony and in Northern Nigeria; - part of the series is introduced for the purpose of comparison.

The soil over the greater part of the area is sandy/

sandy, irrespective seemingly of the geological formations. The lateritic soils present a problem in that they are not suitable for farming, the major livelihood of the local native. Certain areas of lateritic soil are now within forest reserves and it will be interesting to see how the natural combretaceous vegetation improves, it certainly has already demonstrated its ability to grow and densify quickly, and to see whether the lateritic soils are broken up and improved.

During the dry season there are many square miles of hard, dry, cracked and fissured areas of clay soil which carry no vegetation, although Vageler records that these soils are thoroughly mixed to a depth of several metres due to the constant mixing of the soil minerals by leaching and, in time of flooding, by the raising of these mineral constituents. He states that this type of soil responds to draining and cultivation provided that the base content is not so high as to give a reaction much above $_{p}H$ 8·5. It is possible that some of these swamp soils may be used in the future for local irrigated farming of wheat and rice.

The writer is of the opinion that the soils of this area suffer from exposure and insolation to a very marked extent and it seems evident that they differ in productivity in these areas where there is some protection by natural vegetation, as opposed to the heated, loose friable soil, exposed to the sun and the wind without protection even of grass and weeds.

It/

It is considered that Jenny's law as enunciated by Corbet [(1)] in Malaysia, appears to apply to the area of the Western Sudan; it reads as follows:-

> "The nitrogen and organic matter content of the soil decreases with increasing insolation and temperature, provided that the same conditions of humidity obtain."

There is no doubt that protection of the soil by natural vegetation is one of the most important aims in the improvement of the soil and its consequent productivity.

It is now accepted by pedologists that climate is very closely connected with soil formations and soil properties and Corbet states in this connexion:-

> "It is now generally recognised that the soils are related primarily to the climatic conditions under which they are found, and only indirectly to the parent mineral material. In short, soil is the product of the action of climate upon rocks. Wind is also an important factor in soil formation."

While this may be true over much of the Earth's surface and even over the larger part of Africa, the writer would differ in regard to the large areas of alluvial soils in the Western Sudan. The alluvial sands of the Chad Series within which Gumel and Hadejia Emirates of Nigeria lie, and the argillaceous soil of that vast plain from Timbuctu on the west crossing the Niger to Tahoua and south of Agades, were formed by geological process. While the soils have been governed by climate they are not always the direct product of climate upon the present mineral material.

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1. Biological Processes in Tropical Soils - Corbet, A.S.

As the local native farmers, (and especially the Kano mixed-farmers who have followed their system of permanent farming for some five hundred years or more), have proved, the northern drift soils very materially benefit from the application of farmyard manure; it is equally obvious that the soil benefits from the decaying of the vegetative materials produced by the natural vegetation and that fact is demonstrated in that the soil is rested, in farming rotations, for a comparatively short term of seven to fifteen or twenty years.

The writer recommended in anti-desiccation reports written in 1938 and 1940 that the composting of animal waste products, (including offal from slaughter slabs), and of human excreta should be used, following the methods of the Indian Indore process. Concurrently Dr. Gilles of the West African Medical Service in Kano, evolved methods of composting these materials and there is to-day in both Kano and Katsina areas a very large demand by the farmers for the resulting manure; class and religious prejudices have quickly succumbed, and it is hoped that this method of using waste materials will be spread throughout Nigeria if not throughout West Africa.

In Northern Nigeria and southern Niger Colony the winds of the tornado seasons cause much damage by the removal of the loose surface soil and it is common during these seasons to see a wall of fine dust some five hundred feet high, approaching from a considerable distance at a speed of about twenty miles an hour. It is certain that much mechanical and physical disturbance is caused to the/

the soil, and the formation of farm boundary trees and hedges is being urged and is generally appreciated by the native, although he is slow to act on advice.

The following table gives the Chemical analysis of a representative number of soil samples from Northern Nigeria and from Niger Colony, and they illustrate the diversity of the types of soil in the area being described.

Table/

(A) The milligram Equivalent of a base is the weight of hydrogen in grams which it will replace, multiplied by 1,000.

(B) Parts per million (An available phosphorous content of less than 10 parts per million is usually regarded as indicating a defi-:ciency, but does not always apply.)

ANALYSIS OF SOIL SAMPLES.

NORTHERN NIGERIA and FRENCH NIGER COLONY.

Sample No.	1164	4508	4509	4510	4511	4512	4513	4514	1298	4005	1681	4527
Locality	Katsina	Daura	Gumel	Gumel	Gumel Seasonal Swamp Soil		Hadejia		Sokoto	Nguru	S.W.Cor-:ner of LakeChad	West of Agades
Depth	(Kafin Sole) 0-12"	(Bum-:bum) 0-24"	0-9"	9-15"	0-6"	6-12"	0-12"	12-24"	0-12"	0-15"	0-12"	0-12"
Colour	-	Light Brown	Greyish Brown	Brown	Brown Grey	Mottled	Yellow-ish Grey	Reddish Brown	-	-	-	Chocolate Brown
Stones	·02%	-	-	-	-	-	·2	·9	2·9	Nil	Nil	-
Coarse Sand %	57·4	51·5	22·8	17·3	18·1	21·4	26·0	23·8	19·4	10·5	26·4	·4
Fine Sand %	38·2	47·5	60·5	70·5	64·7	73·5	67·0	52·9	62·6	72·4	36·6	21·6
Silt & Clay %	4·4	1·0	16·7	12·2	17·2	5·1	2·1 silt 4·9 clay	1·2 silt 12·1 clay	4·8 silt 13·2 clay	17·1	37·0	22·2 silt 55·8 clay
Texture Figure	21·7	99·0	5·0	7·2	4·8	18·6	13·3	5·9	-	-	-	0·3
p H	5·4	6·1	6·1	5·8	6·0	6·7	6·1	5·0	5·3	8·6	7·1	8·8
Exchange p H	-	5·0	5·3	4·6	5·0	5·8	5·4	4·3	-	8·3	6·5	7·2
Exchange Base Present	-	·56	2·24	2·88	1·76	5·20	2·04	2·40	3·22	13·02	8·99	43·08
ME% (A) absorbed	33·4	·7	1·1	1·5	1·30	1·1	1·0	2·0	2·0	Nil	Nil	-
Total Capacity	-	1·26	3·34	4·38	3·06	6·30	3·04	4.40	5·22	13·02	8·99	-
Base Saturation	60·0	44·0	67·0	66·0	58·0	83·0	67·0	55·0	62·0	100	100	100
Carbon %	-	·084	·208	·123	·269	·207	·277	-	·378	·257	·691	·145
Nitrogen %	-	·009	·016	·012	·019	·018	·019	-	·028	·017	·058	·018
C/N Ratio	-	9·3	13·0	11·1	14·1	11·5	14·6	-	13·5	15·1	11·9	8·1
Available (B) Phos-:phorous ppm	-	6·6	4·0	3·2	6·0	2·8	6·8	5·0	3·0	54·0	39·0	260

In a paper on Lateritic Ironstone the late Mr. Brynmor Jones of the Geological Survey Department of Nigeria recorded the following interesting analysis of laterite in Gwandu Division of Sokoto Province, and from southern Niger Colony near the Sokoto frontier:-

	Kurukuku Sokoto Province	Agoulou	Niger Colony Tacan Amatt	Ezel	Tabafat
S_iO_2	2·00	3·05	22·0	9·00	10·14
F_2O_3	77·47	73·28	56·10	55·52	47·07
AL_2O_3	-	8·98	14·80	·16	8·31
T_iO_2	0·21	-	-	-	-
$M_{n3}O_4$	-	-	-	15·92	12·35
C_aO & M_gO	-	-	-	6·70	4·97
P	·84	-	-	-	-
S	·018	-	-	-	-
Loss on ignition	12·80	14·80	7·30	12·95	15·75

It is pointed out that the specimens from Ezel and Tabafat are exceptionally rich in manganese.

The writer has made a series of observations since October 1937 on the formation of lateritic concretions in the light sandy soils of the northern portions of Kano and Katsina Provinces in Nigeria. Photographs were taken of laterized soils in Daura in that year, and pits formed in Katsina, in the building of the Forestry house were also examined at intervals. The writer suggested in 1940 that laterite was in the process of being formed today, but specialist forest officers stated that it could only have been formed under the conditions of temperature and rainfall of the last Pluvial Age.

The writer in the course of his military duties observed /

observed slit trenches and weapon pits dug in March of 1941 in the soft sandy soil of Northern Daura Emirate close to the international boundary; by March of 1944 'laterite' had already formed in the first six inches of the soil profile in a series of these pits. This is the first time the writer had been able to obtain actual dates of the for:mation of pits and careful measurements were made. It is interesting to note that over distances of a mere thirty feet laterization can take place at a different rate and is probably dependent upon what the vegetation was for some years prior to the pits being made. A series of pits have been fenced off so that measurements can be made regarding the rate of formation of the lateritic concretions.

It is obvious therefore that laterization can take place in this region within three years even on light sandy soils and the observations made at Daura in March of this year show how very close the farmland soils are to laterization if no adequate cover is provided.

Large areas of former farm-land round Daura are now covered with Combretum micranthum which invariably denotes a degraded soil and will usually indicate a lateritic soil. It is the only vegetation which can survive on extensive surface concretions and deep lateritic formations. Once the concretions occur in depth then the soil is no longer possible for farming, nor can natural improvement of the combretaceous scrub be effected quickly. The writer started a small series of experiments in October of 1937 in regard to combretaceous scrub/

scrub and its rate of recovery from coppice in its exploitation for fuel. It has now been shown that Combretum micranthum requires ten years completely to recover and that after six and a half years the regrowth is not quite so tall, at an average of six feet, as the untouched vegetation, nor is it so dense. The soil is more exposed and must have suffered from insolation and lack of vegetable material being returned to it.

The farmers can obtain crops from an area of combretaceous scrub where the soil has not begun laterization; crops, in spite of manuring, are poor in the first and second years and are better in the third and fourth years; they then fall off in the next two or perhaps three years when the area is abandoned.

The writer carried out experiments of direct sowing of indigenous seeds and the introduction of indigenous cuttings in areas of pure combretaceous scrub, in an endeavour to improve the type of vegetation, to protect the ground surface and to return more to the soil. It is now obvious that the farmers should introduce Bauhinia thonningii and Guiera senegalensis, the natural scrub species in this region, so that better protection and a better return can be given to the soil.

It is quite evident that if no steps are taken on these lines that very large areas in the northern Emirates of Nigeria and in southern Niger Colony will become unfarmable and will become non-productive areas of 'laterite' with the most degraded type of combretaceous scrub. This is being considered, at the request of the writer, in the rural development schemes in Kano and Katsina provinces in Nigeria.

CHAPTER 5

C L I M A T E

The climate of the area under review varies greatly because of the range from south to north in an area support:ing sub-desert and desert conditions. It is only some portions however, of the northern part of the area which are not influenced by the moisture-bearing south-west winds from the Gulf of Guinea; on the other hand no part of the area is unaffected by the Harmattan desert wind from the north-east which blows or rather is effective during the dry winter months (from latitude 5^{o}N to 30^{o}N). It has recently been stated by French climatologists that the Harmattan in actual fact blows throughout the year, that during the rainy season it is at a very high altitude, too high to affect the area over which it is passing, and which is influenced by the lower altitude moisture-bearing air currents from the Gulf of Guinea during the summer months.

The climate indeed is directly influenced by the air currents and a much more intensive study of these is necessary before we have full data enabling the climate as a whole correctly to be appreciated. Data collected for air services during the period of hostilities is un:fortunately not at present available. Maps, however, showing the air currents, the rainfall and the temperatures during the dry and rain seasons are included, from data which are available from various sources.

A tabular statement of the meteorological data during the months of January, April, August and November for/

for Sokoto, Katsina, Kano, Hadejia and Maidugari, is included to illustrate the range in conditions between these places at different seasons of the year.

Climate is largely influenced by topography and that of the Aïr region, for instance, is very different from that of the surrounding desert. There is an obvious difference in climate between the northern Guinea zone and the Sudan zone and a very large difference between that of the latter and the desert zone. Vegetation, in fact, demonstrates the difference in climate between two zones, just as it can show differences in micro-climates.

The whole area is characterized by having a dry and a rain season which vary in length according to the distance from the sea coast of the Gulf of Guinea, and it is interesting to note that the isohyets in spite of irregularities caused by uplands or by mountain masses, tend in general, to follow the curve of the sea coast a long distance to the south. Rivers such as the River Niger influence the climate, but the influence is local and is much less marked than is generally believed to be the case, as can be seen from the aerial photographs of different portions of the River Niger. Even the large area of Lake Chad has a limited influence in the local climate. Thus in the southern portion of this area the Kano region enjoys some five months of rain, while Agades, to the south of the Aïr Mountains, has approximately one month of rain, which falls mostly in August, and in areas to the north of Agades rain may fall only a few days in the year.

With regard to winds it has already been proved that while the Harmattan or desert wind originates from the north-east, it is influenced so much by the mountain masses that in certain areas it is found to vary very much in direction. Thus in Southern Niger Colony and Northern Nigeria/

Nigeria it approaches from the north-east but appears to be influenced by the large land masses of the Jos and Cameroons Highlands and veers from the north-east, cross-:ing the Kano and Katsina areas from the east and at times approaching Sokoto from the east and south-east; at the same time the air currents approaching the Jos Highlands from the north-east swerve on becoming affected or influenced by the mountain masses and turn towards the south-east.

A like phenomenon is recorded in connexion with the rain-bearing or monsoon winds of the summer months originating from the central Atlantic, crossing the Gulf of Guinea and Southern Nigeria from a south-westerly direction; on reaching the highlands of Central Nigeria, the wind bifurcates and approaches north-western Nigeria from the south-east and north-eastern Nigeria from the south-west. In the northern Emirates of Nigeria and in southern Niger Colony however, the influence of the central Nigerian uplands has been lost and the rain-bearing winds approach from the south-west, west-south-west, or even from the west. A statement of the wind velocities in miles per hour, in Sokoto, from December 1932 to November 1933, is included in this section; it clearly demonstrates the difference in the wind velocities throughout the twenty-four hours and from month to month.

A series of climatological experiments was (1) carried out by the writer at Katsina in 1940. Perhaps the most interesting is a record of the comparative measure-:ments/

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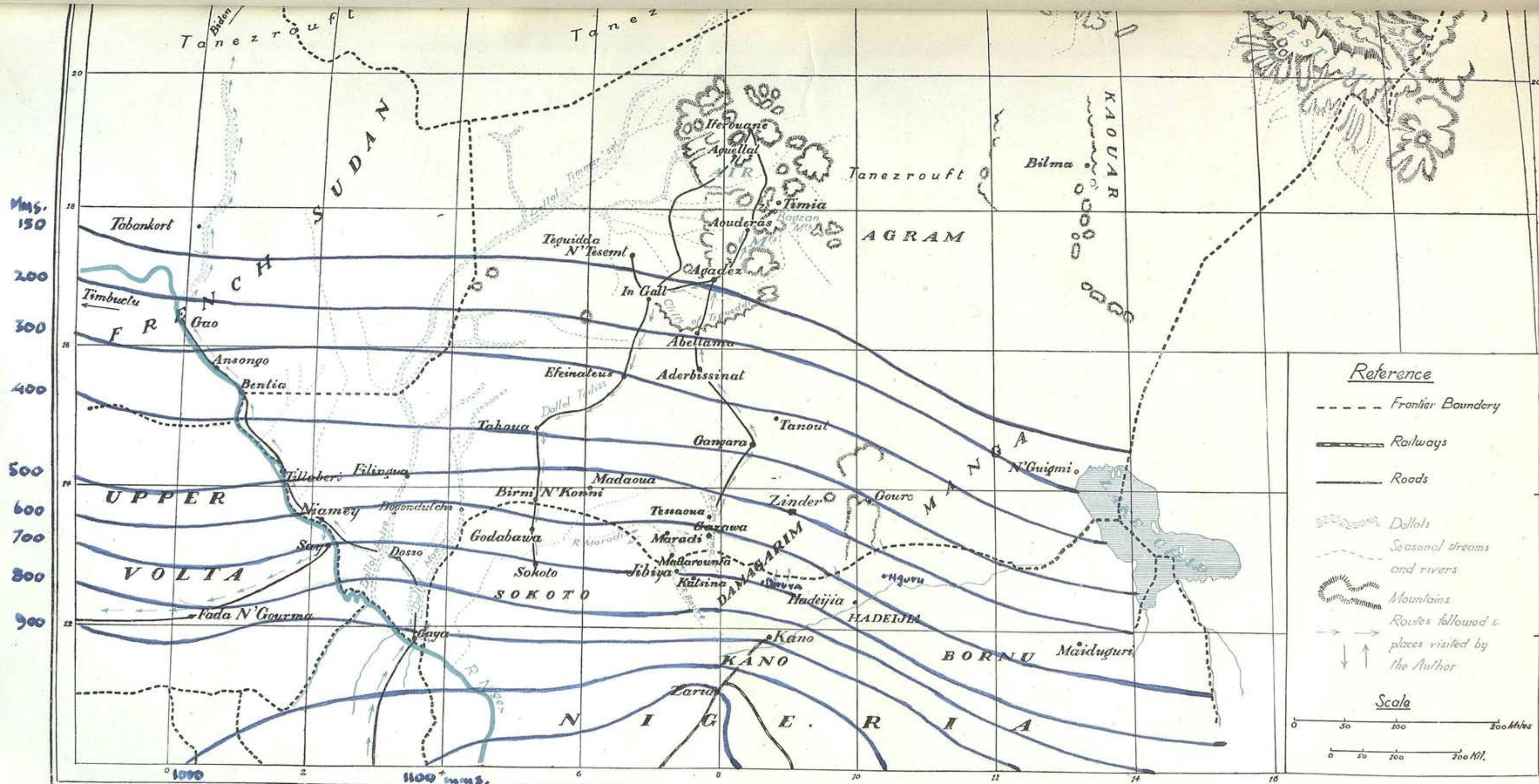
1. The Nigerian Forester. Vol. I. No 2 November, 1940 Ecological and Climatic Studies in Kano and Katsina.

measurements of wind force influenced by different types of vegetation. It had been suggested in Nigeria that isolated trees and hedges probably had no material influence on wind force. The writer disagreed with this and carried out a series of tests on the comparative measurements of the force of air currents, and the effect on them of different types of vegetation. The results were much as one had been led to believe from Russian and American research in this field. The results from these experiments are described in a later chapter.

Four wind measuring guages were made, which showed even slight air currents and all were adjusted to give exactly the same results. Comparative measurements were made at different times on the effect on wind force of shelter belts of different types, such as plantations, a single row of close-growing trees, a double row of avenue trees, avenue trees with a thick hedge at their base, scattered trees and isolated trees and hedges. Measurements were taken generally at intervals of ten yards for some distance to windward and leeward of the obstruction, a control being retained at its base. It was demonstrated that the wind force is reduced for some distance to windward and also to leeward of the obstacle.

The final results proved that the force of the air currents is reduced by shelter belts, plantations, hedges, scattered trees and, at soil level, even by grass only a few inches high.

The vegetation is mainly determined by the amount of atmospheric precipitation and as such the rainfall is of vital interest in the study of the vegetation of/



RAINFALL MAP. ANNUAL.

ISOHYETS IN MILLIMETRES.

of this area. The vegetational zones conform to the isohyets unless there is any fundamental reason for a deviation therefrom, as in the case of the Aïr Mountains, or, for instance, the Niger along whose banks the vegetation differs from the surrounding country.

The rainfall becomes progressively less the further one travels from the coast and it is interesting to note that the isohyets tend to follow the line of the coast except where the physiography causes a deviation.

The extremes of rainfall are significant; in the southern portion of the area rain falls from May to October, in the Aïr region one month's rain may occur about August, in some regions of the desert there may be a few days'rain and in large areas of the true desert, especially in the Tanezruft (which means 'Land of thirst') a shower of rain may occur in ten or twelve years, while in some areas it is unknown.

A map is included which clearly demonstrates the range in the amount of rainfall from south to north. The isohyets are indicated from the River Niger to east of Nguru in Bornu Province of Northern Nigeria. It will be noticed that the isohyets run generally east and west, although they tend to turn towards the south-east in the eastern portion of the area.

It will be seen from the rainfall map that the rainfall is approximately 900 mms.per year on the latitude of Gaya and Kano, that it is 700 mms.on the Say - Sokoto - Daura line, 400 mms.from north of Tillaberi to north of Zinder/

Zinder, 200 mms. from a little north of Gao to the Cliffs of Tigueddi, and to the north of the latter the rainfall diminishes rapidly.

A table is included showing the monthly average rainfall in millimetres at special observation points in Niger Colony and in the north-east portion of the Upper Volta at Fadan Gourma. The rainfall figures for the principal stations in Northern Nigeria are also included for comparison. It is interesting to note from these figures the short rain season at Agades in the southern portion of the desert, as compared with that of Kano with its rainfall of 35 inches, which supports a very well developed area of permanent farmland.

Maps are also included showing the air currents during the winter months and during the summer, the temperatures in January and in July, the atmospheric pressure during these months and, as opposed to the actual rainfall, the mean annual rainfall for the area under review.

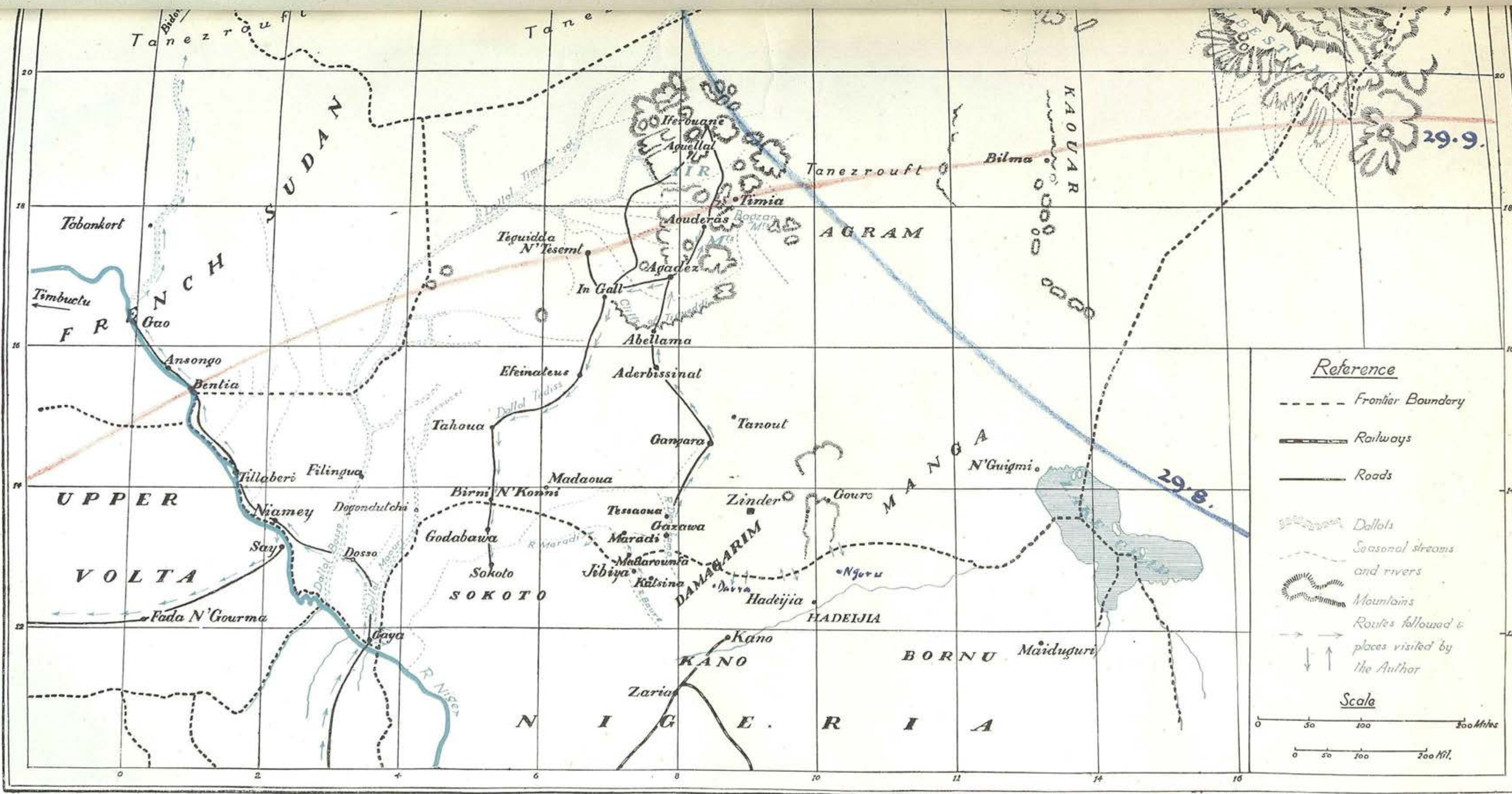


DIAGRAM OF ATMOSPHERIC PRESSURES.

PRESSURE JANUARY 29.9

PRESSURE JULY 29.8.

METEOROLOGICAL DATA - 1938 - NORTHERN NIGERIA

PERIOD	JANUARY (Dry Season)					APRIL(Beginning of rains)					AUGUST (Mid-Rains)					NOVEMBER (Dry Season)				
STATION	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maidugri
Degrees Far. Mean Temp. in Shade.	78·7	72·4	70·5	72·1	71·7	93·4	88·5	87·2		91·1	80·1	76·5	75·6	77·5	78·1	86·1	79·1	77·3	77·9	78·1
Highest do.do.									110											
Greatest dir. variation	42	35	38	43	44	44	37	36		39	25	20	18	18	18	39	36	36	40	40
Mean temp. at depth 1'			76·7°					93·4°					78·9°					84·1°		
Mean temp. at depth 4'			80·3°					89·7°					81·4°					85·1°		
Mean humidity at 9 a.m.	43%	25%	31%	45 %	34%	34%	-	43%	42%	27%	87%	85%	89%	86%	84%	40%	23%	41%	47%	34%
do.do.at 3 p.m.	13%	21%	15%		17%	16%		23%	33%	14%	61%	67%	72%	73%	69%	23%	9%	19%	41%	16%
Total Rainfall per month (ins.)	Nil	Nil	Nil	Nil	Nil	Nil	3·38	0·08	Nil	·12	11·57	13·21	15·89	11·40	9·28	Nil	Nil	Nil	Nil	Nil
No.of days rain	0	0	0	0	0	0	8	1	0	1	19	17	22	15	21	0	0	0	0	0

(Continued)

METEOROLOGICAL DATA - 1938 - NORTHERN NIGERIA (Contd.)

PERIOD	JANUARY (Dry Season)					APRIL (Beginning of rains)					AUGUST (Mid-rains)					NOVEMBER (Dry Season)				
STATION	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maiduguri	Sokoto	Katsina	Kano	Hadejia	Maiduguri
Bar. mean reading Jan. corrected to 32°F. Lat.45° and M.S.L.	-	-	29·980	-	-	-	-	29·803	-	-	-	-	29·891	-	-	-	-	29·906	-	-
Mean Dir. of Wind	NE	ESE& E	ENE	-	NNE	SW	SW& N	WSW NNW	WNW SE	WNW NNE	SW	W	SW	W	SW WSW	NE	SE	ENE	-	NE
Aver. Force (Beaufort) or M.P.H.	1·8	2·7	7·5 mph	2·9	10·1 mph	1·9	3·1	8·3 mph	2·7	9·1 mph	1·9	2·3	6·1 mph	1·5	1·6	2·1	1·5	8·8 mph	2·5	11·2 mph
Amount of Cloud. (in tenths).	Nil	3/10	3/10	Trace	3/10	6/10	5/10	5/10	1/10	4/10	8/10	8/10	9/10	8/10	8/10	5/10	Trace	4/10	Nil	4/10

AVERAGE WIND STRENGTH ON BEAUFORT SCALE.

STATION	1931	1932	1933	1934
Hadejia	0·98	·93	·96	1·00
Kano	2·15	1·71	2·48	1·36
Katsina	-	2·88	2·13	1·83
Sokoto	3·14	3·17	4·71	0·94
Maiduguri	1·07	1·78	3·23	2·29

Average Velocity in M.P.H. in periods.

S O K O T O

Year 1932	Daily Av. Vel.	Hours during Day								Av. Vel. 0600	Av. Vel. 1800	Max. Vel.
		0/3	3/6	6/9	9/12	12/15	15/18	18/21	21/24	1800	0600	
Dec.	6·83	4·87	5·62	6·85	11·22	9·90	6·99	4·87	4·34	8·74	4·92	18·5
1933 Jan.	6·69	4·87	5·6	6·24	10·76	8·99	6·89	5·07	5·08	8·22	5·16	22·4
Feb.	5·49	4·47	4·76	3·76	10·60	7·79	5·40	3·76	4·12	6·90	4·25	18·4
Mar.	5·16	4·41	4·24	4·09	8·10	6·80	5·50	3·86	3·84	6·12	4·07	17·5
Apr.	6·14	5·51	5·55	5·94	8·59	7·46	6·50	4·43	5·52	7·12	5·27	30·0
May	6·50	7·07	6·73	6·63	8·07	7·33	6·25	4·40	5·52	7·70	5·94	20·6
Jun.	6·90	7·50	6·64	6·26	7·87	7·67	6·58	5·64	7·46	7·09	6·81	42·0
Jul.	5·19	4·70	4·82	3·95	7·20	6·26	5·02	4·12	5·49	5·85	4·78	32·0
Aug.	4·92	4·29	3·77	3·61	7·30	6·86	5·53	3·90	4·39	5·82	4·62	20·0
Sept.	3·99	4·37	2·80	1·88	5·01	5·50	4·59	3·52	4·18	4·25	3·72	24·0
Oct.	2·25	1·45	1·25	1·72	2·81	5·28	3·40	2·60	1·00	3·40	1·57	16·0
Nov.	2·40	2·43	1·25	0·60	4·79	3·14	1·41	1·49	2·43	2·35	2·00	-

MONTHLY AVERAGE RAINFALL In mms. in NIGER COLONY STATIONS.

STATION	No. of Years	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	No.1 Month's Rain
Agades	12	·1	0	0	·5	2·1	5·3	37·3	85·1	10·2	·1	0	0	147·7	1
Tahoua	11	1·0	0	0	4·4	12·9	47·4	113·6	133·1	37·3	7·3	0	0	359·0	2·5
Dori	11	3·7	0·1	0	5·9	21·1	40·6	109·6	158·9	87·4	25·9	3·4	0	459·6	3
Tillabery	10	0·1	0	0	3·4	34·6	53·6	135·4	185·3	52·9	14·1	0·2	0	479·6	3
Zinder	11	0	0	0·1	·6	16·0	60·9	168·8	202·5	58·5	10·9	0·8	0	519·1	3
Niamey	12	0	0	0·8	7·1	36·1	90·6	141·5	244·1	89·2	30·3	1·4	0	641·1	4
Maradi	2	0	0	0	0	28·3	54·6	203·1	154·6	177·8	24·5	0	0	642·9	3·5
Dogon Dutsi	10	0·1	0	0·2	6·3	36·4	83·8	153·6	251·9	98·2	19·1	2·4	0	652·0	4
Say	6	0	0	0	21·3	48·4	116·6	187·1	284·2	108·2	20·6	3·5	0	789·9	4·5
Fadan Gourma	11	0	5·2	9·05	28·1	88·3	128·7	187·9	221·6	137·6	27·4	3·3	0	837·6	4·5
Gaya	2	0	0	8·0	0	97·0	168·0	203·3	240·8	159·6	14·3	0	0	891·0	5
Diapaga	3	0	0	7·7	28·1	147·3	101·3	162·3	224·8	219·8	42·7	19·3	0	953·3	5

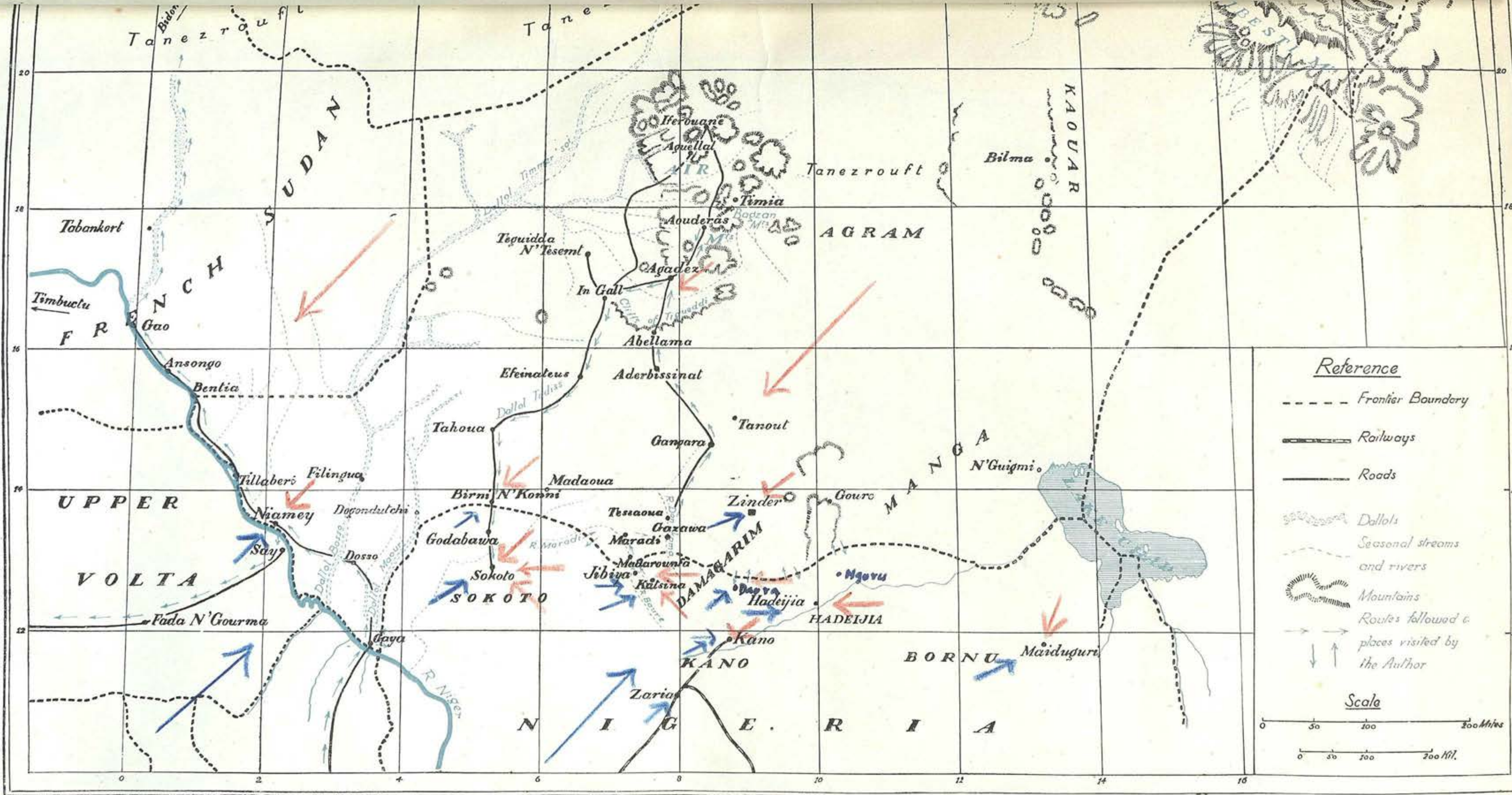
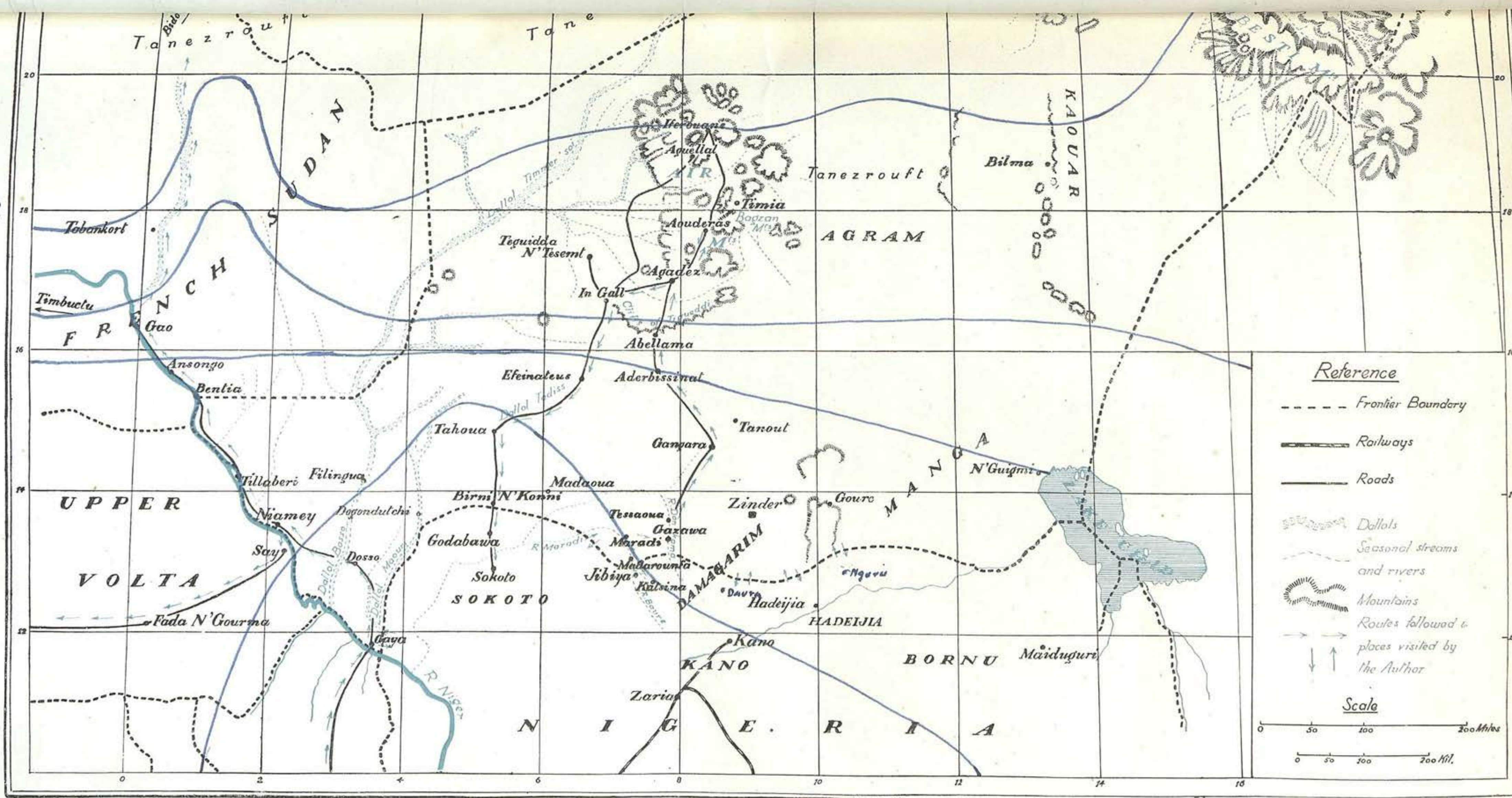


DIAGRAM OF AIR CURRENTS.

DRY SEASON (WINTER).

RAIN SEASON (SUMMER).

INCHES
1."
2"
4"



6 INCHES.

RAINFALL MAP - JULY.

RAINFALL IN INCHES.

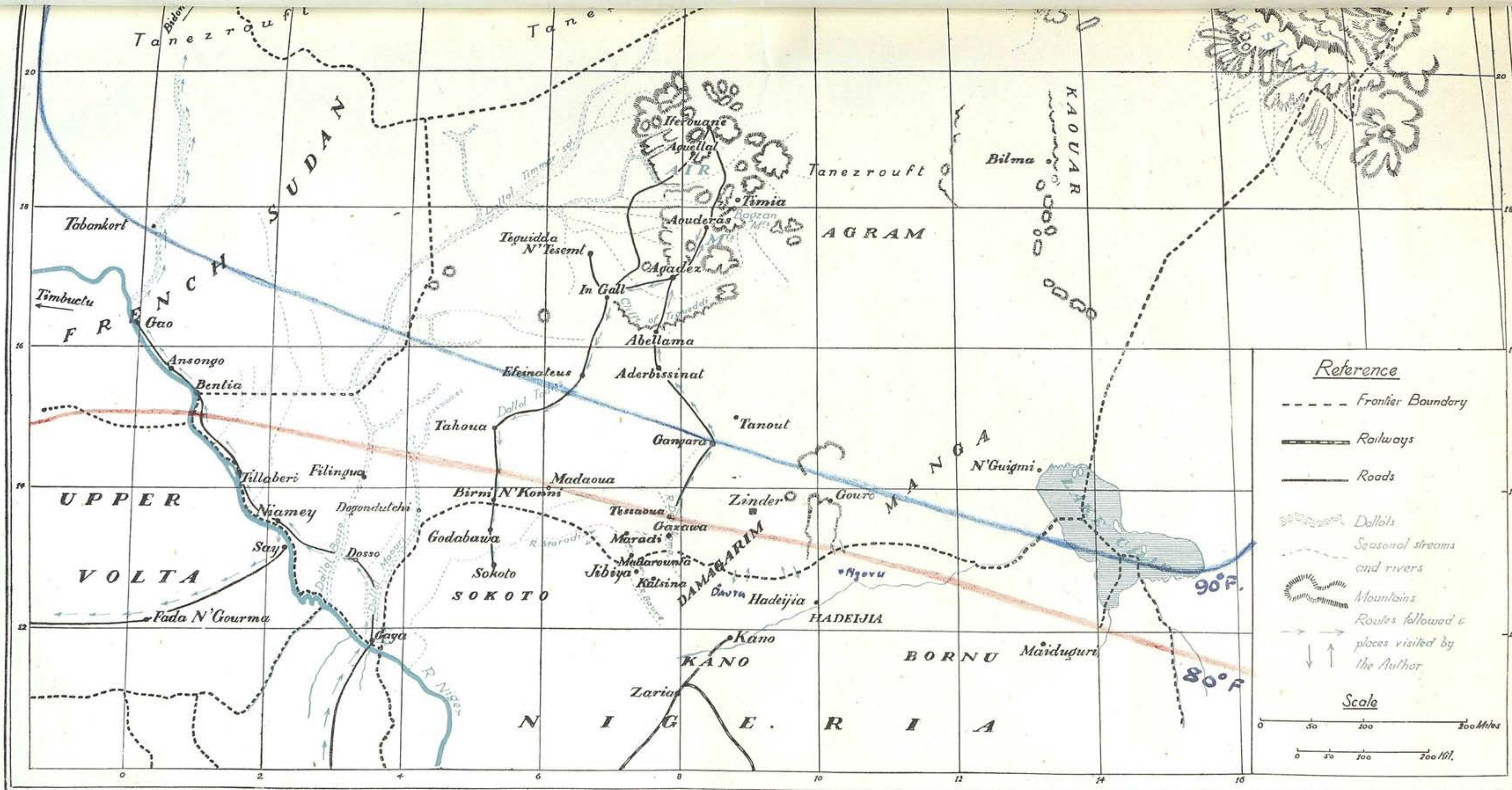


DIAGRAM OF TEMPERATURES

JANUARY AVERAGE 80° F.

JULY AVERAGE 90° F.

CHAPTER 6

POPULATION

The population of the Central Western Sudan is v e ry mixed covering as it does the region in the south, from the middle Niger eastwards to near Lake Chad, and on the north, from the area of the Niger bend near Timbuctu, to the Aïr Mountains. By far the most densely populated area is that of Northern Nigeria wherein the numbers are as high as a hundred per square mile over large areas; the least densely populated region is that of the Niger Colony in the north where the numbers average less than one per square mile.

In Northern Nigeria the region is made up of a number of Moslem states, and some nomadic Muslim cattle people, (the nomadic Fulani or "cattle" Fulani, as opposed to the settled Fulani in the Hausa Emirates). The Muslim states are divided into two, the Bornu region which is an entity in itself, and the remaining Emirates which owe but a nominal allegiance to the Sultanate of Sokoto. The total Hausa population is over three and a half millions and the Fulani just over two millions. In the individual provinces parts of which are within the area under review, Sokoto has a density of 45 to the square mile, Katsina 109 per square mile, Kano 138 per square mile and Bornu 24 per square mile. The city of Kano, which is a large commercial centre has a population which in the trading season, very greatly increases in population; the fuel supply in that area is somewhat of a problem, and is partially met by the fuel plantations made by the Forest Department.

The/

The density of the population has had a very marked effect on the vegetation. Prior to the British penetration at the beginning of the century large areas of forest and woodland remained untouched because of the necessity for the natives remaining near their own defensive areas, which in some cases were quite small; with the advent of the British penetration the natives were able to roam far afield and open up new areas for farming and grazing. The result is that large areas of woodland have been destroyed in recent decades, and only a small portion of it has been saved by forest reservation. The Emirs and the Native Administration officials are now more enlightened and large areas have been reserved in the last five years. As an illustration of this sixty-six reserves proposed by the writer in 1940 have been constituted.

The population in the French Niger Colony is also a most diverse one; the numbers are large and the races and tribes numerous. Abadie, in his description of the population, classifies it under the "race noire" and the "race blanche"; the former is divided into twenty-five different tribes, including the less well known; the more important are the Songhai, Kourtei, Djerma, Maouri, Hausa and Kanuri; the "race blanche" includes the Choua (Shuwa), Ouled-Slimam, Almoussak, Touareg, Bella, Tourbou and Fulani. He records the following figures:-

Niamey and Dosso	484,000
Birnin Konni and Tahoua	133,000
Tessawa	78,000
Zinder	203,000
Gouré	48,000
N'guigmi	57,000
Agades	14,000
Bilma (including Tibesti)	4,000
	1,021,000

The/

The density of the population although it is no guide to the distribution, is 1·04 per square kilometre. In the Niamey - Dosso region the density is approximately 60 per square kilometre, in the central region about 80, and in the desert area nearly zero. There are, however, numerous nomads in the latter area, and only in some re-:gions can a fixed population be assessed. In this connexion the following nomad population figures from Abadie are of interest:-

Agades	2,420	Tanout	42
In Gall	1,175	Timia	400
Teguidda N'Tesemt	420	Aguellal	40
Adouderas	220	Baguezan	250
Iferouane	50	Aderbissinat	5

These figures were recorded before 1927, and they are probably somewhat larger to-day; at Aderbissinat, for instance, visited by the writer in 1939, the popula-:tion was much larger than that recorded by Abadie.

The population is naturally most dense round the larger native towns and round the oases in the desert.

The most important tribes are the Songhai, who occupy the area north and north-east of the Niger bend, the Hausa who are found throughout the central area, the Shuwa who occur between Zinder and Lake Chad, and the Fulani, who have both settled and nomadic sects, who are found throughout the area excepting the desert region. The Fulani are largely cattle people, they are a clever vigorous race, able to ascend to the ruling classes. They have had a very decided effect on the vegetation because of the large cattle population which they control and from which much damage has been caused to the tree vegetation/

vegetation; the cattle, however, are recognised by the native to have a beneficial effect on the soil because of the manure, and some Fulani in Nigeria are paid by the Hausa farmers to bring the cattle onto the farmlands.

The Hausas and the Shuwas are agriculturists and traders and they have greatly altered the climax vegetation by their methods of shifting cultivation, in which the rotation is becoming smaller with the increase in the population.

In Niger Colony as in Nigeria, although forest protection is perhaps better in the former than in the latter, a policy of correct land utilization is desirable, with suitable protection, control and exploitation of the vegetational growth. This problem should be considered internationally and not parochially and separately in the two colonies.

CHAPTER 7

VEGETATIONAL CLASSIFICATION

The vegetation of the Western Sudan is interesting because of its proximity to the Sahara Desert, because of the biotic factors which have influenced and in some places wholly changed it, because of the differences of opinion in regard to its status and classification and finally because no serious attempt has been made intensively to study and record its composition.

The writer considers that vegetationally the northern limit of the Guinea Zone follows approximately the 900 millimetre isohyet, that the Sudan Zone lies approximately within the 900 and 700 millimetres' isohyets, the Pre-Sudan zone between approximately the 700 and 400 millimetres' isohyets and the Sahara zone approximately in the areas of less than 200 millimetres of rainfall in the year; in the latter lie the semi-desert and true desert. A zonal vegetational map is included in this paper. The zonal boundaries do not invariably follow the isohyets which are, amongst other things, influenced by the configuration of the country; in the region south of Agades, for instance the southern boundary of the Saharan zone follows the Cliffs of Tigueddi. These cliffs demonstrate one of the instances of a clear cut delineation of a vegetational zonal boundary with no tension belt, due to the fact that the soil to the south is the sandy one of the Hausaland plain, while that to the north of the cliffs, on the bed of a former sea, is a clayey sand with water-washed pebbles and gravel, supporting an entirely different vegetation.

Under/

Under the three main divisions of the Edaphic moist Woodland, Climatic Dry Woodland and Desert, the following formation-types are described:-

Edaphic Moist Woodland.	Tropical Riparian Woodland.
	Tropical Swamp Woodland.
Climatic Dry Woodland.	Tropical Savanna Woodland.
	Tropical Thornland.
	Tropical Grassland.
Desert.	Tropical Desert.

A classification has been prepared for the Sudan, Pre-Sudan, Pre-Saharan and Desert zones in the Central Western Sudan from an extensive examination of the vegetational types which, as far as the writer is aware, have not been previously recorded for the area. No true picture can be obtained in a list of components in any type of vegetation without an indication of the silvi:cultural dominants, the vegetational or controlling dominants and whether the species are abundant, frequent, occasional, rare or local.

The following symbols are used, therefore, throughout this paper:

E.D. - An emergent dominant, whose crown or the major part of whose crown, emerges above the general canopy.

D. - A dominant, which irrespective of its habit, has a controlling or determining influence on all the vegetation growing in its immediate vicinity and on the remainder of the plant community to which it belongs.

a - Abundant

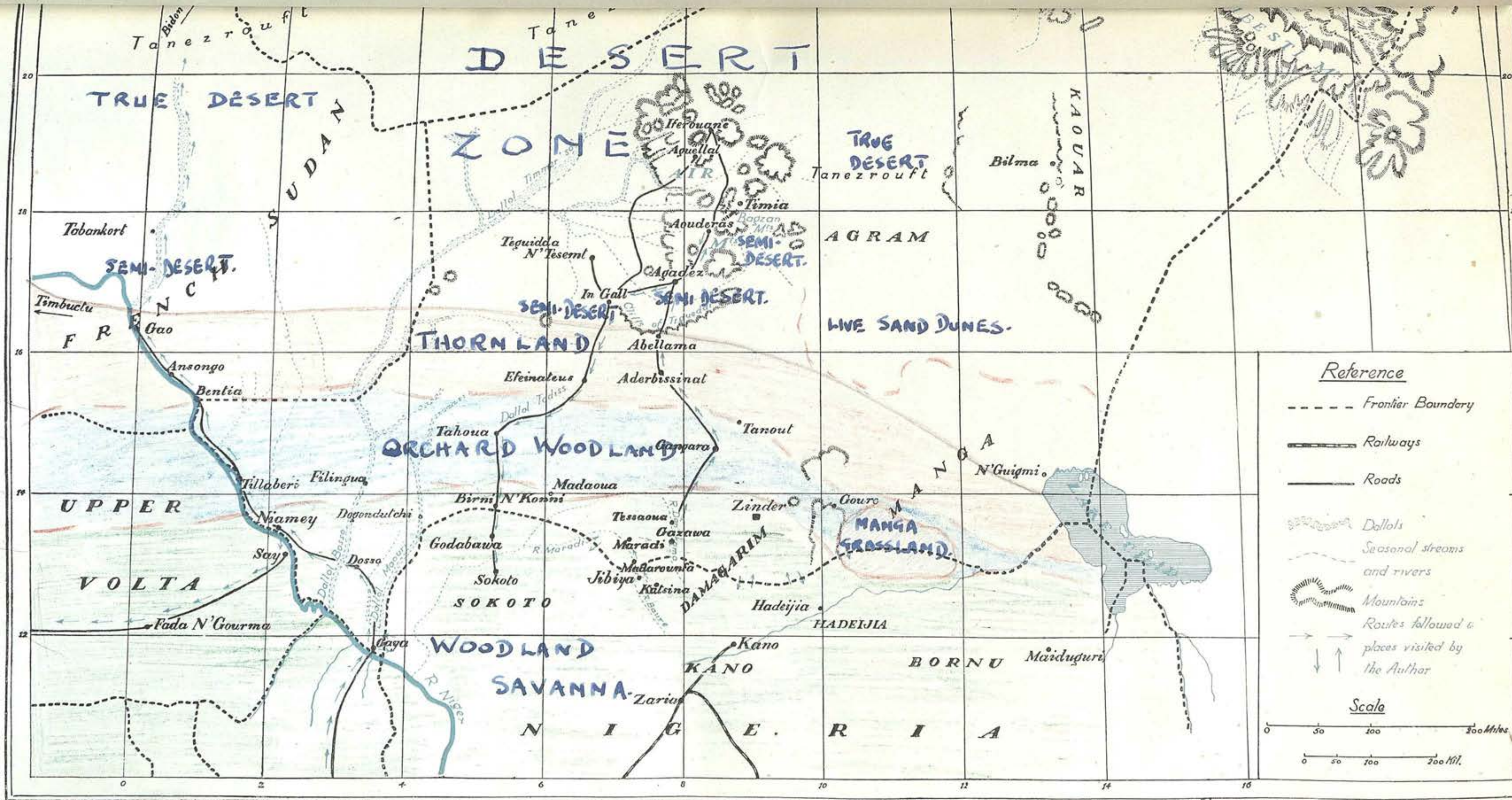
f - Frequent

o - Occasional

r - Rare.

l - Local.

In intensively cultivated areas such as Northern Nigeria and southern Niger Colony, which are almost purely agricultural countries, farms and fallow-land cover a very large percentage of the total area, and tree vegetation is limited/



APPROXIMATE VEGETATIONAL DIFFERENTIATION.

63A.

limited to a certain extent. An endeavour is therefore made to indicate the scrub vegetation of fallow land, where the soil is being allowed to recuperate under the method of shifting cultivation, which in this region must continue to be accepted until better agricultural methods can be introduced. It is only in the vicinity of Kano that permanent cultivation under the system of mixed farming, with its use of cattle and farmyard manure, is found to any extent.

The writer's vegetational classification of the Central Western Sudan is followed throughout this paper, and is based on experience of the types observed in Northern Nigeria and in French West Africa.

The definitions of formation - types, formations, sub-formations, association, and clans are those of Tansley as described in The British Islands and Their Vegetation. Where it is desirable the diagramatic representation of ecological succession is indicated in various formations.

A. Edaphic Moist Woodland.

Formation-Type I.	Tropical Riparian Woodland.
Formation 1.	West African Riparian Woodland.
Sub-formation 1a.	Bamboo Brakes.
Sub-formation 1b.	Dallol Vegetation.
Formation 2.	West African Riparian Thornland.
Formation-Type II.	Tropical Swamp Woodland.
Formation 3.	West African Swamp Woodland.
Formation 4.	West African Swamp Thornland.

B./

B. Climatic Dry Woodland.

Formation-Type III.	Tropical Savanna Woodland.
Formation 5.	West African Woodland Savanna.
Sub-formation 5a.	Inselberg Vegetation.
Sub-formation 5b.	Hill-Scrub Savanna.
Sub-formation 5c.	Combretaceous Scrub.
Formation 6.	West African Orchard Woodland Savanna.
Formation 7.	West African Dry Palm-Stands.
Formation-Type IV.	Tropical Thornland.
Formation 8.	West African Thorn Woodland.
Formation 9.	West African Thorn Savanna.
Formation 10.	West African Thorn Scrub.
Formation-Type V.	Tropical Grassland.
Formation 11.	West African Savanna.
Formation 12.	West African Grass Steppe.
Formation 13.	West African Marsh Grassland.

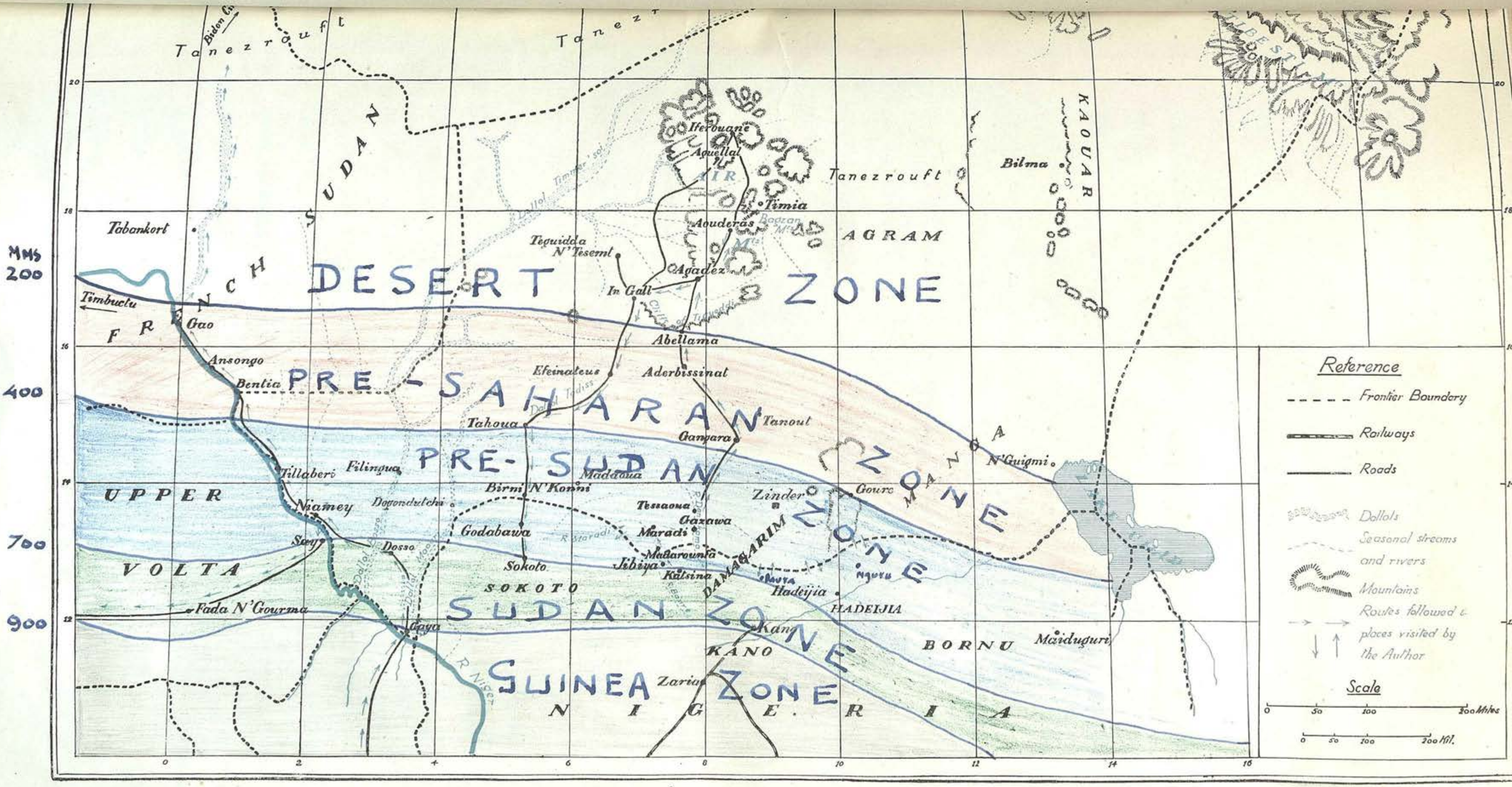
C. Desert.

Formation-Type VI.	Tropical Desert.
Formation 14.	West African Semi-Desert.
Sub-formation 14a.	West African Desert Palm-Stands.
Formation 15.	West African True Desert.

Fifteen formations and six sub-formations are distinguished under the six formation types and all are described in some detail. It is pointed out that, as described more fully later, Schimper is followed with regard to the concept of semi-desert and true desert. He states ... "Transition forms between desert on the one hand, and woodland and grassland on the other are termed semi-desert," and that, "desert ..... originates when, on account of too great drought or cold, climatic conditions are hostile to vegetation". These concepts are accepted by the writer and that part of the true desert which, although it supports no vegetation, has been recorded in the vegetational classification.

With regard to the classification of Acacia raddiana Savi (formerly Acacia tortilis (Forsk.) Hayne), and Acacia seyal Del., the writer would point out that he has collected/

collected specimens of the latter and that they have been authoritatively identified as such, by the late Dr. Burtt Davy and by Mr. A.C. Hoyle of the Imperial Forestry Institute, both of whom have studied specimens from various herbaria, in the field, and from collectors; the writer therefore disagrees with the name Acacia seyal for Acacia raddiana Savi and with Acacia stenocarpa for the true Acacia seyal Del. The association which has at times been called Commiphora africana - Acacia seyal is actually Commiphora africana - Acacia raddiana which is not uncommon in the Central Western Sudan and which, as one would expect, is also found in the Egyptian Sudan.



VEGETATIONAL ZONES.

CHAPTER 8

VEGETAL ZONES

It is now accepted that vegetal differentiation is dependent upon the climate and the amount of rainfall combined with its periodic distribution. In a critical examination of the vegetation of the Central Western Sudan, while it is found that there is a certain variation due to soil and configuration, it is obvious that the vegetation varies both floristically and in habit with the distribution of rain-days and the length of the dry season.

Close examination of the vegetal changes indicates that in general those changes, which are usually gradual, can be reconciled with the climatic factors of rainfall and temperature. It is interesting to note that in the Western Sudan, the isohyets, provided there is no radical change in either the soil or configuration, give reasonably accurate zonal lines of vegetal change. Statistics are required from a large series of meteorological stations before accurate data can be compiled, and it is regretted that such stations are not at present available in areas in Nigeria or elsewhere in West Africa.

It is recognised that climate has more to do with the formation and composition of the soil than the underlying geological formations and the vegetation is dependent both on soil and rainfall. In Silviculture of India [1] Champion has quoted Braun-Blanquet as writing: "All soils have a tendency under certain conditions to develop into a certain type, the soil climax. The soil types of the earth are in the main climatically conditioned; the geological substrata influence soil development only to a small degree as compared with the effects of climatic factors."

A/

1. Vide Silviculture of India. H.G. Champion.

Riparian woodland in the northen Guinea Zone on the road from Niamey to Ouagadougou.

Riparian woodland on the river Volta in the French Sudan.

Riparian woodland at Kalgo on the river Thomas. Anogeissus, Mitragyna inermis, Bauhinia thonningii and Acacia arabica.

A study of the rainfall maps available at present in the area under discussion shows that the isohyets give a good indication of the vegetal changes and there is little difficulty in co-relating with them, the gradual floristic changes in the area. From a careful examination of the isohyets in the Central Sudan and the changes in vegetation in the field, from the northern limit of the Guinea zone to the desert, the writer would record the following zones:-

Guinea Zone	South of the isohyet 900 millimetre.
Sudan Zone	Approximately between the 900 and 700 millimetres' isohyets.
Pre-Sudan Zone	Approximately between the 700 and 400 millimetres' isohyets.
Pre-Sahara Zone	Approximately between the 400 and 200 millimetres' isohyets.
Sahara Desert Zone	Approximately less than 200 millimetres of rain:fall per year.

THE GUINEA ZONE

While the Guinea zone lies to the south of the area under consideration it may be of interest, since it has a distinct influence on the vegetation of the Western Sudan, to give a brief description of its vegetation. In Nigeria, Dahomey and the Ivory Coast it is an area with extensive farmland and it is found that the natural vegetation is for the most part altered, if not partially or wholly destroyed, by the shifting cultivation of the farmers. Speaking generally the vegetation consists of the formation-type Tropical Savanna Woodland, in which the two formations Savanna Woodland and Orchard Woodland Savanna can be recognised. The scrub savanna, which is found on fallow-land, is a transi:tion or seral stage between farmland and savanna woodland, to which, however, it is rarely allowed to revert. To all/

all intents and purposes only the two formations can be considered as climax vegetation under this formation type.

The formation-types Tropical Riparian Woodland and Tropical Swamp Woodland also occur but there is not the floristic difference between them in the Guinea Zone that one can observe in the Sudan and Pre-Sudan Zones.

There is no true Tropical Thornland in the Guinea Zone, but under the formation-type Tropical Grassland, the formations Savanna and Marsh Grassland occur. Ignoring the tension belt between the Sudan Zone and Guinea Zone, the vegetation in the northern portion of the latter is seen in comparison, to be denser, although the trees are smaller in height, and that there is less ground flora, although grass may be more abundant, than in the Sudan Zone. The vegetation of the woodland savanna in Nigeria and the adjacent French Colonies, has a wide range from north to south and changes little between say Zaria in Northern Nigeria and the River Niger at Jebba. In the southern portion the tree vegetation is found to vary from about twenty to forty feet in height, with a fairly dense espacement, while in the northern part in the Orchard Woodland Savanna the trees vary from about fifteen to thirty feet, with a more open espacement.

In the southern portion the following Woodland-Savanna species occur and may be considered fairly typical:-

Daniellia oliveri	ED. a.	Butyrospermum parkii	D. a.
Albizzia brownei	ED. f.	Boswellia dalzelii	D. f.
Albizzia zygia	ED. f.	Detarium senegalense	D. f.
Afromosia laxiflora	ED. f.	Entada sudanica	D. f.
Afzelia africana	ED. f.	Erythrophloeum guineense	D. f.
Antiaris africana	ED. f.	Hymenocardia acida	D. f.
Khaya senegalensis	ED. f.	Stereospermum kunthianum	D. f.
Lophira alata	ED. f.	Syzygium guineense	D. f.
Parkia oliveri	ED. f.	Vitex cuneata	D. f.

Pterocarpus erinace~~o~~us	ED.f.	Adina microcephala	D.o.
Terminalia avicennioides	ED.f.	Bauhinia thonningii	D.o.
Terminalia senegalensis	ED.f.	Celtis integrifolia	D.o.l.
Borassus flabelifer	ED.o.	Crossopteryx febrifuga	D.o.
Ekebergia senegalensis	ED.o.	Eugenia guinensis	D.o.
Lannea acida	ED.o.	Sclereocarya birrea	D.o.
Lannea barteri	ED.o.	Sterculia setigera	D.o.
Paranari macrophylla	ED.l.	Bridelia ferrugineae	f.
Prosopis africana	ED.o.	Cussonia nigerica	f.
Uapaca guineensis	ED.o.l.	Gardenia erubescens	f.
		Gymnosporia senegalensis	f.
		Alchornea cordifolia	o.
		Anthocleista vogelii	o.

In the more northerly portion of the Guinea Zone the following species occur, and where trees are common to both areas, the trees in the northern portion are smaller in height:-

Daniellia oliveri	ED.a.	Hymenocardia acida	D.f.
Anogeissus schimperi	ED.f.	Securidaca longipedunculata	D.f.
Borassus aethiopum	ED.f.	Sterculia setigera	D.f.
Boswellia dalzielii	ED.f.	Tamarindus indica	D.f.
Butyrospermum parkii	ED.f.	Vitex cuneata	D.f.
Detarium senegalense	ED.f.	Acacia campylacantha	D.o.
Entada sudanica	ED.f.	Ficus ieotophylla	D.o.
Khaya senegalensis	ED.f.	Ficus gnaphalocarpa	D.o.
Prosopis africana	ED.f.	Ficus platyphylla	D.o.
Adansonia digitata	ED.o.	Lonchocarpus griffonianus	D.o.
Diospyros mespiliformis	ED.o.	Sclerocarya birrea	D.o.
Lannea acida	ED.o.	Stereospermum kunthianum	D.o.
Lannea barteri	ED.o.	Ziziphus mucronata	D.o.
Lophira alata	ED.o.		
Parinari oliveri	ED.o.	Bombax buonoposense	f.
Psorospermum guineense	ED.o.	Combretum verticellatum	f.
Pterocarpus erinace~~o~~us	ED.o.	Annona senegalensis	o.

Terminalia avicennioides	ED.o.	Cassia arereh	o.
Terminalia glaucescens	ED.o.	Cussonia nigerica	o.
Parinari curatellifolia	ED.l.	Combretum lecananthum	o.
Parinari macrophylla	ED.l.	Combretum leonense	o.
		Heeria insignis	o.
Isoberlina doka	D.a.		
Bauhinia thonningii	D.f.		
Commiphora africana	D.f.		

The following small tree and shrub species also occur:-

Guiera senegalensis	f.	Gardenia erubescens	o.
Annona senegalensis	o.	Ximenia americana	o.
Bauhinia rufescens	o.		
Cassia aschrek	o.		
Cassia sieberiana	o.		
Dichrostachys glomerata	o.		

The riparian woodland in the northern portion of the Guinea Zone is a subject of certain argument. The writer believes that these are not relics of an extensive higher type of vegetation in a climatic phase of a previous geological age, but climax vegetation which is an outlier of the tropical forest, and has reached and retains its present status because of telluric moisture coupled with the presence of a good and sufficiently deep soil to support such a type of vegetation. These tongues of forest or closed woodland running into the area of Savanna almost invariably occur in depressions or valleys, in which there is usually perennial flowing water or available water, at no great depth.

The species found in these tongues of vegetation are closely akin to the mixed deciduous forest which occurs much further south near the tropical high forest. While these outliers are akin floristically they do not have the same height or size, nevertheless they are of great value in that they can provide timber, protect the rich soils of the valleys and prevent both erosion and shortening of the period of flow of the rivers and streams. Amongst the species found in these 'outlier' forests are:-

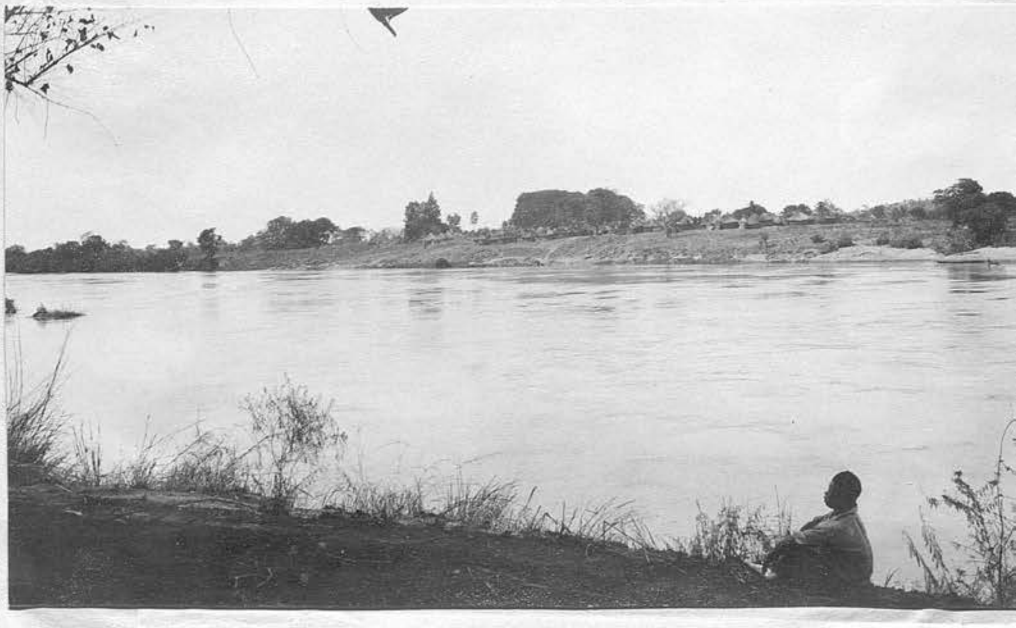
Antiaris africana	ED. f	Lophira alata	D. o
Afzelia africana	ED. f	Prosopis africana	D. o
Khaya grandifoliola	ED. o	Sarcocephalus esculentus	D. o
Khaya senegalensis	ED. f	Adina macrocephalla	f
Piptadenia kerstingii	ED. f	Hymenocardia acida	f
Chlorophora excelsa	ED. o		
Albizia brownei	D. f	Uapaca guinense	D. f.l.
Berlinia auriculata	D.f	Erythrina senegalensis	D. f
Celtis intergrifolia	D.f	Eugenia guinensis	D. f
Diospyros mespiliformis	D.f	Kigelia aethiopica	D. o
Ekebergia senegalensis	D.f.	Lonchocarpus griffonianus	D.o

There is no great difference between the riparian and swamp woodland in the northern portion of the Guinea Zone, partly due to the fact that there are not the areas of seasonal swamps, (owing to the configuration and to better drainage), that are found further to the north in the Sudan Zone. Where they do occur the species are the more typical ones of the riparian woodland, such as *Celtis integrifolia*, *Albizzia brownei*, *Lophira alata*, *Bauhinia thonningii*, *Uapaca guinense*, *Diospyros mespiliformis*, *Erythrina senegalensis* and *Hymenocardia acida*.

These notes therefore give an idea of the composition of the more important vegetation types to the south of the Sudan Zone. They are representative of the area some two hundred miles to the south of the latter and there is a very wide tension zone between the two.

Examples of the vegetation of the Guinea Zone occur in the southern limits of the areas under discussion, principally in the Fadan Gourma area of south-west Niger Colony; they also occur in the White Volta between Fadan Gourma and Ouagadougou, but rather surprisingly, there is no riparian woodland or forest on the River Niger in the Gaya area, which is a region of open grassland and scattered trees, which can be seen from the panoramic photograph of the Niger at Gaya.

It is an interesting physiological fact that the height of the trees of the savanna woodland and orchard woodland areas with an average height of 25' in the Guinea Zone, is much smaller than those of the southern Sudan Zone where the trees may average about 35 feet, and larger trees such as Khaya senegalensis and Ceiba pentandra may attain a height of 80 feet.



The River Niger near Gaya, showing the scattered nature of the vegetation in the area.

Back water of the river Niger at Gaya.

(A.P.A. LAMB).

Open savanna woodland in southern Niger Colony
north of the Nigerian frontier at Jibiya.

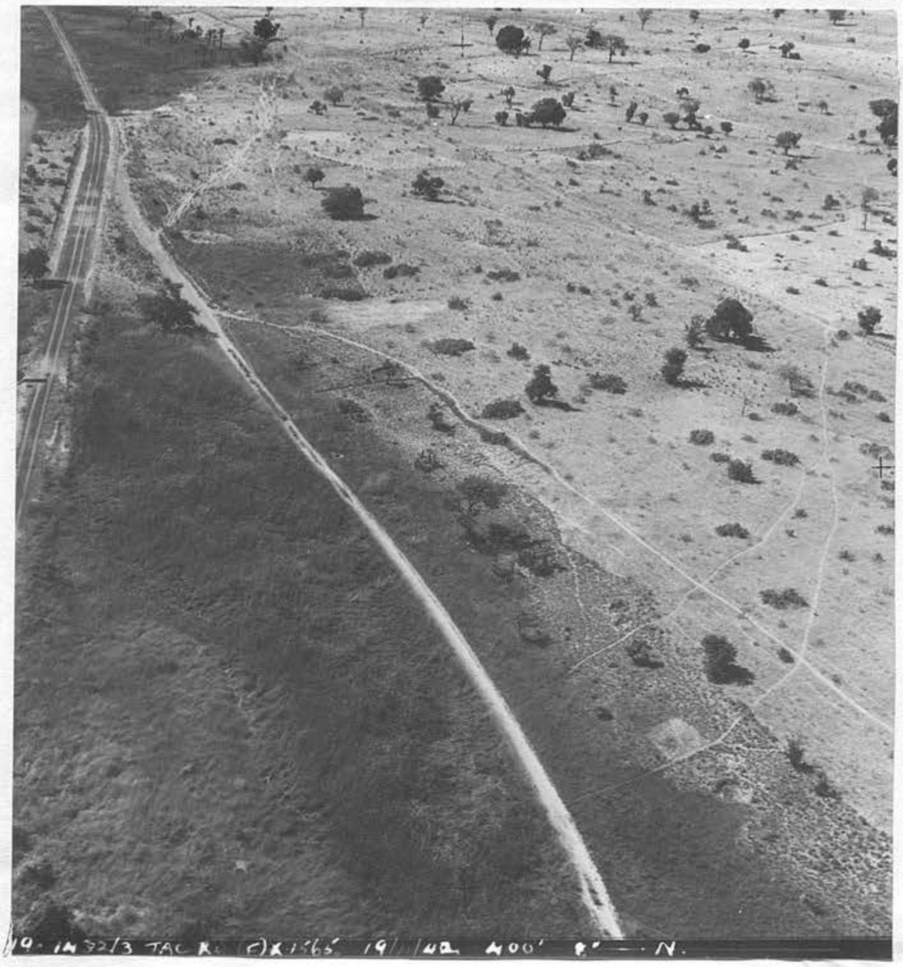
THE SUDAN ZONE

The Sudan zone lies in the comparatively narrow belt between the 900 and 700 millimetres' isohyets. It appears to be approximately fifty miles in depth and its southern boundary runs approximately through Fadan Gourma, Gaya, Birnin Kebbi, and Kano, while the northern boundary runs approximately through Say, Dosso, Sokoto, Katsina, Daura and Nguru. The tension belt on the northern boundary is very narrow indeed, and in Sokoto, Katsina and Kano provinces in Nigeria, it is possible almost to say that north of a certain line the pre-Sudan vegetation appears.

The Sudan vegetation is taller than that of the northern Guinea zone but the trees are less dense, the ground flora is more frequent and grass more abundant. There are few areas exhibiting the climax growth because of the extensive cultivation, and it is practically only in forest reserves in Nigeria and in the unfarmed areas in French territory, that one can observe the climax type of vegetation.

The following species occur in the Sudan zone:-

Acacia albida	ED.f.	Acacia senegal	D.o.
Adansonia digitata	ED.f.	Bombax buonopozense	D.o.
Anogeissus schimperi	ED.f.	Cassia arereh	D.o.
Parkia oliveri	ED.f.	Cassia aschrek	D.o.
Tamarindus indica	ED.f.	Cassia sieberiana	D.o.
Borassus aethiopum	ED.o.	Combretum ellottii	D.o.
Butyrospermum parkii	ED.o.	Combretum passargei	D.o.
Celtis intergrifolia	ED.o.		
Khaya senegalensis	ED.l.	Detarium senegalense	D.o.
Prosopis africana	ED.o.	Hyphaene thebaica	D.o.
Acacia seyal	D.a.	Lannea acida	D.o.
Bauhinia thonningii	D.a.	Lannea barteri	D.o.
Sclerocarya birrea	D.a.	Pterocarpus erinaceous	D.o.
Acacia arabica	D.f.	Securidiaca longipedunculata	D.o.
Balanites aegyptiaca	D.f.	Terminalia avicennioides	D.o.
Commiphora africana	D.f.	Vitex cuneata	D.o.
Diospyros mespiliformis	D.f.	Acacia sieberiana	D.l.
Sterculia setigera	D.f.	Parinari macrophylla	D.l.



The east bank of the former river valley north of Matamaye.

Forest of thorn woodland south of Zinder. Tension belt between the Sudan and Pre-Saharan zones. Vegetation includes Acacia arabica, A. seyal, A. senegalensis, Balanites aegyptica and Ziziphus mauritiana.

Scrub vegetation of the tension zone. The north boundary of the Sudan zone. Vegetation includes Terminalia avicennioides, Balanites, Acacia albida, Commiphora africana, Cassia singueana, Sclerocarya birrea, Bauhinia thonningii, Annona, Combretum verticellatum and various grasses.

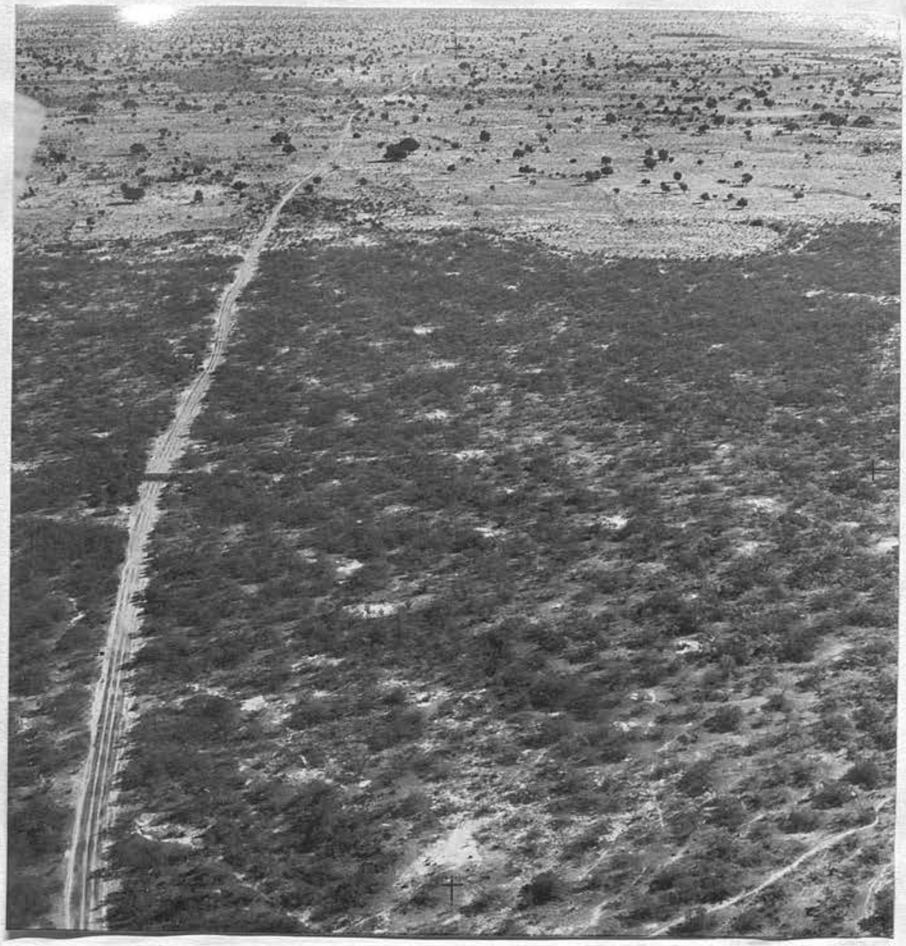
The vegetation south of Zinder which is probably climax vegetation on the southern boundary of the Sudan Zone.

Combretum micranthum	a.	Annona senegalensis	o.
Guiera senegalensis	a.	Boscia angustifolia	o
Ziziphus mauritiana	a.	Boscia salicifolia	o.
Bauhinia rufescens	f.	Boscia senegalensis	o
Combretum verticellatum	f.	Cassia singueana	o.
Dichrostachys glomerata	f.	Feretia canthioides	o.
Ziziphus spina-christi	f.	Gardenia erubescens	o.
		Grewia mollis	o
		Leptadenia lancifolia	o.
		Lonchocarpus griffonianus	o.
		Ximenia americana	o.
		Ziziphus mucronata	o.

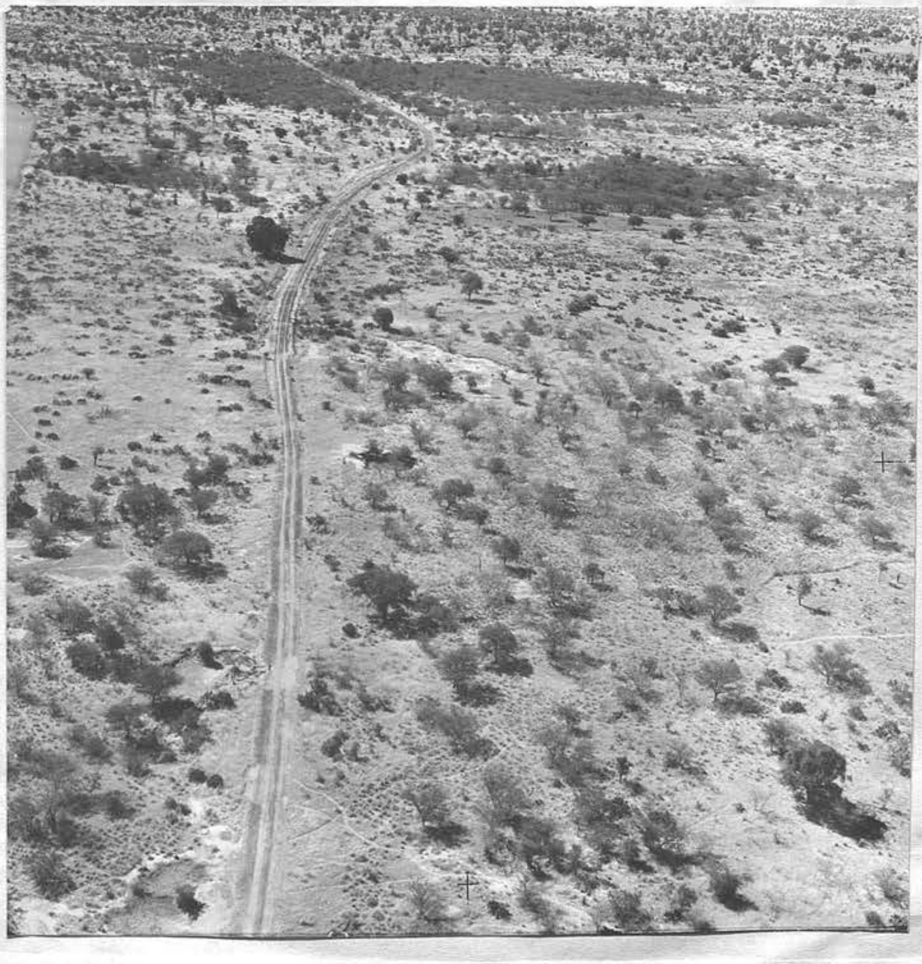
It will be noted in a list of species occurring in the Sudan zone there are a number common also to the northern Guinea zone, but in many cases the habit is slightly different and the height less in the former than in the Guinea zone. New species appear which are better able to stand a smaller and a more irregular rainfall and also a poorer type of soil. Some areas occur in which the soil is better and where more moisture is available, such as in river valleys or stretches of swamp, and there the species exhibit the same habit as they do in the Guinea zone.

PRE-SUDAN ZONE.

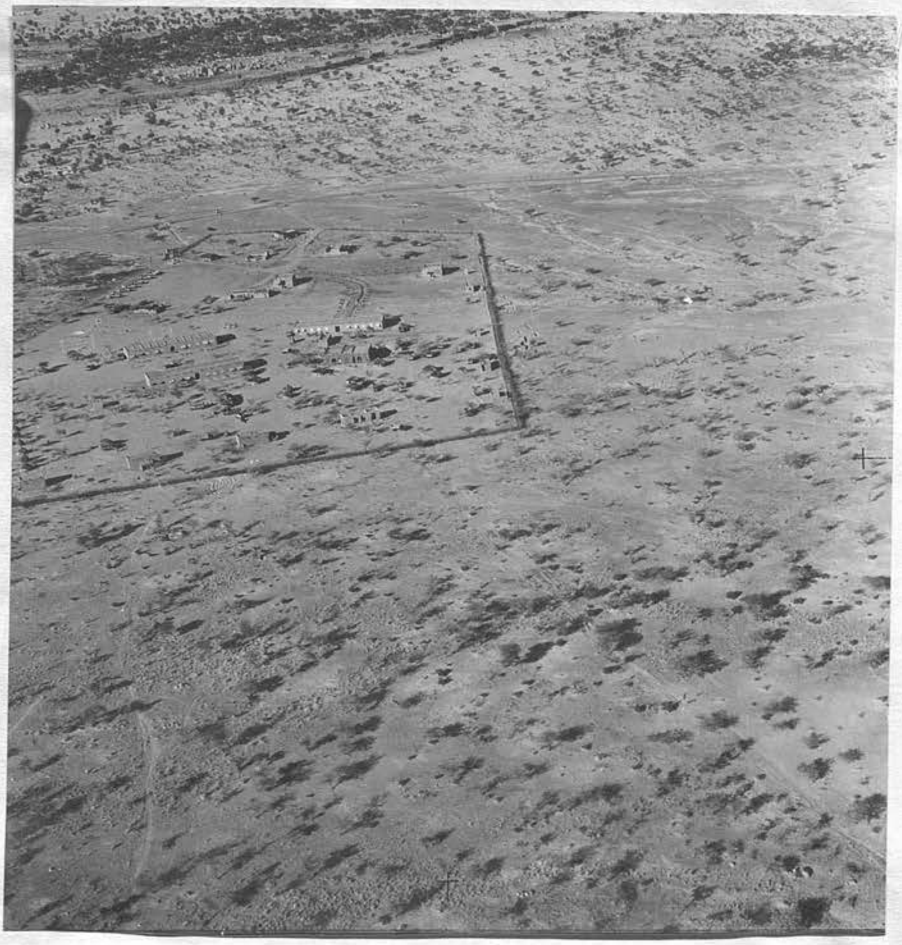
This zone lies approximately between the 700 and 400 millimetres' isohyets and the northern boundary lies, in general, on the line through south of Bentia on the Niger, Tahoua, Gangara (on the road from Tessawa to Agades), and Zinder. It will be noticed that the boundary is much further north on the west than on the east and the isohyets actually curve towards the south-east in the area under review. The line crosses the road from Magariya to Zinder some seventeen miles south of Zinder, at a point where the pre-Sudan and pre-Saharan zonal boundary is most distinct, the /



An example of almost continuous thorn scrub on a degraded type of soil south of Matamaye.



A consociation of Acacia seyal in a moist depression south of Takieta. Guiera scrub and grass tussocks can be seen in the foreground.



Military camp south of Zinder showing scattered remnants of Acacia seyal in the foreground. This should be compared with the photographs opposite page 77.

Low oblique of Zinder from the west, showing scattered Acacia albida and Acacia seyal in the distance.

the type of vegetation changing in a little over a mile, the tension belt being extremely and most unexpectedly narrow. The two photographs taken on the north and south boundaries of the tension belt demonstrate the difference in vegetation quite clearly.

The flora of the pre-Sudan has definite affinities with that of the Sudan zone, but on the other hand is ab-:solutely distinct from that of the pre-Saharan zone; the list of species, (and their frequencies), occurring in both show the very clear differentiation.

Again the species in the pre-Sudan zone are smaller in size than those of the Sudan zone, although some striking exceptions occur, as, for instance, when Khaya senegalensis with a height of over fifty feet, with a very large luxuriant crown, appears in the depressions of former river valleys of the Quaternary period. A photo-:graph of this species taken on the road from Sassumburum to Matamaye, clearly demonstrates this and similar examples were seen at Angua Biri only thirty-one miles south of Zinder.

The following species occur in the pre-Sudan zone:-

Acacia albida	ED.f.	Securi~~d~~daca longipedunculata	D.o.
Anogeissus schimperi	ED.f.	Vitex cuneata	D.o.
Balanites aegyptiaca	ED.f.	Ziziphus mauritiana	D.o.
Diospyros mespiliformis	ED.f.	Ziziphus spina-christi	D.o.
Hyphaene thebiaca	ED.f.	Acacia macrostachya	f.
Lannea acida	ED.o.	Boscia angustifolia	f.
Lannea barteri	ED.o.	Cassia singueana	f.
Prosopis oblonga	ED.f.	Combretum verticellatum	f.
Sclerocarya birrea	ED.f.	Commiphora africana	f.
Tamarindus indica	ED.f.	Guiera senegalensis	f.
Acacia arabica	D. f.	Annona senegalensis	o.
Acacia seyal	D.o.	Bauhinia rufescens	o.
Bauhinia thonningii	D.a.	Calotropis procera	o.
Cassia arereh	D.o.	Leptadenia lancifolia	o.
Entada sudanica	D.o.	Maerua crassifolia	o.
Lonchocarpus griffonianus	D.r.		

Thorn scrub one mile east of Zinder. Almost pure Acacia seyal with some Boscia senegalensis, Acacia arabica and Combretum macranthum. Looking towards the east.

Thorn scrub one mile south-east of Zinder, looking west to the hill Dutsin Bidawa. Vegetation includes Acacia seyal, Boscia senegalensis, Acacia arabica and Combretum micranthum.

Photograph corresponding to the ground photograph above, showing thorn vegetation, the hill Dutsin Bidawa in the middle distance and the aerodrome in the distance.

THE PRE-SAHARAN ZONE.

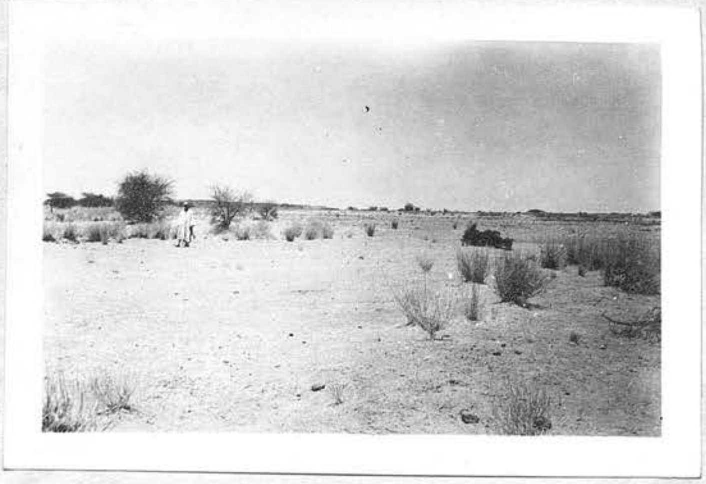
The vegetation of the pre-Saharan zone, is totally different from that of the vegetal zones to the south, although some Sudan species occur in it and, conversely, some pre-Saharan species occur in the Sudan zone. The floristic difference however is very apparent to the observer, and the comparisons of the frequencies show how diverse this zone is. Its northern boundary runs from north of Gao on the River Niger east to In Gall, and thence follows the cliffs of Tigueddi to the east of the road from Aderbissinat to Agades, thence it curves towards the south-east on the eastern boundary of the area being described.

It follows, therefore, approximately the 400 millimetre ioshyet on the south and the 200 millimetre isohyet on the north. The rainfall is irregular in distribution, and falls mostly in the months of August and September, although it may be experienced in other months. The soil is for the most part a sandy one although there are large areas of lateritic soil in the southern portion of the zone, as, for instance, near Tahoua and Gangara on the road from Tessawa to Aderbissinat.

The species are small in number and are, for the most part, xerophylious; the Acacias have a numerical preponderance.

The following species occur in the pre-Saharan zone:-

Acacia arabica	ED.o.	Bauhinia rufescens	D.r.
Acacia laeta	ED.f.	Boscia angustifolia	D.o.
Acacia seyal	ED.o.	Boscia senegalensis	D.f.
Acacia raddiana	ED.a.	Combretum micranthum	D.r.
Balanites aegyptiaca	ED.o.	Combretum verticellatum	D.f.
Bauhinia thonningii	ED.r.	Hyphaene thebiaca	D.l.
Celtis integrifolia	ED.r.	Cadaba farinosa	o.
Commiphora africana	ED.f.	Bauhinia rufescens	o.
Maerua crassifolia	ED.a.	Calotropis procera	o.
Mitragyna inermis	ED.r.	Cassia obovata	o.
		Cassia tora	o.
		Leptadenia lancifolia	f.
		Ziziphus mauritiana	f.



Thorn scrub immediately to the south of the Cliffs of Tiguiddi on the road to Agades. Vegetation consists of Acacia raddiana, Balanites aegyptica, Maerua crassifolia and Boscia senegalensis.

The Petit Tadiss Dallol north of Tanoua. The right bank of the dallol is seen in the distance. The vegetation consists of Acacia laeta, A. seyal, Balanites aegyptica and Bauthonningii.

Thorn scrub near the Cliffs of Tigueddi showing Acacia raddiana, Maerua crassifolia, Balanites aegyptica and Boscia senegalensis.

Gao from 8,000, illustrating the absence of vegetation in the vicinity of the River Niger, and the desert conditions even on the outskirts of the town.

Flats of the river Niger at Gao. Compare with aerial photographs.

THE DESERT ZONE.

The formations Semi-desert and True Desert constitute the Desert zone and it will be shown under their descriptions how vastly different they are. This zone approximately is bounded on the south by the 200 millimetre isohyet, but is by no means rigid because of various contributory factors including soil, rain, altitude, and configuration generally. It should be noted that although the desert is hostile to all vegetation, the trees and shrubs occur, but are stunted and gnarled; the soil supports the vegetation, including herbs and grasses, which can remain alive in spite of the severity of the climate.

True desert conditions were observed by the writer in the Bagzan area of the Aïr Mountains, and in the Tanezrouft north of Tabankort, in the north-western portion of the area being described.

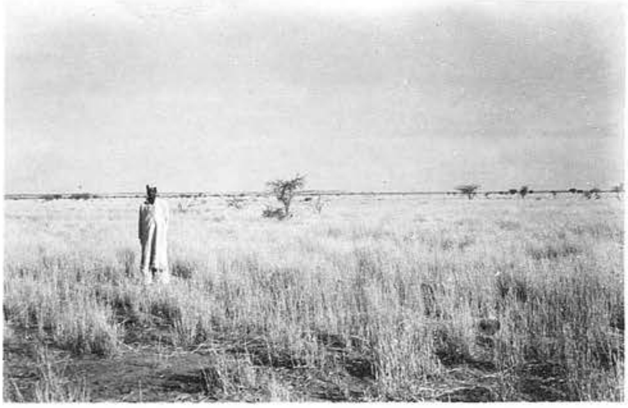
In the latter true desert occurs, for the area supports no sign of life, no vegetation, no birds or animals, - indicating the final phase described by Abadie as 'le desert dans le desert'.

The following species were recorded by the writer in the Aïr Mountains and in the semi-desert in other areas in the Western Sudan:-

Acacia raddiana	a.	Cadaba farinosa	o.
Acacia seyal	f.	Calotropis procera	o.
Boscia senegalensis	f.	Cassia obovata	o.
Hyphaene thebiaca	f.	Commiphora africana	o.
Maerua crassifolia	f.	Leptadeniam spartium	o.
Salvadora persica	f.	Ziziphus mauritiana	o.
Acacia arabica	o.		
Acacia ataxacantha	o.		
Balanites aegyptiaca	o.		

~~Aubreville~~ /

Thorn savanna at the well of Eliki, south of Aderbissinat. The vegetation consists of Acacia seyal, Acacia arabica, Balanites aegyptica and Ziziphus mauritiana.



Xerophilous grassland with scattered trees, west of Agades on the road from Agades to In Gall. The trees consist of Acacia raddiana and the gras provides good grazing for the local cattle.

Clay flats on the road from Agades to Teguiddan Tessoum. There is some grass vegetation .

Riparian woodland in the Jibiya reserve.
Note Borassus, Anogeissus schimperi and Acacia
albida.

CHAPTER 9.

A. EDAPHIC MOIST WOODLAND..

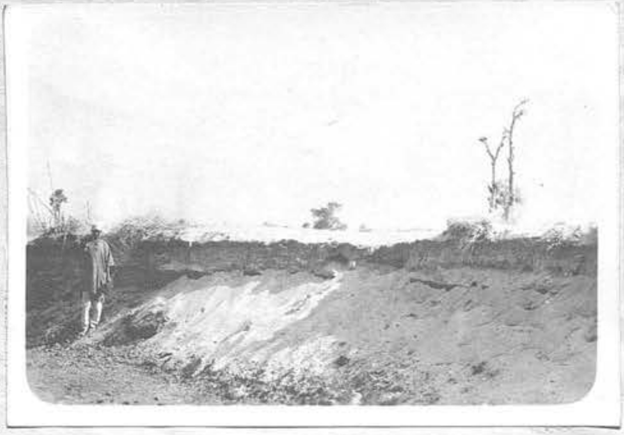
FORMATION TYPE I. TROPICAL RIPARIAN WOODLAND.

Formation 1 - West African Riparian Woodland.

This inextensive formation which in Northern Nigeria and the adjacent territory has decreased very considerably in the last two decades with the increase in cultivation, is almost wholly dependant on telluric moisture. It differs floristically, as will be shown from enumeration records, from the edaphic formation of swamp-woodland, which occurs in the vicinity of perennial swamps, seasonal swampland and on areas in which the water table is near the surface. The Riparian Woodland attains a greater height in the southern portion of the area; a reduction in height (of ten to fifteen feet), may be seen as one travels northwards for say fifty miles when less telluric moisture is available, although floristically the composition is the same. Thorn thickets occur in this formation,but are described separate-:ly under the association thorn-thickets.

Riparian woodland is frequently dense and approaches close-canopied tree growth, yet with sufficiently light a canopy in certain areas to allow of some scrub and grass growth. There is occasionally a subordinate tree layer with an average height of twenty feet, and there is finally a third, the shrub layer. This is the type of woodland which could provide a small demand for building timber in the southern portion of the area,and arrangements are being made to exploit it in the present economic and welfare development plans.

This /



Portion of exposed and eroded river-bank on the River Jibiya north of the forest reserve.

Portion of the River Jibiya bank protected inside the Jibiya forest reserve.

This formation does much to prevent the quick loss of rain water and to protect the river banks and soil adjacent to the rivers. It is regrettable that so much of it has been widely destroyed by farmers with consequent loss, by river flooding, of much fertile soil and in places, of actual land. Protection of the trees growing on the river banks would have been invaluable. In the Jibiya area of northern Katsina it has been proved by the writer by actual surveying and plotting of the banks, that a considerable area of land has been lost in the last five years by the breaking down of the river banks. At the original suggestion of the writer, fifteen feet from the high-water level of the rivers has been protected in the Native Authority Forestry Rules for the Northern Provinces of Nigeria, introduced legally in July 1943. This also applies to the vegetation for fifteen feet on both sides of all permanent motor roads, dry-season roads, cattle routes, trade routes and main paths. Photographs of the River Jibiya area in July 1940 are included and the farmland lost between July of 1940 and March of 1944 has been plotted, as shown in the ground plan, over a distance of 500 feet; ·25 acres of good farmland have been lost in four years.

In Northern Nigeria species such as Butyrospermum parkii and Khaya senegalensis may grow to heights of sixty and seventy feet in riparian woodland, an interesting and unexpected sight in a region where the savanna woodland is some thirty feet high.

When riparian woodland is totally destroyed it is difficult for nature to replace it even with rigid protection from man and fire, and it seems it can now never be so luxuriant or so numerous in species as it was originally; this is not necessarily true, of course, of the same type in the Guinea zone.

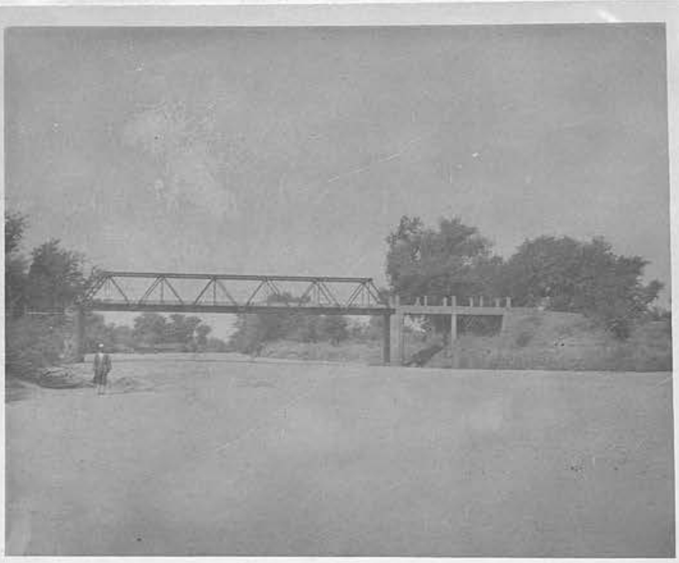
Riparian woodland occurs only in the southern portion of/

of the Western Sudan and it is at times surprisingly inter-:mittent and almost inexplicably missing. The best woodland is found in north-eastern Sokoto province, and in the northern Katsina and Kano provinces of Nigeria. Good examples are found in small areas of Niger Colony, such as that along the River Dankama, (aerial photographs of which are included), along portions of the rivers flowing into the Sokoto river and thence into the River Niger. Examples of it are also found on the tributaries of the Niger crossing the road from Say to Fadan Gourma and Ouagadougou. This type of woodland is conspicuously absent in the region of Gaya, Say and Niamey on the Niger; a panoramic photograph of this river at Gaya, shows how devoid of trees are the river banks.

The presence of a dense and healthy belt of riparian woodland in the area between Dankama and Gazawa on the river Dankama, (which later becomes the river Maradi), inclines one to the belief that it is a relic of a local higher type of vegetation having occurred in the shallow valley in comparatively recent times. It was certainly more extensive in 1851 when that patient and meticulous observer, scientist and explorer, Dr. Barth, recorded that near Dankama he saw elephant tracks and that one of his followers saw an elephant disappearing into the forest. There are no elephant in this area today. Nor would Barth use the word forest without some justification. His descriptions of the vegetation in the regions he covered are most interesting, and are valuable for the comparison with the vegetation of today.

A complete enumeration of the trees and shrubs in a representative area, (measuring ten chains by one chain), of this formation south of Agie in southern Niger Colony gave the following results:-

Species	2 - inch diameter classes.													Total	Per-cent-age.
	0·2	24	46	68	810	1013	1214	1416	1618	1820	2022	2224	24		
Acacia albida													1	1	·431
Acacia arabica	8								1					9	3·879
Acacia ataxacantha	16													16	6·896
Anogeissus schimperi		5			4	3	4			3		3	2	24	10·344
Crataeva adansonii	4		1		3	6	5			2				21	9·051
Combretum micranthum	3													3	1·293
Diospyros mespiliformis	17	4	7	12	9	9	8	5	3		2	2	6	84	36·204
Ficus iteophylla													1	1	·431
Fluggea virosa	6	4	2											12	5·172
Hippocratea richardiana	12													12	5·172
Mitragyna inermis	8	4	3			4	3				4		1	27	11·637
Tamarindus indica					1	1								2	0·862
Ziziphus mucronata	15	5												20	8·620
TOTALS	89	22	13	12	17	23	20	5	4	5	6	5	11	232	99·992



Madarunfa bridge showing almost pure Acacia albida.

South of the Madarunfa bridge at the road junction. The vegetation includes Acacia, Ficus, Tamarindus, Diospyros, Bauhinia and Cassia.

Madarunfa bridge from the north. The vegeta-:tion includes Ficus ieotophylla, Bauhinia thonningii and Acacia albida.

The following species and their frequencies have been recorded in riparian woodland:-

Tamarindus indica	ED.f.	Raphia vinifera	D.o.
Anogeissus schimperi	ED.f.	Vitex cuneata	D.o.
Mitragyna inermis	ED.f.	Ficus iteophylla	D.r.
Acacia albida	ED.o.	Ficus platyphylla	l.
Borassus aethiopum	ED.o.	Sterculia setigera	D.l.
Khaya senegalensis	ED.o.	Acacia ataxacantha	o.
Hyphaene thebaica	ED.o.	Acacia camplyacantha	o.
Butyrospermum parkii	l.	Acacia sieberiana	o.
Diospyros mespiliformis	a.	Combretum micranthum	o.
Acacia arabica	D.f.	Crataeva adonsonii	o.
Balanites aegyptiaca	D.o.	Fluggea virosa	o.
Bauhinia thonningii	D.o.	Hippocratea richardiana	o.
Boswellia dalzielii	D.o.	Maerua crassifolia	o.
Pterocarpus erinaceus	D.o.	Ziziphus mucronata	o.
		Dichrostachys glomerata	l.
		Mimosa pigra	r.
		Oxytenanthera abyssinica	l.

The following species form part of the ground flora in this formation:-

Andropogon gayanus	Guiera senegalensis
Cassia tora	Gymnosporia senegalensis
Cenchrus biflorus	Ipomea repens
Combretum micranthum	Leptadenia lancifolia
	Pennisetum pedicellatum

Thickets are of frequent occurrence in riparian woodland and are of considerable importance in this formation. The thorn thicket association is of importance as it serves to /

to protect, build up and conserve the soil; it protects river banks and the adjacent ground and provides cover and binding to a soil which, with the inevitable openings in the woodland, would otherwise become exposed and subsequently bare. The soil is frequently clayey and therefore once it has lost the necessary surface vegetation, it becomes cracked and fissured and, with leaching, produces a soil surface on which it is difficult, if not impossible, for any vegetation to exist; when the soil is a sandy one, disintegration quickly follows after the vegetation is destroyed or removed.

These thickets also protect the soil from insolation and radiation, which are important factors in the Sudan area. Herbs, grasses and leaves and, further north, sand collect at the bases of the numerous stems, which usually occur in clumps, and the seeds of the woodland species and thickets have an opportunity of germinating and producing seedlings which, with protection, can establish themselves. The leaves, grasses and other vegetative material also disintegrate in time to form soil, which though it may not be highly fertile, is of consider:able value and is not the poor degraded soil that would result if there was no protection, and soil erosion generally, would be produced if not accelerated.

The thorn thickets bind the soil in the vicinity of rivers and streams and will cover and support almost vertical banks. This is most clearly demonstrated on the River Jibiya in northern Katsina province, where within the forest reserve, as the photographs included show, the banks are almost vertical but are wholly protected, while outside the reserve they are exposed, heavily eroded, unstable and can be very easily broken down by man, cattle, rain and, not least, by the river. As a result many acres of farmland have been washed away by the rivers in recent years. The accompanying/

accompanying diagram[(a)] of the line of the river bank on a portion of the River Jibiya, two miles north of the town, in 1939 and in 1944 is illuminating and shows how rapidly the banks can be broken down and large areas of farmland lost along such rivers. It was as a result of these observations that legislation was effected with regard to the full protection of the vegetation fifteen feet from the banks of all rivers and streams.

In the thorn thickets of riparian woodland south of Agie in Tessawa district of Niger Colony the following species were found to occur:-

Acacia albida	ED.f.	Combretum micranthum	o.
Acacia arabica	ED.o.	Dichrostachys glomerata	D.a.
Acacia ataxacantha	D.a.	Guiera senegalensis	o.
Acacia macrostachya	D.o.	Mimosa pigra	D.f.
Acacia senegal	D.o.	Ziziphus mauritiana	D.f.
Acacia seyal	o.	Ziziphus spina-christi	ED.o.
Acacia sieberiana	f.		

The following herbs and grasses also occur:-

Andropogon gayanus	o.	Ipomea ripens	o.
Cassia tora	f.	Leptadenia lancifolia	o.
Cenchrus biflorus	o.	Pennisetum pedicellatum	o.
Gymnosporia senegalensis	o.		

When thorn thickets are lightly cut over such as for farming purposes, regrowth is usually rapid and little damage is done; when the thickets are severely cut back for fuel or for farming then the stronger thorny species such as Acacia albida, Acacia ataxacantha, Mimosa pigra and Ziziphus mauritiana are the first to recover and partially to cover the/

a. Vide paper on Forestry Research.

the area; the less strong species such as Acacia arabica, Acacia seyal, Combretum micranthum and Guiera senegalensis may or may not reappear and in fact the association, poor as it is originally in species, is likely to degenerate floristically.

When the thorn thickets are completely destroyed with removal of the stumps and roots in farming operations, then intermittent scrub savanna in the woodland savanna and intermittent thorn scrub in the thornland area, result, and will degenerate to low scrub and grassland, reaching the final stage of an exposed lateritic or clay soil, or of unstable sand with little or no binding vegetation of grass or weeds.

Once the stage of intermittent low thorn-scrub is reached, then there is merely a poor vegetal covering to the soil, which is quite unable to conserve atmospheric precipitation or to effect soil adhesion and protection; accelerated erosion quickly follows with gullying and breaking-down of the ground, and finally there occurs loss of parts or of long stretches of the river banks, proving that the thorn thickets are of very real value in protecting the soil, reducing the run-off of surface water, conserving atmospheric precipitation and preventing erosion and loss of river banks and of farmland.

SUB-FORMATION (1a) BAMBOO BRAKES.

The so-called 'bamboo' brakes are uncommon. They are almost invariably found in close proximity to riparian woodland in the area of the southern Central Western Sudan. This 'bamboo', Oxytentanthera abyssinica is /

is actually a tall bamboo-like woody species belonging to the Gramineae; it may grow to a height of thirty or even fifty feet, although this is uncommon in the area under review, where it attains an average height of about twenty feet. It is found throughout West Africa.

It is interesting to note that Chevalier records the common Bamboo, Bambusa vulgaris Schrad, to be sub-spontaneous in the forests of Liberia and the Ivory Coast,

Oxytenanthera is common on the banks of the hill streams in the Jos Plateau mountain area in Nigeria where it is most prolific. It occurs spasmodically along rivers and streams in Northern Kano Province, but it is by no means common.

The products of this woody grass are most valuable to the native, and are used for house rafters, canoe poles, implement handles, arrows and, by some of the Jos Plateau pagans, for bows; split stems are used for cattle fencing, and in former days the stems were also used for spear shafts. Charcoal is also made from Oxytenanthera, and it is so useful that it should be encouraged artificially, as indeed it is, in parts of Northern Nigeria. It is also useful, of course, in protecting the soil on river banks and in preventing accelerated erosion on hillside streams.

SUB-FORMATION (1b) /

SUB-FORMATION(1b.) - DALLOL VEGETATION

The vegetation of the 'dallols' or dry river courses, former river valleys of Quaternary times, is not easy to classify, since they occur from the northern Guinea zone to the desert area. They have, however, a common factor in that usually they contain running water for part of the year; while in the northern area they form drainage channels of varying sizes, carrying surface water perhaps for a day or two in a decade, in the southern portion they carry seasonal rivers in the wet season and form a chain of swamps holding water, or form a series of dried up swamps in the dry season. The dallol vegetation can therefore be classed as riparian in its widest sense, and the vegetation is most correctly classed as a sub-formation in the Riparian Woodland formation. The fact that the dallols in the southern Sudan zone carry the Dry-zone Mahogany (Khaya senegalensis), and the Fan-Palm(Borassus aethiopum), whilst the small dallols and drainage channels of the Air region have one foot-high Acacia raddiana, makes their floristic classification more difficult, and they must be differentiated by the four zones from the Sudan zone to the Desert zone.

It will be observed from the hydrographical map that there are four main dallols, the Tilemsi Dallol flowing into the Niger north of Gao, the Dallol Bosso, which is called the Dallol Timmer'soi, west of Aïr, running south from Dosso, the Dallol Maouri which joins the Niger south of Gaya, and the Petit Tadiss Dallol north-east of Tahoua, which joins the Dallol Maouri.

The dallol vegetation is therefore described later within the four vegetational zones of the Central Western Sudan.

FORMATION /

Maradi showing the Acacia woodland, farmland and the lighter toned area of the landing ground at the right hand lower corner of the photograph.

Consociation of Acacia arabica below the escarpment at Maradi. River bed on the left in the middle distance. Compare with aerial photograph.

FORMATION 2. WEST AFRICAN RIPARIAN THORNLAND.

This is a formation which occurs infrequently in the Pre-Sudan zone, commonly in the Pre-Saharan zone and less commonly in the Sahara zone itself. It is somewhat restricted therefore from north to south. It occurs only on the banks of rivers and streams, and is thus inextensive in area compared with the surrounding thorn-savanna and thorn-scrub. The formation exhibits the edaphic climax and its occurrence is due solely to telluric moisture. In the desert area riparian thorn:land may exist because of the sub-surface occurrence of river water.

The thorn species of which the Acacias are preponderant in this formation, frequently occur pure or almost pure on the river banks. The commonest is Acacia arabica, although Acacia seyal, Acacia laeta and Acacia raddiana also occur in pure stands. Consociations of Acacia arabica and Acacia seyal occur in the southern area, while consociations of Acacia laeta, Acacia nilotica and Acacia raddiana occur in the pre-Saharan and Saharan zones. The former are frequently found as an association, the latter are not usually found as such.

An excellent example of riparian thornland was studied to the south of Tessawa, in a wide valley of what was a considerable river in Quaternary times. A general photograph of it is included, and one also of a small enumeration plot made in it, the figures of which are given below. A photograph is also shown of a narrow strip /

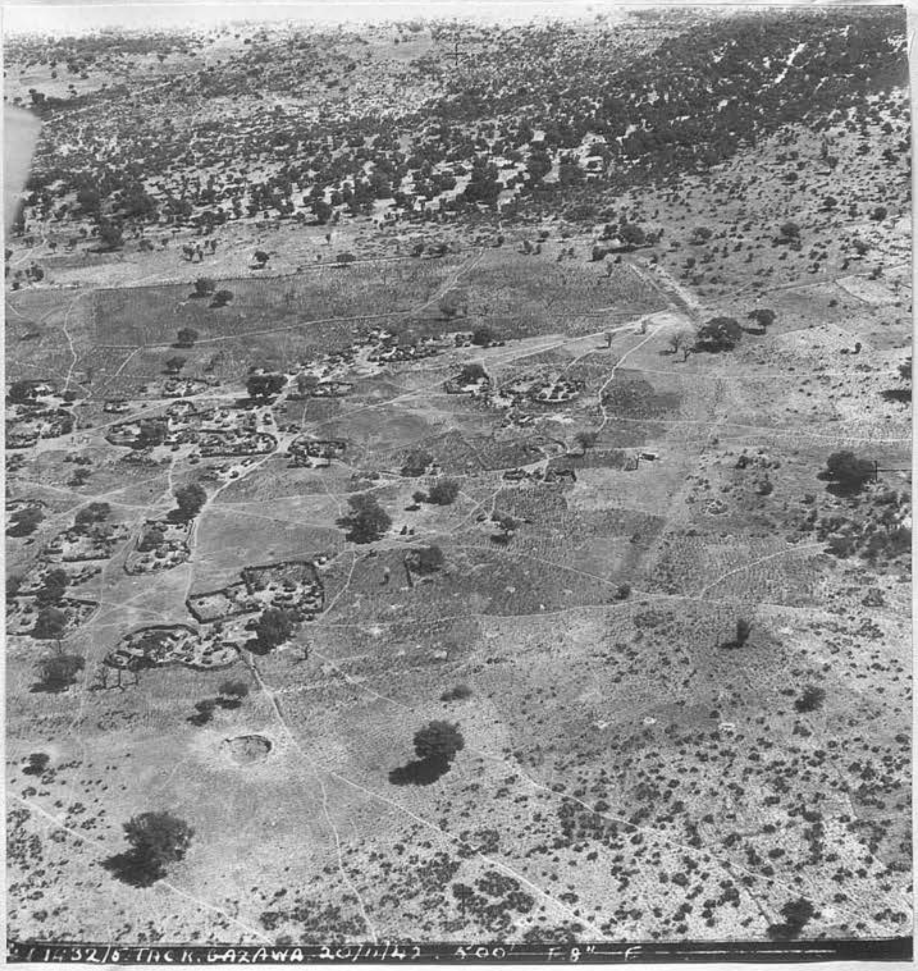
strip of riparian thornland in a belt of almost pure Acacia arabica on the road from Gangara to Aderbissinat.

In the desert the formation is found, as for example north-east of Agades, on the banks of seasonal streams of only some days' duration each year, and Acacia raddiana is even found, in very stunted form, along the edges of natural shallow surface drainage channels. This is clearly demonstrated on the aerial photographs of the ground in the vicinity of the Agades aerodrome.

In the pre-Sudan zone the following species are found in riparian thornland:-

Acacia arabica	ED.a.	Acacia seyal	D.f.l.
Hyphaene thebaica	ED.a.	Balanites aegyptiaca	D.f.
Acacia laeta	ED.f.	Acacia ataxacantha	o.
Acacia albida	ED.o.	Bauhinia rufescens	o.
Acacia nilotica	ED.o.l.	Bauhinia thonningii	o.
Diospyros mespiliformis	ED.o.	Cassia singueana	o.
Mitragyna inermis	ED.o.	Combretum verticillatum	o.
		Leptadenia lancifolia	o.
		Ziziphus mauritiana	o.

A /



Riparian thornland in the top left-hand portion of the photograph, taken at Gazawa in southern Niger Colony.

Former river valley of Quaternary times south of Tessawa. Photograph taken from the east "bank." Vegetation includes Acacia arabica, A. laeta, A. seyal, Hyphaene thebaica, Balanites aegyptica, Bauhinia thonningii, Commiphora africana and Leptadenia lancifolia.

Plot enumerated, on the road from Gazawa to Tessawa, in the valley, a tributary of the river Niger in Quaternary times.

A small enumeration plot, one acre in extent, was made in the riparian thornland eleven miles south of Tessawa on the road from Gazawa to Tessawa, and gave the following figures:-

SPECIES	Two-Inch Diameter Classes 0·2	24	46	68	810	1012	12 +	Total	Percentage	Approximate Av. No. trees per sq. mile
Acacia arabica	2							2	2·666	1,280
Acacia laeta		9	17	9	1			36	48·000	23,040
Acacia seyal				4	1			5	6·666	3,200
Balanites aegyptiaca	3	2	5	1	5		1	17	22·666	10,880
Bauhinia rufescens			6					6	7·998	3,840
Commiphora africana	1							1	1·333	640
Hyphaene thebaica				1			4	5	6·665	3,200
Leptadenia lancifolia	3							3	3·999	1,920
Totals	9	11	28	15	7	-	5	75	99·993	48,000

Acacia arabica may be found pure or almost pure in the four zones from Northern Nigeria to the desert; Acacia nilotica is the more moisture-loving and is found north to the pre-Saharan zone, near swamps and streams and it is this species which occurs as a consociation round the Aderbissinat lake. The former is found north to the Bagzan area in the Aïr Mountains. Acacia laeta is found pure or in association with Acacia arabica and Acacia seyal in the pre-Sudan and pre-Sahara zones; it is more restricted than the other Acacias.

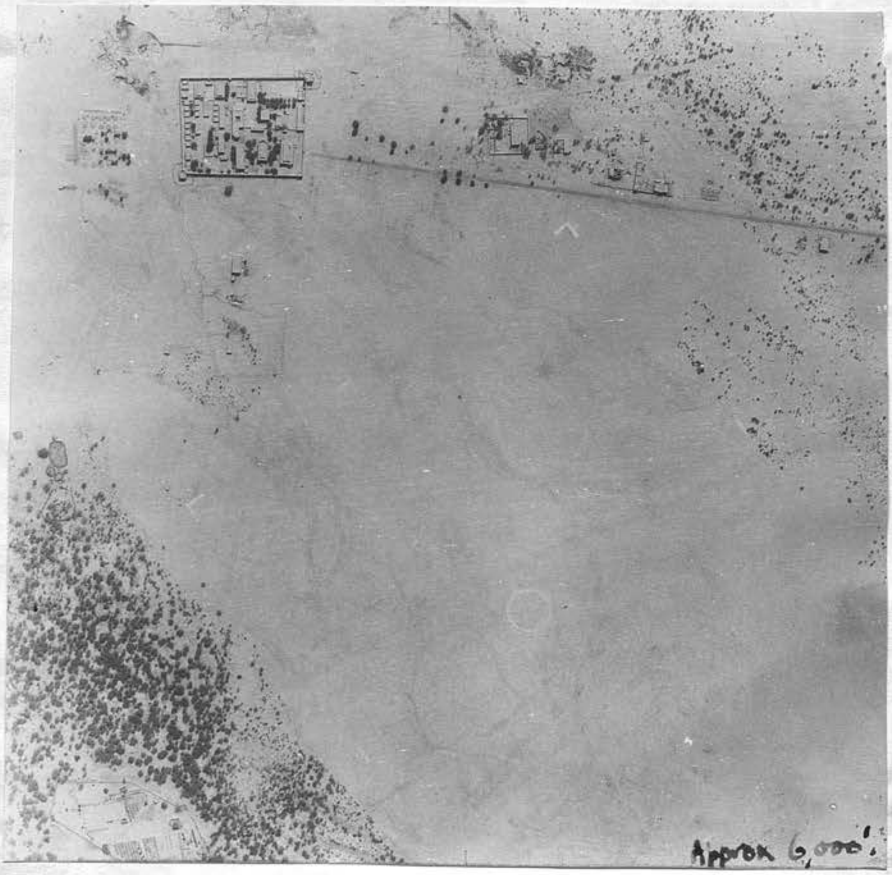
Acacia seyal is found from Northern Nigeria north to the Bazgan area of Aïr. It is found pure and in association with Acacia arabica, Acacia laeta and Acacia raddiana.

Acacia raddiana is found in the pre-Saharan and Saharan zones and has the narrowest distribution from north to south, of the Acacias in the area.

The formation riparian thornland presents a very different picture in the pre-Saharan and Saharan zones. The vegetation varies from five to twelve feet in height and the species are usually somewhat scattered.

The vegetation in the vicinity of Aderbissinat Lake is interesting and apart from the pure stands of Acacia nilotica, this species is found also in association with Acacia seyal and the ubiquitous Balanites aegyptiaca, which is found from the southern Sudan zone north to the desert.

North of Agades along the banks of the River Agades, Acacia raddiana, Acacia seyal and Acacia arabica are found in association. Hyphaene thebaica are also common on the banks on which the irrigated farming of wheat is carried out. On this river the riparian vegetation consists of Acacia raddiana, Acacia seyal, occasional Acacia arabica, Balanites aegyptiaca, Boscia salicifolia, Cadaba farinosa, Maerua crassifolia, Salvadora persica and Ziziphus mauritiana.



AGADES.

The river Agades approximately 30 miles from Agades on the road from Agades to Iferouane, showing riparian thornland.

Agades from the top of the Mosque, showing the fort and the landing-ground in the middle distance.

In the desert area stunted Acacia raddiana are found on the banks of small streams and even on the edge of small surface drainage channels.

In the northern examples of the formation riparian thornland, consociations of Acacia raddiana and of Acacia seyal occur and associations of the two species with Acacia arabica, Balanites aegyptiaca and Boscia salicifolia. The grass is tussocky and stunted and is of course, frequently absent.

In this formation the following species occur:-

Acacia arabica	o	Cadaba farinosa	f.
Acacia laeta	D.f.	Cassia obovata	r.
Acacia nilotica	D.r.	Comniphora africana	o.
Acacia seyal	o	Hyphaene thebaica	D.a.
Acacia raddiana	D.a.	Maerua crassifolia	f.
Balanites aegyptiaca	o.	Salvadora persica	f.
Boscia salicifolia	f.	Ziziphus mauritiana	o.

The following species occur in this formation in the desert zone:-

Acacia arabica	o.	Cassia tora	o.
Acacia ataxacantha	o.	Commiphora africana	o.
Acacia laeta	f.	Leptadenia spartium	o
Acacia raddiana	D.f.	Maerua crassifolia	f
Acacia seyal	o.	Salvadora persica	f.
Balanites aegyptiaca	D.f.	Ziziphus mauritiana	o.
Hyphaene thebaica	D.f.	Cadaba farinosa	o.
Boscia senegalensis	f.		
Calotropis procera	o.		
Cassia obovata	o.		

In vegetation of this kind it is impossible to record any of the species as emergent dominants although the silviculture dominants can be recognised.

Aubréville /

Aubréville in his Niger Colony Forestry expedition records, as already stated, the following in the Bagzan region, (not covered by the writer), in addition to the above list:-

Anogeissus leiocarpus	Ficus salicifolia
Bauhinia rufescens	Ficus teloukat
Bauhinia thonningii	Sclerocarya birrea
Boscia salicifolia	Tamarindus indica
Cordia garaf	
Diospyros mespiliformis	
Grewia betulifolia	
Grewia flavescens	
Dichrostachys glomerata	

A number of these species commonly met with in the Sudan and pre-Sudan zones seem to indicate that those in Air, are relict species of a time when conditions in that region were much more humid than they are to-day.

Thorn thickets in riparian woodland become less common as one preceeds northwards since thickets demand a certain amount of subsoil moisture, and in the desert area, it is only on the banks of the larger river beds that true thickets occur.

In the Sudan and pre-Sudan zones the following species occur:-

Acacia arabic	o.	Mimosa pigra	f.
Acacia ataxacantha	a.	Ziziphus mauritiana	f.
Acacia seyal	o.		
Balanites aegyptiaca	f.		
Dichrostachys glomerata	f.		

In/

In the pre-Saharan zone the thorn thickets consist of the following species:-

Acacia arabica	o.	Balanites aegyptiaca	f.
Acacia ataxacantha	f.	Ziziphus mauritiana	o.
Acacia laeta	f.		
Acacia raddiana	f.		
Acacia seyal	o.		

On the large rivers in the Agades area in the Saharan zone the following species occur:-

Acacia arabica	o.	Balanites aegyptiaca	o.
Acacia ataxacantha	o.	Ziziphus mauritiana	o.
Acacia raddiana	f.		

These thorn thickets are only a few feet wide in the desert zone but they are useful in protecting the river banks and thus restricting the width of the rivers. The river Agades, for instance, thirty-five miles north-east of Agades on the road to Iferouane, is no less than 175 feet wide. These thickets may be as tall as twenty feet, as illustrated on the accompanying photograph of the River Agades at the point mentioned.

CHAPTER 10

FORMATION-TYPE II TROPICAL SWAMP WOODLAND.

Formation 3. West African Swamp Woodland.

The West African Swamp woodland is an edaphic climax in the vegetational division edaphic moist woodland. Although the formation is relatively inextensive in the Western Sudan there are nevertheless appreciable areas of land covered by it; these are most striking in that they frequently form islands of tall thick woodland growing to fifty feet or more in the middle of a sea of scrub savanna, thorn scrub or extensive farmland, with few trees or even without any tree vegetation.

This formation can be differentiated from the formation Riparian Woodland by the floristic composition although some species are common to both. These islands are often found in the more arid areas, outside the desert zone, frequently round seasonal swamps of varying duration, and in the dry season they surround open areas having a hard, clayey, cracked and fissured soil.

The following species occur in this formation in the northern Emirates of Nigeria:

Acacia arabica	ED.a.	Acacia ataxacantha	D.f.
Acacia nilotica	ED.a	Dichrostachys glomerata	D.o.
Diospyros mespiliformis	ED.a.		
Mitragyna inermis	ED.a.	Acacia seyal	f.
		Combretum micranthum	f.
Anogeissus schimperi	ED.f.		
Balanites aegyptiaca	ED.f.	Acacia sieberiana	o.
Celtis integrifolia	ED.f.	Bauhinia thonningii	o.
Hyphaene thebaica	ED.f.	Cassia singueana	o.
		Feretia canthioides	o.

A good example of swamp woodland on the road from Zinder to Takieta.

Remnant of swamp woodland at the permanent lake north of Dankama. Vegetation includes Tamarindus indica and Hyphaene thebaica.

Example of partially destroyed swamp woodland north of Dankama. It consists of Anogeissus schimperi, Diospyros mespiliformis, Hyphaene, and Acacia albida.

Acacia campylacantha	ED.o.	Guiera senegalensis	o.
Borassus aethiopum	ED.o.	Mimosa pigra	o.
Khaya senegalensis	ED.o.	Ximenia americana	o.
Tamarindus indica	ED.o.	Ziziphus mauritiana	o.
		Acacia senegal	r.

Contrary to what one would expect, there is little sign of natural regeneration except in occasional cases of Diospyros mespiliformis.

The history of many of these areas in Nigeria and in Southern Niger Colony is interesting. They were protected, prior to European occupation, so that the Hausa indigenous population could retire to the thick woodland when their villages were attacked by the horse-mounted Fulani, a formerly powerful, war-loving people, against whom the Hausa people could fight with spears and arrows. The Fulani disliked fighting on foot, and the Hausas when hard pressed, retired to these islands of swamp-woodland, into which the mounted Fulani could not ride and who therefore did not enter. So these islands of vegetation were protected for defensive purposes and they remain today. Now they are fortuitously protected, because the heavy clayey soil is unsuitable for farming and the woodland growth is consequently left untouched. Many of the trees are over-mature and since natural regeneration is difficult it is doubtful if, without treatment of the soil to encourage regeneration, the species will long continue. Certain of the species do not coppice and are unlikely to occur in normal succession; it is probable that a poor type of vegetation will ultimately cover the area. The soil should be drained and loosened, under management, so as to allow regeneration to occur. The soil is in itself a good /

(A. F. A. LAMB).

Swamp woodland in southern Niger Colony north of the Nigerian boundary at Dankama.

good one provided water-logging is prevented.

At the high-water level of some of the seasonal swamps an association of swamp-scrub occurs, consisting of Acacia ataxacantha , Acacia sieberiana and Mimosa pigra (the only species of Mimosa found in West Africa); herbs and grasses occur on the temporary exposed soil.

If the swamp-woodland is destroyed it is followed by scrub and develops into poor grassland and degraded scrub. The final stage is a poor,hard,surface soil, sometimes covered with water-washed pebbles with loss of the good surface soil. In the areas of pure clay soil the ground is cracked and fissured in the dry season and is too dry and hard to support even the rankest grass and early colonizing herbs.

Swamp-woodland is even more restricted in Niger Colony than it is in Northern Nigeria, although patches occur far to the north; one area was recorded as far as eighty-five miles north of the Nigerian frontier, on the road from Tessawa to Agades. In Niger Colony the formation is found round seasonal pools and back-waters and in the depressions or portions of 'dallols' or valleys,in the old beds of the former rivers of Quaternary times. In the area referred to, of which a photograph is included, were recorded Anogeissus schimperi (a), Acacia arabica (f), Mitragyna inermis (o), Ziziphus mauritiana (o).

The soils in the Niger Colony areas are identical with those in Nigeria, although the soil of the surrounding country is infinitely drier and more sandy. It is now considered by soil scientists, (and recorded by Vageler[(1)]), that such soils which are subject to alternate flooding and drying, contain valuable mineral salts brought to the surface with /

(1) Vageler,P: Introduction to Tropical Soils.

with the rise in the water table, and that only draining is required, (which is usually out of the question), to make them valuable soils. This, as has been indicated, should be done in those areas in forest reserves in Northern Nigeria.

A total enumeration of one acre of swamp-woodland south of Gazawa, on the road from Katsina to Tessawa, gave the following results:-

SPECIES	Numbers in 2-inch diameter classes 0- in. 2	2- in. 4	4- in. 6	6- in. 8	8- in. 10	10- in. 12	12- in. 14	14- in. 16	16- in. 18	18- in. 20	20- in. 22	22- in. 24	24in. plus	Total	Per- cen- tage
Acacia arabica	8	-	-	-	-	-	-	-	-	-	-	-	-	8	3·520
Acacia ataxacantha	6	2	-	-	-	-	-	-	-	-	-	-	-	8	3·520
Acacia senegal	3	-	-	-	-	-	-	-	-	-	-	-	-	3	1·321
Acacia seyal	12	3	-	-	-	1	-	-	-	-	-	-	-	16	7·040
Acacia sieberiana	-	-	-	-	-	-	-	-	-	-	-	-	1	1	·440
Balanites aegyptiaca	9	1	-	-	-	-	-	-	-	-	-	-	-	10	4·400
Capparis tomentosa	1	-	-	-	-	-	-	-	-	-	-	-	-	1	·440
Cassia singueana	4	1	-	-	-	-	-	-	-	-	-	-	-	5	2·200
Combretum micranthum	41	6	-	-	-	-	-	-	-	-	-	-	-	47	20·704
Crateva adansonii	-	-	-	-	-	1	1	1	-	-	-	-	-	3	1·321
Diospyros mespilifor- :mis	15	7	5	4	6	9	6	2	4	4	1	-	4	67	29·515
Hippocratea richardiana	11	2	-	-	-	-	-	-	-	-	-	-	-	13	5·726
Hyphaene thebaica	-	-	-	2	-	5	3	3	-	-	-	-	-	13	5·726
Mitragyna inermis	3	4	3	3	6	5	3	2	1	-	-	-	-	30	13·200
Ziziphus mauritiana	2	-	-	-	-	-	-	-	-	-	-	-	-	2	·880
	115	26	8	9	12	21	13	8	5	4	1	-	5	227	99·953%

At the high water level of some of the seasonal swamps in this region occurs an association of swamp-scrub species, amongst which Acacia ataxacantha, Acacia sieberiana, Dichrostachys glomerata and Mimosa pigra occur.

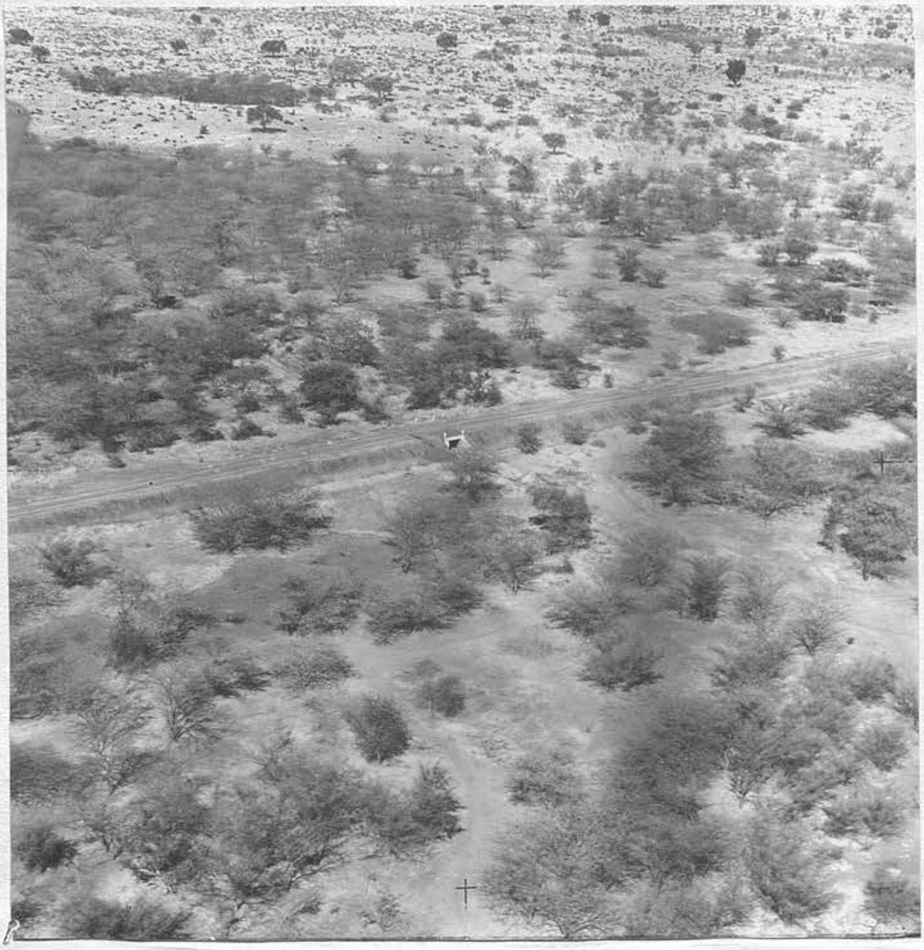
Aerial and ground photographs are included of the West African Swamp Woodland; the aerial photographs illustrate their situation within the Climatic Dry Woodland division, and the ground photographs their density on the ground.

Formation 4. West African Swamp Thornland.

This is a restricted formation, the floristic composition of which differs from that of the riparian thornland; there is a variation in the frequency of species, as one would expect, between the pre-Sudan and pre-Saharan zones. In the former the species in swamp-thornland may attain a height of twenty five to thirty feet, while in the pre-Saharan zone, as at Aderbissinat, the species grow up to twenty feet. In one area of swamp-thornland south of Tessawa, Acacia albida, Acacia arabica, Acacia seyal, Balanites aegyptiaca and Ziziphus mauritiana were noted in association with Hyphaene thebaica. In a second, south of Gangara, Acacia arabica, Balanites aegyptiaca and Ziziphus mauritiana were observed, with occasional Anogeissus schimperi and Mitragyna inermis; near these, the writer recorded an association also of Acacia arabica and Anogeissus schimperi.

Perhaps the most striking area is that at Aderbiss-:inat Lake where there occurs a consociation of Acacia nilotica, although other areas in the immediate vicinity have a distinct association of Acacia nilotica and Balanites aegyptiaca. Close to Aderbissinat an association of Acacia nilotica, Acacia seyal and Balanites aegyptiaca occur. Associations were also observed of Acacia nilotica, Acacia raddiana and Balanites /

Pure stand of Borassus flabelifer, in which there is some natural regeneration. The Jibiya reserve 27 miles west of Katsina.



Consociation of Acacia seyal south of Takieta.

Almost pure Acacia seyal with some Bauhinia thonningii. Culvert one half-mile south of Takieta.

Balanites aegypitaca. A photograph of the Swamp Thornland at Aderbissinat is included, and it can be seen how close growing the formation can be.

This formation was also observed on the route from In Gall to Tahoua, north of Efinateus, approximately on the same latitude as Aderbissinat. In the Efinateus area Acacia laeta occurred and was found in association with Acacia arabica, Acacia seyal, Acacia raddiana and Balanites aegyptiaca. On this route however, swamp-thornland is uncommon, riparian thornland being much more common.

Acacia laeta was found to occur as a consociation in swamp thornland, and in association with Acacia seyal, as far south as Zinder on the road from Zinder to Takieta. A photograph illustrating the shallowness of the roots of Acacia laeta is included, and demonstrates the size to which that specimen will grow in swamp-thornland. The Acacia seyal in the background are on dry ground.

Swamp-thornland rarely occurs in the northern Emirates of Nigeria; it is more common in Niger Colony, but is a very inextensive formation. Patches only were observed north of Gao, on the route from Gao to Tabankort, most of the Acacia raddiana occurring thereon being riparian on the banks of seasonal drainage channels containing flowing water for only a few days in the year.

B. CLIMATIC DRY WOODLAND

CHAPTER 11

FORMATION-TYPE III
TROPICAL SAVANNA WOODLAND

Formation 5 West African Woodland Savanna.

This is the most luxuriant and most common formation in the formation-type Tropical Savanna Woodland, but it only occurs in the southern portion of the region under review, a large area of which is covered with the Orchard Woodland Savanna formation, which will be described later.

The Woodland Savanna is the climax which the vegetation of the northern part of the Guinea Zone and the southern portion of the Sudan Zone can attain, except where biotic, edaphic or physiographic factors intervene. It is regrettable that in Northern Nigeria isolated and comparatively small areas of Woodland Savanna now remain, due mainly to shift:ing cultivation and partly to fuel collection; cattle grazing probably does not materially affect the issue in this case. Here the formation is characterized by a tree-growth of thirty-five to forty feet high; the component species in some areas grow with so close an espacement as to produce almost a closed canopy. On the woodland floor grass is present, but it is not luxuriant and consists, for the most part, of Andropogon gayanus, a good fodder grass and from which most of the native compound - walls are made. There is also a certain number of herbs and shrubs.

A number of associations and occasional consociations are found and, as one would expect, layer societies occur. Anogeissus schimperi is perhaps the commonest emergent dominant.

Niger /

Savanna woodland north of Magariya including Sclerocarya birrea, Prosopis africana, Terminalia avicennioides, and Balanites aegyptica.

Niger Colony differs from Nigeria in having a less dense population and there are consequently fewer farmers - although as can be seen from aerial photographs, the farming in southern Niger Colony is very intensive; that of the Magariya area most clearly depicts this. The farmers are smaller in number than in Nigeria, and have destroyed only part of the woodland savanna. Although it forms a belt extending from east to west, the formation does not occupy a great area from north to south, and merges north:wards into orchard-woodland. Certain untouched or little-farmed portions suggest the former vegetation of part of the northern Emirates of Nigeria, where extensive farming has resulted in the decimation of the woodland-savanna on land suitable for agriculture.

In this area the formation is characterized by a tree-growth of twenty to forty feet high, with a fairly close espacement. Amongst the ground vegetation the grass is present in some luxuriance. Emergent dominants are numerous, layer societies are obvious, and associations and consociations occur.

The following species occur in this formation:-

Angoeissus schimperi	ED.a.	Combretun micranthum	D.a.l.
Bauhinia thonningii	ED.a.	Commiphora africana	D.a.
Sclerocarya birrea	ED.a.	Dichrostachys glomerata	D.a.
Tamarindus indica	ED.a.	Cassia arereh	D.f.
Terminalia avicennioides	ED.a.	Entada sudanica	D.f.
Acacia albida	ED.f.	Bauhinia rufescens	D.o.
Adansonia digitata	ED.f.	Combretum elliotii	D.o.
Balanites aegyptiaca	ED.f.	Combretum lecananthum	D.o.
Boswellia dalzielii	ED.f.	Combretum passargei	D.o.
Butyrospermum parkii	ED.f.	Combretum verticillatum	D.o.
Hyphaene thebaica	ED.f.l.	Acacia macrostachya	D.l.
Lannea acida	ED.f.	Acacia seyal	D.l.
Lannea barteri	ED.f.	Guiera senegalensis	a.l.

Prosopis africana	ED.f.	Ziziphus mauritiana	a.
Parkia oliveri	ED.f.	Acacia arabica	f.
Vitex cuneata	ED.f.	Acacia sieberiana	f.
		Bauhinia rufescens	f.
		Cassia singueana	f.
Bombax buonopozense	ED.o.	Securidaca longipedunculata	f.
Celtis integrifolia	ED.o.	Sterculia setigera	f.
		Stereospermum kunthianum	f.
Detarium senegalense	ED.o.	Acacia senegal	o.
		Annona senegalensis	o.
Diospyrus mespiliformis	ED.o.	Boscia angustifolia	o.
		Boscia salicifolia	o.
Khaya senegalensis	ED.ol	Cassia aschrek	o.
		Cassia sieberiana	o.
Parinari macrophylla	ED.o.	Feretia canthioides	o.
		Gardenia erubescens	o.
Pterocarpus erinaceous	ED.o.	Grewia mollis	o.
		Heeria insignis	o.
		Leptadenia lancifolia	o.
		Ximenia americana	o.
		Calotropis procera	l.

The non-dominants constitute the shrub layer of this formation and do much to protect the soil and to improve it by the disintegration of fallen leaves, which when the area is protected or undisturbed, helps to form humus.

When savanna woodland is heavily damaged or completely destroyed it is succeeded by the almost ubiquitous scrub-savanna, thorn-scrub and grass, which if it in turn becomes degraded, through over-exploitation for fuel or cutting excessively (without a resting period), or through soil deterioration, will become poor grassland with degraded scrub species. If there is heavy soil deterioration from farm soil to lateritic soil, and this can take place, under certain conditions/

conditions, within ten years, combretaceous scrub follows. This has been demonstrated in Katsina and Daura where the scrub has colonized large areas round the town, on former good farmland: the present Emir of Daura remembers this land as farmland forty-five years ago.

If on the other hand the scrub savanna is protected as a seral stage in savanna-woodland it will in time progress to the climax form of woodland-savanna.

In Niger Colony the formation occupies a narrow belt from north to south, stretching through the area from south-west of Say to south of Fadan Gourma, eastwards across the Niger through the Niamay- Gaya area to Dosso, thence by way of Birnin Konni to Maradi, Tessawa and Zinder, to near the Manga grass country, west of Lake Chad.

In the course of a series of botanical surveys the writer has been able to record numerous distinct associations which will be described later. In the woodland savanna formation the following associations are common and are readily recognised:-

(i) Anogeissus - Acacia - Bauhinia association
(ii) Anogeissus - Lannea - Sclerocarya association.

A description of each is as follows:-

(i) Anogeissus-Acacia-Bauhinia Association:

This association is found in southern Niger Colony and is common in the area between Madarunfa and Gazawa north of Katsina. It is interesting to note that good woodland savanna frequently exists north of the frontier in French territory, whereas on the Nigerian side, farmland with few trees continues to the boundary. This is shown in an aerial photograph of a part of the international boundary in Northern Katsina. The former i.e. the good woodland-savanna, shows the type of woodland which existed previously in parts of the northern emirates. The country in/

in this area is undulating and the River Jibiya, flowing northwards to Maradi, passes at no great distance to the east of the motor road. The area bears woodland inter:spersed with good farmland. The soil is sandy but fertile, and overlies rock and granite, both of which appear in outcrops. Part of the woodland soil is gritty, derived from disintegrating granitic rocks. A photograph of this area is included. The following enumeration of one acre of typical woodland in this region was recorded:-

Enumeration South Maradi Area. 1 Acre. 28.V.1940 - Two inches diameter classes

SPECIES	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	Total	Percent:age
Guiera senegalensis	42									42	18·260
Combretum micranthum	40									40	17·391
Bauhinia thonningii	24	13	1							38	16·521
Cassia singueana	21	7								28	12·173
Acacia seyal	13	8	4	1						26	11·304
Anogeissus schimperi	1	-	2	4	5					12	5·217
Boscia senegalensis	8									8	3·478
Feretia canthioides	7									7	3·043
Ziziphus mauritiana	5	1	1							7	3·043
Lannea barteri			3	1		1	1			6	2·608
Commiphora africana	5									5	2·173
Grewia mollis	3									3	1·304
Combretum verticellatum	2									2	·869
Acacia senegal	1			1						2	·869
Acacia sieberiana	2									2	·869
Sclerocarya birrea									1	1	·434
Calotropis procera	1									1	·434
Totals	175	29	11	7	5	1	1		1	230	99·990%

(ii) <u>Anogeissus-Lannea-Sclerocarya Association.</u>

This is a second association in the southern portion of Niger Colony, and is interesting in that it is found to occur on a soil consisting largely of grit with only a fraction of soil, in the accepted sense. It is purely a forest soil and could never be used as an agricultural one. It is in this type of area that forest reserves in northern Kano and Katsina provinces of Nigeria are now being chosen for reservation, rather than good farm soils which are required for the food and general welfare of the native population.

It is thought that humus is formed by the disintegration of leaves and other vegetable matter and washed into the grit derived from the disintegrating granite. There is also evidence of lateritic rock formed by undue exposure of the surface soil. In places however, sand overlies lateritic rock and water-washed lateritic pebbles, which in turn overlie the ancient granitic rock. The area is undulating and has been cut into by the seasonal but rapidly-flowing streams.

The following species were recorded in this association:-

Anogeissus schimperi	ED.a.		
Commiphora africana	ED.f.	Dichrostachys glomerata	D.o.
Lannea barteri	ED.f.	Guiera senegalensis	D.o.
Sclerocarya birrea	ED.f.	Maeura crassifolia	o.
Balanites aegyptiaca	ED.o.	Ziziphus mauritiana	o.
Diospyros mespiliformis	ED.o.	Acacia senegal	o.
Hyphaene thebaica	ED.o.	Calotropis procera	o.
Bauhinia thonningii	D.f.	Cassia singueana	o.
Combretum micranthum	D. f.	Combretum verticillatum	o.
Acacia seyal	D.o.	Grewia mollis	o.

It/

It will be appreciated that in the two associations recorded there can be a considerable difference in the component species and their numerical frequency, and even within an acre extreme fluctuations may be observed.

The formations in the Tropical Savanna Woodland formation-type are vulnerable to retrogressive succession although woodland savanna is less so than the formations described later under the formation-type tropical thornland.

Nevertheless when the woodland savanna is partially or wholly exploited, or destroyed for farming or other reasons, the inevitable succession is from the weedy growth at the end of the farming season; this is followed by the first seral stage of low-scrub savanna, thorn-scrub and grass, consisting of Bauninia thonningii, Guiera senegalensis, Ziziphus mauritiana, Cassia singueana and other species; Acacia seyal, in certain areas, is likely to be the commonest mimosaceous invader. The early colonizers on open farmland are listed later under the description of farmland. Given the opportunity, either by fortuitous protection or by deliberate reservation, the low scrub densifies in five years; the savanna woodland species gradually assert themselves and progress through a Bauhinia-Guiera association, which is the second seral stage to savanna woodland. The second stage has been proved by the writer to take approximately fifteen years, but there are as yet no records to prove the number of years it takes to return to climax of woodland savanna. The writer considers it will be reached in about fifty years. Photographs are included showing open farmland, farmland at the end of the farming period and finally the two seral stages recorded above.

When the scrub savanna is continuously destroyed, a degraded type of scrub follows, the soil deteriorates, is finally unable to support Bauhinia and Guiera and the poor species such as Combretum micranthum only can exist; if /

The landing ground at Tessawa showing the air-field and adjacent farmland; the darker tones indicate Bauhinia and Guiera. This should be compared with the ground photograph taken at the left hand corner.

if it is destroyed and laterization ensues, then the vegetational covering may become impossible, and a hard exposed infertile lateritic plain is left.

Under the Formation West African Woodland Savanna four seral stages occur in the ecological progressive succession from exposed ground, such as farmland, to woodland savanna. These are scrub savanna (in which three stages occur), and low-woodland savanna. Scrub savanna is preceded however, by early colonizers such as herbs and grasses, but the former are quickly eradicated and the scrub species continue.

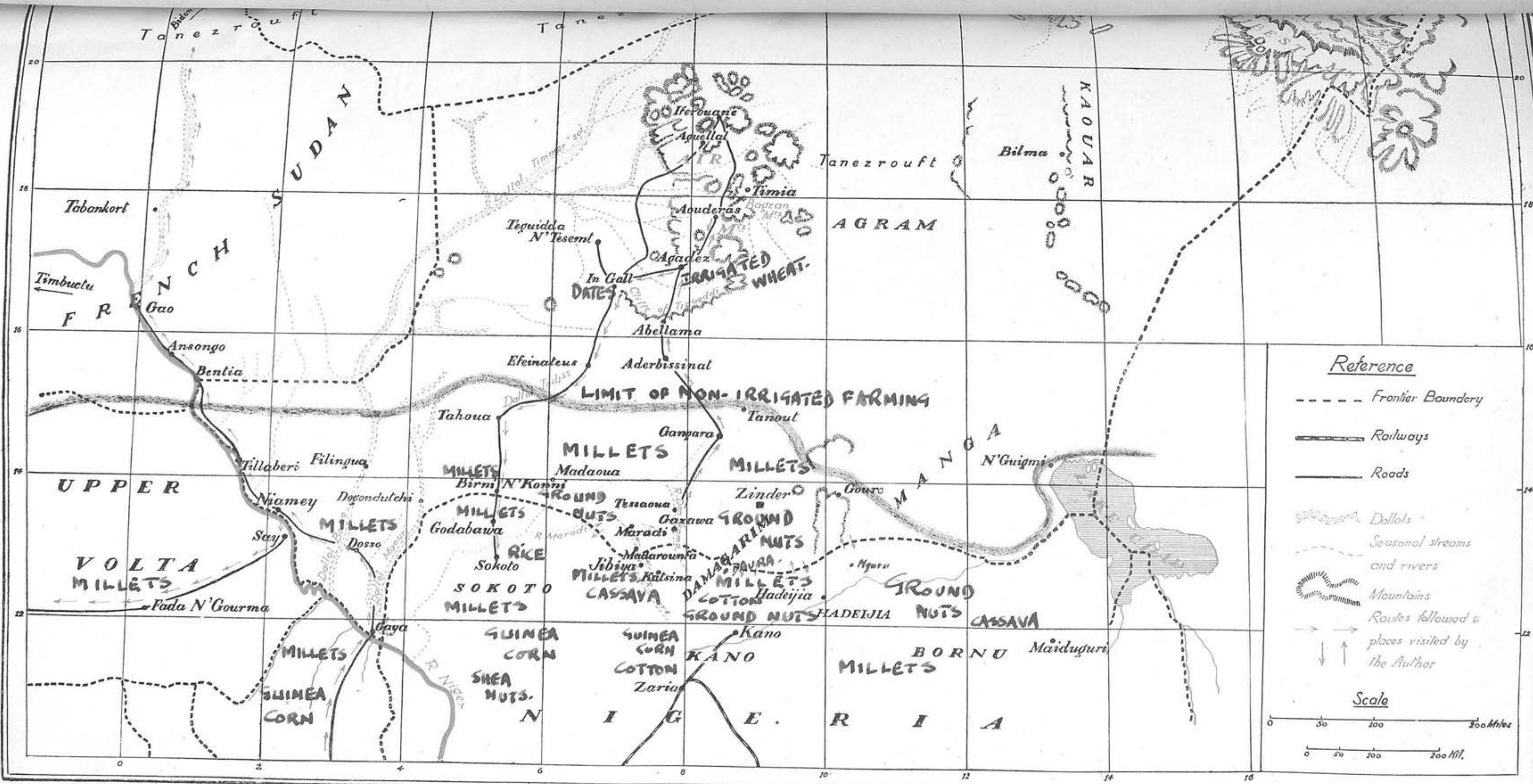
These seral stages are neither formations or true associations, although temporary associations can be named, as the vegetation proceeds through the seral stages. The five stages are therefore as follows:-

(i) Pre-scrub vegetation
(ii) Farm scrub
(iii) Low-scrub savanna
(iv) Tall scrub savanna
(v) Low-woodland savanna.

These are described separately and photographs illustrate the different stages.

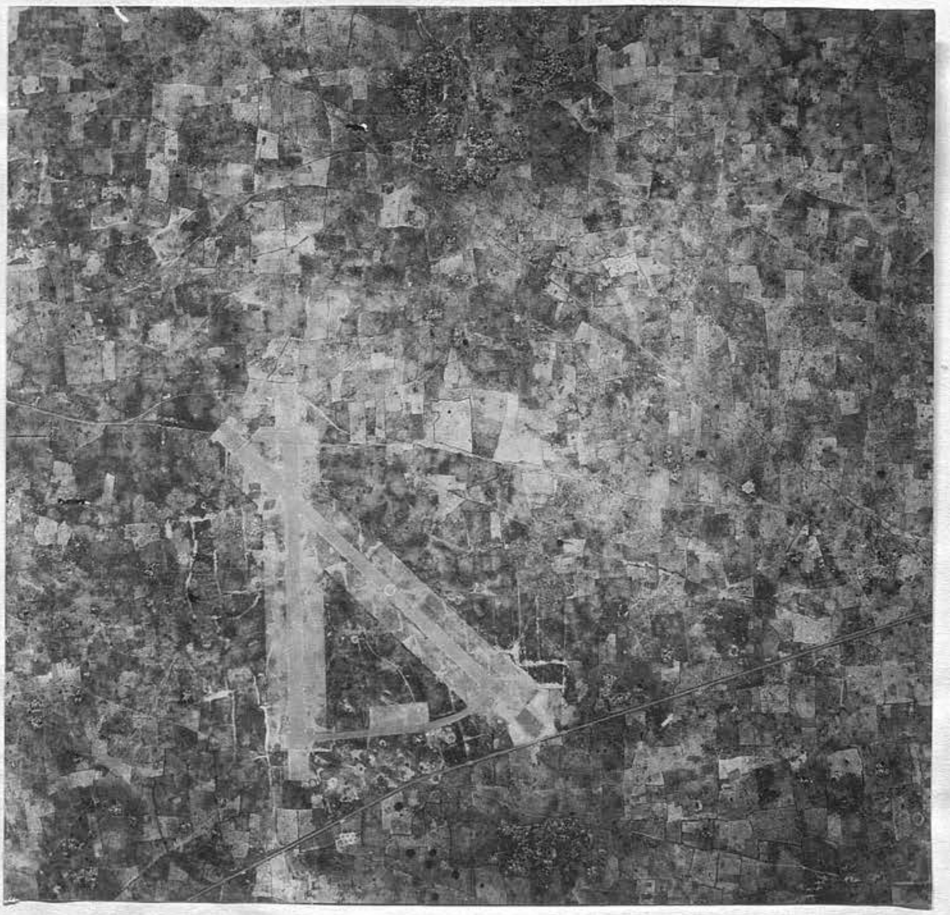
Northern Nigeria and southern Niger Colony are essentially agricultural areas, and it is estimated that approximately 75% of the country is devoted to farming; the only non-agricultural land consists of granitic and lateritic hills, areas of waste land such as Combretaceous scrub, (which is only cleared for farming in times of land hunger), and pure forest land on so poor a type of soil that farming cannot be carried out. Agriculture is the principle means of livelihood of the peasant and in the vicinity of the towns and villages all land that can produce agricultural crops is farmland.

It /



CROP MAP.

110A.



Magariya from 10,000 feet, showing the intensity of the farming. The fallow-land can be clearly distinguished and is approximately seventy-five per cent of the total farming area.

The outskirts of Ouagadougou showing areas of swamp-land and of waste land.

Typical Kano farmland with Acacia albida and
Parkia oliveri in the background.

Millet farms in fairly dense stands
of Acacia albida with some Vitex cuneata
north of Magariya in southern Niger Colony.

It can be seen from the aerial photographs included in this paper that, in an area of agricultural land in the Sudan zone, 50% to 75% is left as fallow-land. In the farming rotation any one farmer usually has approximately one-third of his land under cultivation and the remainder is resting. This is 'shifting cultivation' within a permanent area and agriculturists are beginning to believe that this is the best method of agriculture for the Western Sudan. Under this system the soil is rested, it is improved by leaf fall and the formation of humus, the ground is protected from accelerated soil erosion and from insolation and with the addition of farmyard manure and village sweepings, the soil is kept at a relatively high degree of fertility. The whole farming rotation appears to be about twenty-one years, except where permanent cultivation is carried out near Kano city. The farmer usually has three areas, which may be widely scattered, and two-thirds rest while he works the other third. He will work the area for approximately seven years, and the other areas are in comparison, seven to fourteen years and fourteen to twenty-one years in their resting stage.

Thus in a farming community the land is almost entirely devoted to agriculture; one third is under cultivation, two thirds are covered with low-scrub and low-woodland; the latter will come under cultivation in the next period. The major portion of a farming area therefore appears to be poor scrub, but it must be realized that this is fallow-land on a good agricultural soil. The low-scrub is the commonest type of vegetation; the casual observer is inclined to treat this as poor scrub without any great value, which is wrong, it is virtually first class fallow land.

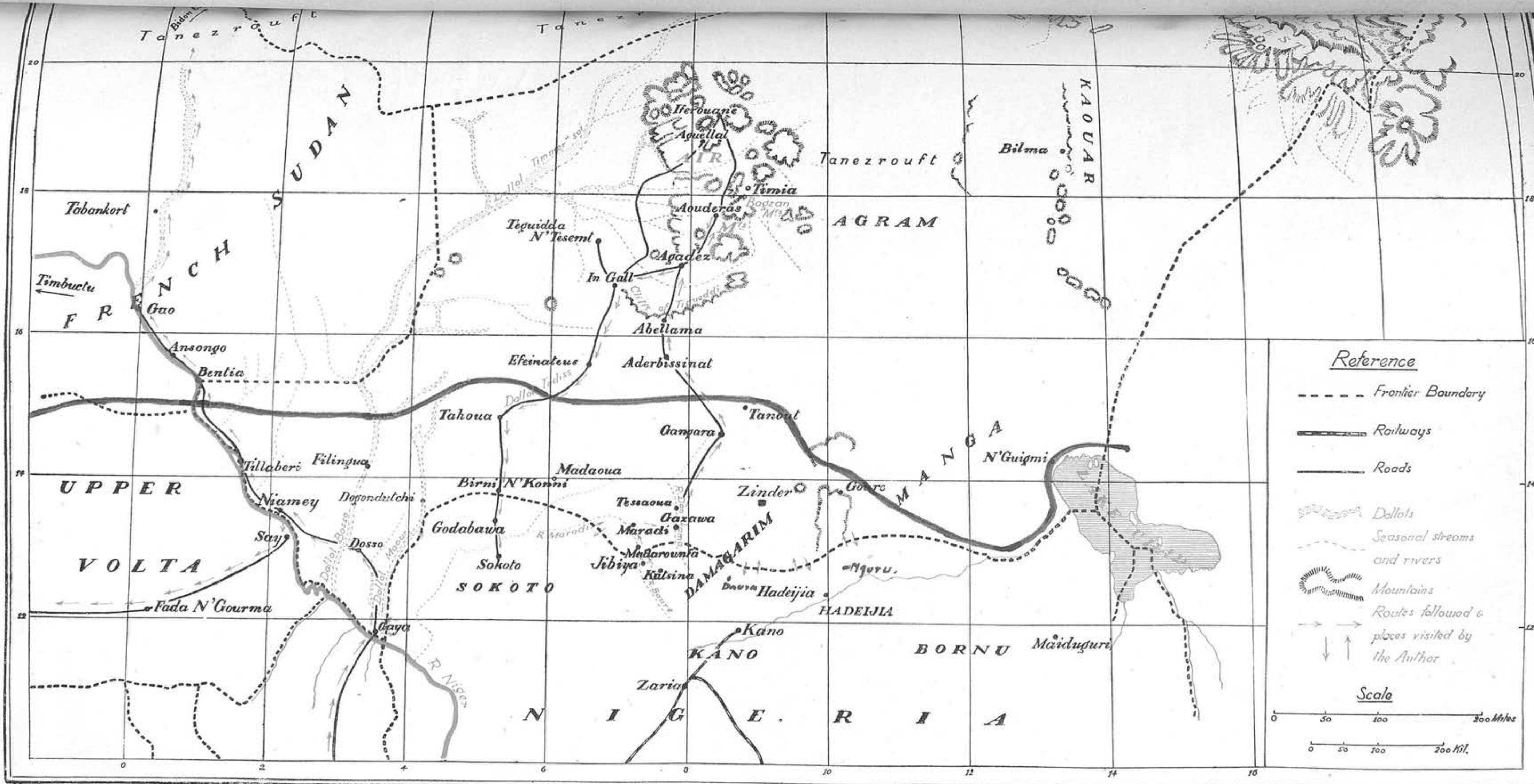
When/

When an area of low-woodland savanna, after approximately fourteen years' rest is about to be used for farming again, the farmer cuts and burns the trees, leaving probably one or two of the valuable trees, i.e. those like Parkia oliveri from which he gets a few shillings each year from the produce ; the ground is cleared and cleaned to a certain extent and the ash from the trees is spread over the soil, but the area is not used until the following year. It is then carefully prepared for its use over a period of about seven years and is finally hoed-over in preparation for the sowing of the seed.

This practise is widespread and while it sounds wasteful and undesirable it has been proved by the native to be the best method of obtaining good crops. In the last decade the cutting and burning of the tree vegetation on farmland has been reduced in northern Nigeria by publishing in the Native Administration rules, lists of farmland trees that may not be cut or destroyed without permission from an agricultural officer or his representative. This has done much to preserve large trees on open farmland on which no trees would now have been left.

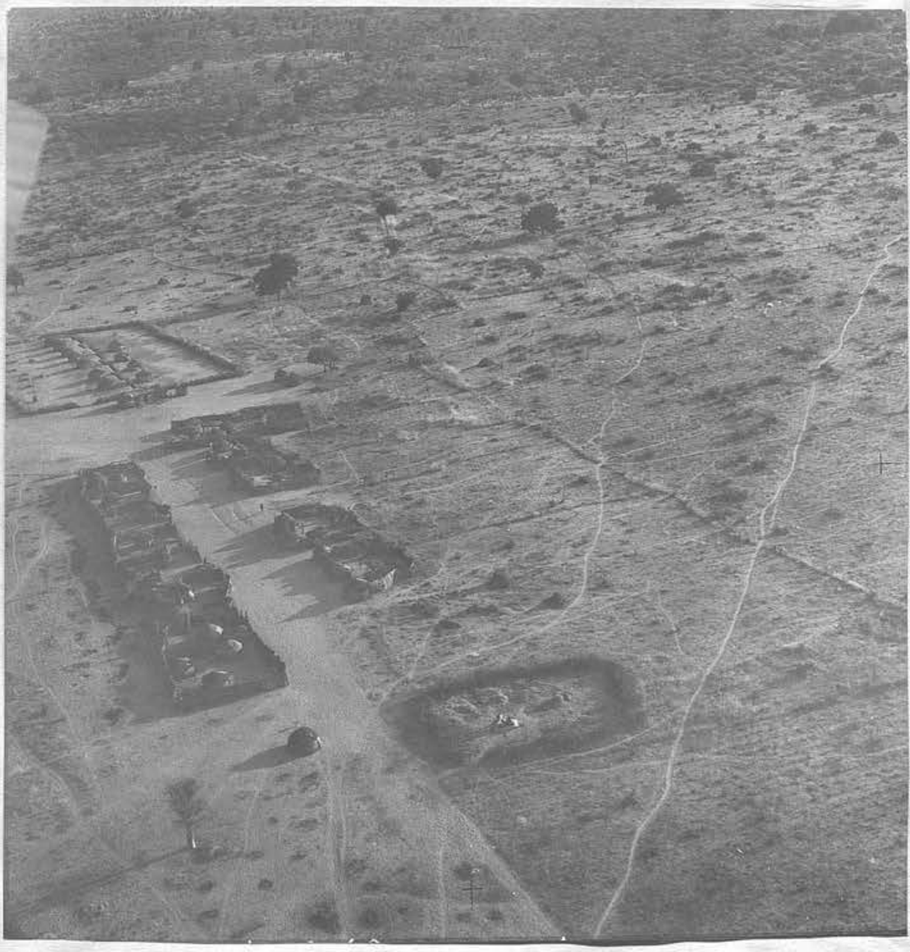
Thus in two successive years low-woodland savanna is reduced to more or less open farmland with an exposed soil on which the first colonizers are herbaceous species and grasses with light wind-borne seed. Weeding has therefore to be carried out while the young crop is growing; when the crops have been removed the stool shoots of some of the tree species such as Bauhinia and Hyphaene coppice, and, with weeds, form a good cover on the soil. The writer believes that it takes some thirty to fifty years for farmland to revert to true climax woodland savanna again.

At /



APPROXIMATE NORTHERN LIMIT OF NON-IRRIGATED FARMING.

112A.



Intensive farming in the neighbourhood of Dashi. The pencilled arrow on the aeroplane wing tip indicates the international boundary.

Madaoua and the surrounding country from approximately 12,000 feet. The interesting area of erosion near the river bend can be seen.

At the beginning of the farming season an area previously under crops is cleared and prepared for the sowing of seed. The crop is sown, tended, weeded and cleaned throughout the growing season and the crops are reaped. Then comes the beginning of the seral stages, as the vegetation endeavours to recover to its natural climax. First comes the pre-scrub vegetation and the five stages are now described.

(i) Pre-scrub vegetation.

As soon as the crops are reaped the weedy early colonizers are left undisturbed, having begun to appear from the beginning of the growing season. Grasses also appear and a herb and sparse grass vegetation, has in a few weeks, established itself on the farm itself. There is a wealth of species and a number of grasses and, during the long dry season, they do much to bind the soil, to prevent wind erosion, and to prevent insolation. Some agricultural officers are now of the opinion that weedy farming should be encouraged, i.e. leaving the weeds and grasses to protect the soil rather than have a clean and tidy, but exposed, farm soil.

Then at the same time as the weeds appear, the first coppice shoots of the scrub vegetation appear from the stools which have been cut back before the farm was cleaned for the sowing of crop seeds. Thus at the end of the dry non-growing season, farms of the previous year have a wealth of grasses, herbs and coppice shoots; the latter are fast growing and in six months are about two feet high.

On one area of normal farmland in the Katsina plantations in which taungya was used, the list of species occuring on a one-year-old fallow reached eighty five in number./

number. These consisted of herbs for the most part, of a certain number of grasses and of some tree species; the more important in each were as follows:-

A. Woody species:

Acacia arabica	Dichrostachys glomerata
Acacia sieberiana	Fluggea virosa
Annona senegalensis	Guiera senegalensis.
Bauhinia thonningii	Leptadenia lancifolia
Calotropis procera	Sclerocarya birrea
Cassia absus	Tamarindus indica
Cassia singueana	Vitex cuneata
Cassia mimisoides	Ziziphus mauritiana
Combretum micranthum	

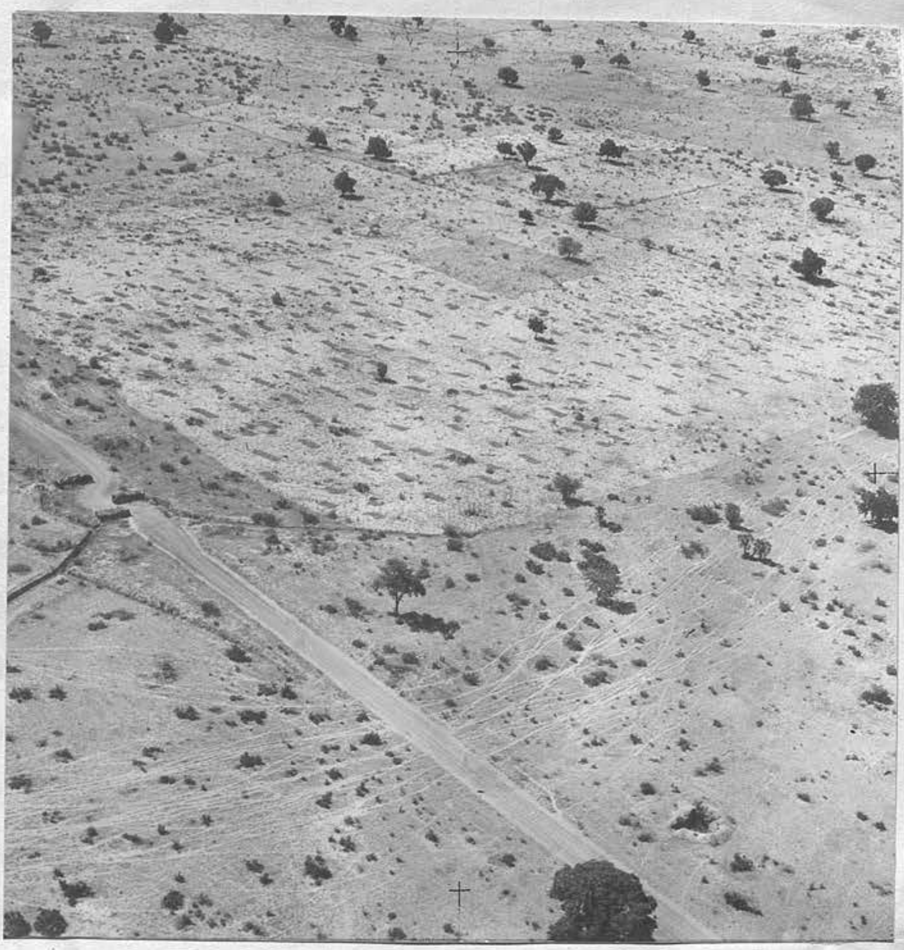
B. Grass species:

Andropogon gayanus	Eragrostis ciliaris
Cenchrus biflorus	Panicum laetum
Ctenium elegans	Pennisetum pedicellatum
Digitaria debilis	Pennisetum polystachyon
Digitaria gayana	Sorghum vulgaris

Herbaceous species:

Borreria stachydea	Indigofera astragalina
Cassia tora	Indigofera prieuriana
Chrozophora senegalensis	Mitracarpum verticillatum
Crotolaria aschrek	Oldenlandia senegalensis
Desmodium lasiocarpum	Sesbania aegyptiaca
Hibiscus asper	Solarium incanum
Hibiscus cannabinus	Tephrosia bracteolata
Indigofera arrecta	

In a second plot of 100 square yards in one year fal-:low on taungya farms in the Katsina plantations, thirty-five species/



Road-block and farmland north of Daura in November of 1942, and as fallow-land in January of 1944. Ground photograph taken from left of the road-block.

Ground photograph of the same area; the road block was in the dip in the road; it will be noted that the farmland is now under fallow.

species were enumerated and did not differ greatly from the above list.

There is no doubt that the weeds and woody growth on abandoned farmland or on one-year-old fallow, have much value in protecting the soil, which so very light and sandy over large portions of the region, requires protection from the strong winds of the so-called 'tornado' seasons, at the beginning and end of the rains in April and October.

An interesting enumeration was made in an area in the Katsina plantations in connexion with the control of the weed Acantho-spermum hispidum, which is in danger of becoming a pest in the Western Sudan, and experiments on which will be described later.

An area hundred square yards was cleared of all vegetation, the soil was dug over to a depth of two feet and all roots were grubbed out in order to get an indication of the early colonizers. The following species invaded this area in four months of the wet season (1.5.1940 - 31.8.1940).

Acanthospermum hispidum	Digitaria debilis
Amaranthus viridis	Hibiscus asper
Cassia tora	Hibiscus sabdariffa
Cochorus olitorius	Pennisetum pedicellatum
Cucumis melo var agrestis,	Tribulus terrestris
Dactyloctenium aegyptium	

Over an area of nine square feet a full enumeration was made of the invading species and the following results were obtained:-

Species /

Frontier.

Farm land with woodland in the background, on the Nigerian frontier at the village of Dashi.

Frontier.

Ground photograph of the same area taken from the actual frontier.

SPECIES	Numbers	Percentage
Corchorus olitorius	34	45·945
Acanthospermum hispidum	14	18·919
Tribulus terrestris	7	9·459
Digitaria debilis	6	8·108
Dactyloctenium aegyptium	5	6·755
Pennisetum pedicellatum	4	5·404
Amaranthus viridis	1	1·351
Cassia tora	1	1·351
Cucumis melo	1	1·351
Cynodon dactylon	1	1·351
	74	99·994

Scrub savanna:

This is the commonest form of vegetation in Northern Nigeria and in southern Niger Colony. It is the seral stage between farmland and savanna woodland and three stages, which are as follows, can be recognised in its growth.

Farm-scrub savanna, one foot to two feet in height;
Low-scrub savanna, about five feet high;
Tall-scrub savanna, approximately eight to ten feet high.

These are described separately:-

(ii) Farm-scrub savanna:-

The farm scrub starts to grow as soon as the crops are harvested and the natural vegetation is no longer cut back; it grows throughout the resting period of the dry season and at the end of the four or five months and before the farmland is prepared for the next year's crop, the scrub is some two feet high. The shoots are strong and fast-growing. The scrub is found on guinea-corn and millet farms, where the vegetation has been cut back to soil level, and more rarely, on ground-nut farms where the ground has been cleared/

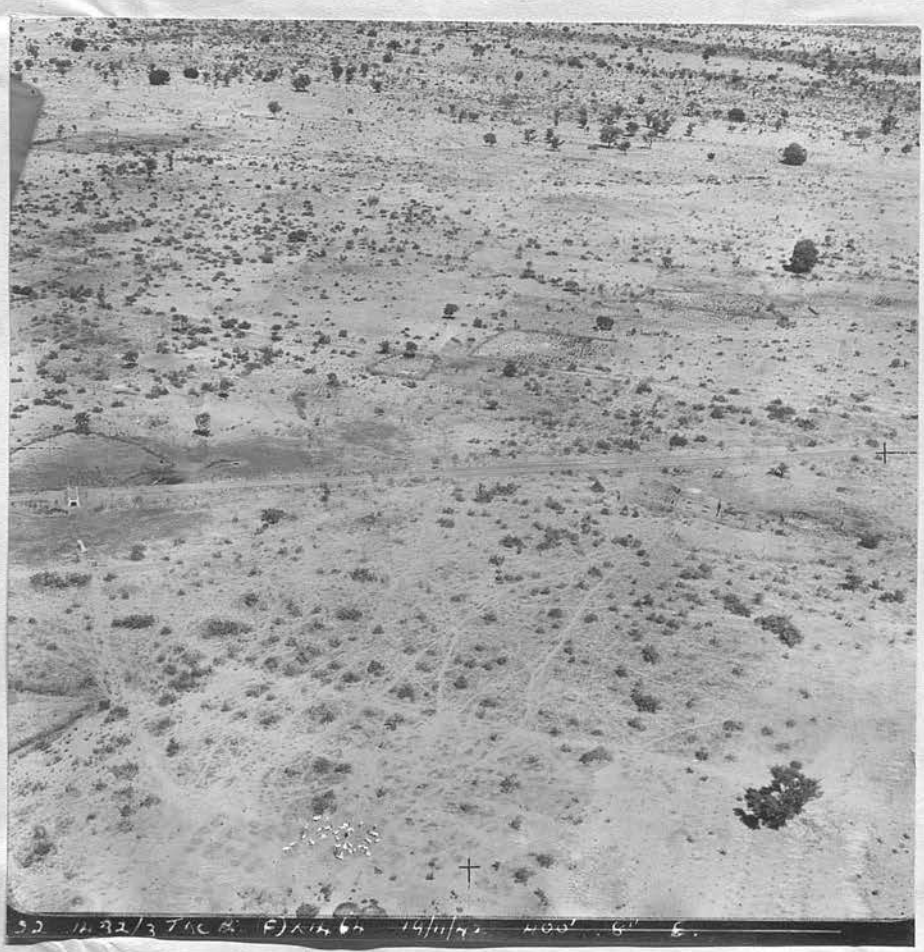
cleared and cleaned and where no stools, or very few have been left to produce regrowth. There is also a wealth of grass and weeds. In northern Katsina province the farmers sow seeds of the Dum Palm (Hyphaene thebaica), on farmland, so that in the dry season coppice shoots of Hyphaene occur on the ground; these are cut and burned and the ash spread on the farmland; this is an accepted practice in that area and is highly beneficial to the soil, but the procedure is not widespread.

The commonest species in the early scrub-savanna are Bauhinia thonningii, Guiera senegalensis, which are found in a common and widespread association, Ziziphus mauritiana, Acacia albida, Cassia tora, Combretum micranthum, with some grasses and a host of herbaceous species.

The regrowth is cut back and the area is cleaned in March or April if it is again going to be used for agricultural crops. If it is being left as fallow-land then the farm-scrub savanna progresses to low-scrub savanna.

The Bauhinia-Guiera association is the commonest indicator of farmland lying under fallow, yet can be seen in most areas where the vegetation has been destroyed at one time or another. It is also found on hillsides, the vegetation of which has been cut for fuel.

Farms have, on occasion, to be made on lateritic soil if there is anything in the nature of land hunger, and in recent years this has taken place at Daura in northern Nigeria; an example of it is seen in an aerial photograph. The combretaceous scrub consists of almost pure Combretum micranthum, and there are a few other species such as Cassia arereh, Diospyros mespiliformis and Bauhinia thonningii. The combretaceous scrub is cut and burned when a new farm area/



Farmland, in 1942,
and fallow-land, i
photograph, at a c
frontier on the ro

area is made. Farms can only be made for two or three years on this type of soil, as opposed to six or seven years on good farmland. When the area is left for a few months the Combretaceous scrub coppices and grows slowly - more slowly than Bauhinia and Guiera. It takes about one year to grow to a height of one foot. There are only a few species of herbs as the soil is not a good one. The ground recovers slowly and should not be used for farming except where it is quite unavoidable. A list of species found on one hundred square yards of one-year-old fallow was as follows:-

Commelina nudiflora	Mitracarpum verticellatum
Borreria stachydea	Thelepogon elegans
Peristrophe bicalculata	Digitaria gayana
Ceratotheca sesamoides	Cleome monophylla
Cassia tora	Polycarpeae linearifolia
Hibiscus asper	Eragrostis ciliaris
Calonyction muricatum	Digitaria debilis
Pennisetum pedicellatum	Acanthospermum hispidum
Dachyloctenium aegyptium	Bauhinia thonningii
Corchorus olitorius	Evolvulus alsinoides
Tephrosia bracteolata	Waltheriana americana
Hibiscus sabdariffa	Desmodium lasiocarpum.
Centaura alexandrina	

(iii) Low-scrub savanna:

Low-scrub savanna is the commonest vegetation on fallow-land in the Western Sudan and is almost ubiquitous. It varies from approximately two to six feet high and consists almost exclusively of an association of Bauhinia and Guiera. There is a wealth of grass at this stage, but the majority of weeds have disappeared. Photographs taken in/

in an area of scrub-savanna at Daura are included and aerial photographs taken of the same area illustrate the incidence of farmland, fallow-land and combretaceous scrub round Daura. Low-scrub begins to densify after five years and is very thick in seven years, so dense as to be difficult to walk through.

As the association densifies the weeds and early colonizers die or are killed out; the writer has proved, as can be shown from profile drawings to scale, that Dichrostachys glomerata is generally killed out from an area of fallow-land in which Bauhinia and Guiera are growing strongly.

The following shows the number of species (diameter class 0-2 inches), on two separate acres of fallow-land on which good guinea-corn, millet and beans had been produced six and eight years before respectively.

	6 years old	8 years
Acacia ataxacantha	1	-
Acacia macrostachya	4	24
Annona senegalensis	21	45
Bauhinia thonningii	165 (34·5%)	283 (47·4%)
Bauhinia rufescens	1	1
Cassia arereh	6	-
Cassia singueana	18	31
Cassia sieberiana	5	2
Combretum micranthum	55	24
Combretum verticellatum	1	9
Dichrostachys glomerata	51	26
Diospyros mespiliformis	2	2 (1-10"-12")
Gardenia sokodensis	-	4
Grewia mollis	1	-
Guiera Senegalensis	130 (27·7%)	137 (22·9%)
Hyphaene thebaica	1	6
Heeria insignis	1	-
Parkia oliveri	2	-
Sclerocarya birrea	1 (6-8")	1
Stereospermum kunthianum	1	-
Ximenia americana	7	-
Ziziphus mauritiana	3	-
Ziziphus mucronata	1	1
	478	596

It will be noticed that even in the scrub which is eight years old there is already a smaller number of individ-:ual species although there is a bigger number of trees on the ground. Both obviously have a preponderant number of Bauhinia and Guiera as one would expect. All the species except Sclerocarya (which was in the 6-8" diameter class) in the six years old scrub, and all except one Diospyros (which was in the 10" - 12" diameter class), were in the 0 - 2" class.

It is of interest that there is 34·5% Bauhinia and 27·7% Guiera in the six year old scrub while there is 47·4% Bauhinia and 22·9% Guiera in the eight year old scrub; Bauhinia is thus already beginning to be preponderant and it will be shown later that Bauhinia attains a still higher ratio when the scrub has improved to close growing low-savanna woodland at the age of twenty years or more.

Ground photographs illustrate low-scrub savanna but the aerial photograph better shows the actual espacement of an average crop on the ground.

(iv) Tall Scrub savanna:

This is the fourth seral stage in the progress of scrub vegetation from abandoned farmland to the low-woodland-savanna which precedes the climax formation of West African Woodland Savanna.

In the tall-scrub savanna the vegetation varies from approximately eight to fifteen feet; the espacement is close, Bauhinia is preponderant, although Guiera is still present, but in small numbers. This is a striking and important stage in the ecological succession; the soil has been rested and has improved with the accumulation of humus, although it is not thick; it has also been protected from erosion /

erosion and from insolation, and the average soil is ready to produce good farm crops for a period of six or seven years.

The writer has been able for some years to study areas of tall-scrub savanna in protected compartments in the Katsina plantations, and it was at his recommendation in 1939 that two areas were protected from exploitation, so that their full cycle might be observed. The areas were farmed until 1928 and were protected from 1929; they are therefore fifteen years old in 1944. The crop consists largely of Bauhinia and densification has been obvious in the past seven years; a number of poor species as early colonizers, such as Dichrostachys and Guiera are now being eliminated naturally. This is in fact the penultimate stage in succession to climax savanna woodland when better species such as the Cassias, Diospyros, Butyrospermum, Parkia and other higher types are established.

Full enumerations of plots of one-half acre each were carried out on three separate compartments in the Katsina plantations and the result obtained were as follows:-

/

ENUMERATION PLOTS KATSINA PLANTATIONS ·5 ACRE PLOTS

SPECIES	COMPARTMENTS 10				11				12						
	0-2":	2-4":	4-6":	Total	0-2":	2-4":	4-6":	Total	0-2":	2-4":	4-6":	6-8":	8-10":	10-12":	Total
Acacia arabica					1	1		2							
Acacia macrostachya									5						5
Albizzia chevalerii					1			1							
Annona senegalensis	2			2	5	1		6	5						5
Balanites aegyptiaca											1				1
Bauhinia thonningii	25	23	2	50	31	28	4	63	30	24	6		4		64
Cassia singueana	1			1	14			14	40	5					45
Combretum micranthum					19			19	1						1
Dichrostachys glomerata					6			6	15	4					19
Guiera senegalensis	2			2	4			4	2						2
Entada sudanica					1			1							
Parkia oliveri									1					1	2
Vitex cuneata									3	1					4
Ziziphus mauritiana									4						4
	30	23	2	55	82	30	4	116	106	34	7		4	1	152

It will be observed from these enumeration figures that Bauhinia thonningii is the preponderant species. There are insufficient data regarding the previous history of the Compartments, but it was ascertained that Compartment 10 had Cassava (Manihot utilissma Pohl), as the crop immediately before the area was reserved and for the Cassava crop the area was completely cleared of vegetation and the roots were grubbed out. This is one reason why there are so few trees in Compartment 10 as opposed to those in Compartments 11 and 12 where Guinea Corn (Sorghum vulgare), and millet (Pennisetum typhoideum), were grown and in which although the vegetation was cut back, the roots were not grubbed out. The plantations rise from the valley of a small stream; Compartment 10 is nearer the stream and has a better soil than the others which are on the higher ground.

It will be noticed that the tall scrub in Compart-:ment 10 consists of an almost pure crop of Bauhinia, and that out of fifty-five species there are only two Guiera, which has been all but eliminated. In Compartment 11 Bauhinia is almost 55% of the total, and is followed by Combretum micranthum and Cassia singueana, which are far smaller in number, and will eventually die out.

In Compartment 12, Bauhinia is still nearing 50% of the total, and is followed next by Cassia singueana and Dichrostachys glomerata. The writer has made profile measurements in Compartment 12 over a period of five years, and those made in 1944, prove that Dichrostachys have been killed out by the overhead shade provided by Bauhinia and other species. This phenomenon was first recorded by the writer in the Nigerian Forester in 1940.

(v) /

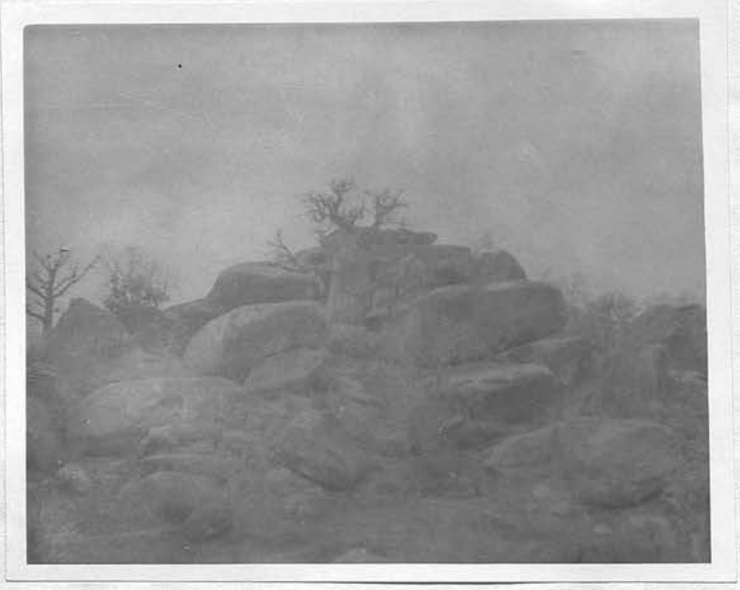
Fifteen to twenty year old Bauhinia-Guiera association on fallow land north of Tinkim.

(v) Low-Woodland Savanna.

This is a distinct and easily recognised seral stage between tall-scrub savanna and the climax formation West African Woodland Savanna. Low-woodland savanna is not common in the northern Emirates of Nigeria because of the land hunger, and the fact that the farmer cannot afford to allow fallow land to lie, as he thinks, idle, for the length of time required for the vegetation to reach this stage. The writer has rarely seen this stage in Nigeria, and indeed the vegetation of Compartments 11 and 12 of the Katsina plantations are the nearest he has seen to this. Low-woodland savanna, the penultimate stage before West African woodland savanna, is, however, much commoner in French West Africa, where there is a smaller population, fewer farmers than in Northern Nigeria and less land hunger.

Low-woodland savanna appears to require approximately twenty to twenty five years to reach that stage. The espacement is fairly close; the height is about fifteen to twenty feet and grass is, of course, present. Better species are established and include Bauhinia thonningii, Terminalia avicennoides and Sclerocarya birrea; Acacia albida may also be present. A photograph is included of this type of woodland savanna, taken some fifteen miles north of the Nigerian frontier on the road, south of Magariya, from Kano to Zinder.

The climax formation would appear to take over thirty years to establish itself, but this cannot, because of the lack of records, yet be categorically recorded.



Inselberg formation in the Ruma Reserve in Katsina Emirate, showing Adansonia digitata and Bombax buonopozense and some A ndropogon gayanus grass.

Sub-formation 5a. Inselberg Vegetation.

This is a physiographic climax with an undoubted resemblance to the formation woodland savanna. Inselberg vegetation is allied floristically to the woodland savanna, but is quite a distinct type of vegetation and is found on granitic outcrops which vary from rounded slabs a few feet high, to hills of two or three hundred feet. Often a number of blocks of varying sizes are seen perched at seemingly precarious angles. Exfoliation and the decomposition of these rocks seem to be comparatively rapid. Inselbergs are common both in Northern Nigeria and in Niger Colony; they occur in Sokoto, Katsina and Kano provinces in Nigeria, and are outstanding at Dogon Dutsi, (the Hausa words for tall rock), Birnin Konni and Zinder; although common they are restricted in area. Writing of the granitic outcrops and perched blocks in the Zinder area, M. Abadie realistically writes: "Certaines se trouvent dans une position d'equilibre invraisemblable."

There is a great variation in species throughout the various inselbergs, but they consist mainly of those that can grow under difficult conditions of poor and shallow soil, of exposure, and little accumulation of water which quickly runs off to the plain below. The commoner species are:- Acacia ataxacantha, Anogeissus schimperi, Commiphora africana, Crossopteryx febrifuga and Ficus vallis-choudae. Scrub growth is represented by Combretum micranthum, Dichrostachys glomerata and Cassia singueana. The most striking tree species are the Adansoina NIA and Ficus. Grasses are frequent and the commonest are Andropogon gayanus and Pennisetum pedicellatum.

The following species have been recorded from this sub-formation:

Ficus /

Ficus vallis-choudae	ED.a.	Crossopteryx febrifuga	f.
Adansonia digitata	ED.f.	Acacia seyal	o.
Anogeissus schimperi	ED.f.	Boscia angustifolia	o.
Sterculia setigera	ED.f.	Boscia salicifolia	o.
Balanites aegyptiaca	ED.o.	Combretum hypopilinum	o.
Bombax buonopozense	ED.o.	Commiphora africana	o.
Lannea acida	ED.o.	Detarium senegalense	o
Lannea barteri	ED.o.	Diospyros mespiliformis	o.
Sclerocarya birrea	ED.o.	Feretia canthioides	o.
Acacia ataxacantha	D.f.	Guiera senegalensis	o.
Combretum micranthum	D.f.	Hyphaene thebaica	o.
Bauhinia thonningii	D.o.	Maerua angolensis	o.
Dichrostachys glomerata	D.o.	Pterocarpus erinaceus	o.
Cassia singueana	f.	Stereospermum kunthianum	o.
Cassia sieberiana	f.	Ficus kawuri	l.

The following table shows the results from a full enumeration of this sub-formation near Jibiya, close to the Niger Colony southern boundary; the area is approximately three acres.

Species.	0 - 2in.	2- 4in.	4- 6in.	6- 8in.	8- 10in.	10- 12in.	12- 14in.	14- 16in.	16- 18in.	18- 20in.	20- 22in.	22- 24in.	24in. plus	Total
	Numbers in 2-inch diameter classes													
Acacia ataxacantha	8	-	-	-	-	-	-	-	-	-	-	-	-	8
Adansonia digitata	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Anogeissus schimperi	-	-	-	1	-	1	1	-	3	-	-	-	2	8
Bauhinia thonningii	1	1	-	-	-	-	-	-	-	-	-	-	-	2
Bombax buonopozense	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Boscia angustifolia	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Boscia saliciifolia	-	2	-	-	1	-	-	-	-	-	-	-	-	3
Cassia singueana	8	2	-	-	-	-	-	-	-	-	-	-	-	10
Combretum micranthum	6	2	-	-	-	-	-	-	-	-	-	-	-	8
Commiphora africana	4	-	-	1	-	-	-	-	-	-	-	-	-	5
Crossopteryx febrifuga	2	3	4	1	1	-	-	-	-	-	-	-	-	11
Feretia canthioides	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Ficus vallis-choudae	6	2	2	4	2	2	-	-	3	-	-	-	-	21
Guiera senegalensis	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Hyphaene thebaica	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Lannea barteri	-	1	-	-	-	1	-	-	1	-	-	-	2	5
Maerua angolensis	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Sclerocarya birrea	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Sterculia setigera	1	1	-	-	-	-	-	-	-	-	-	-	-	2
Stereospermum kunthianum	1	-	-	-	-	-	-	-	-	-	-	-	-	1
	44	14	6	8	4	5	1	-	7	-	-	-	6	95

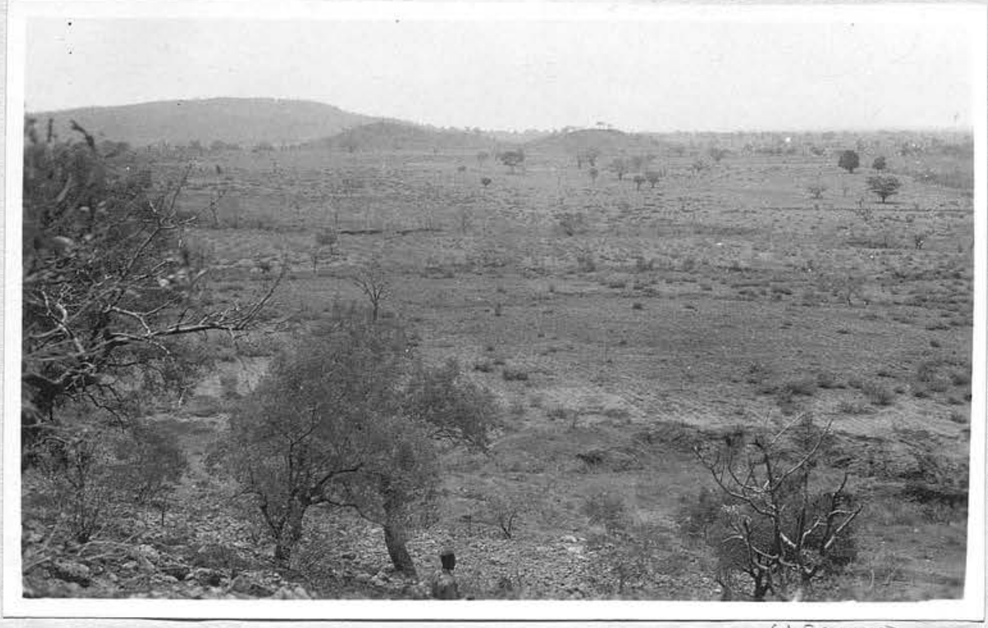
Ground photographs are included of two areas of inselberg in Northern Katsina Emirate and two aerial photographs of these formations at Zinder; the low oblique gives a good representation of inselberg, although the natural vegetation has been removed.

The inselbergs are of value in that they decompose to give a good type of soil, and the vegetation thereon can be used for fuel-wood.

It is worth noting that numerous grasses are also found on inselberg, and the following have been recorded by the writer from the Katsina area:-

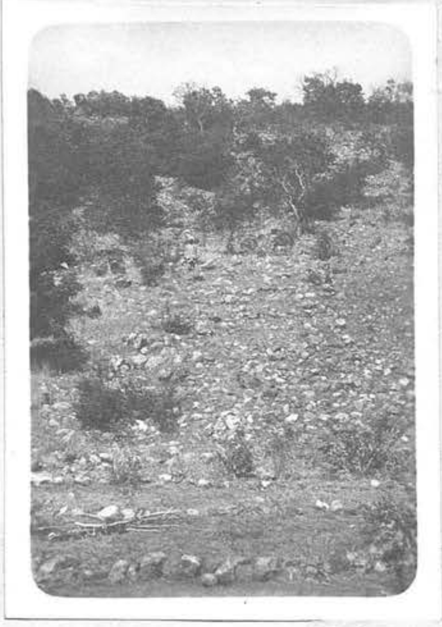
Acroceras amplectens.	Pennisetum hordoides
Andropogon gayanus	Setaria sphacelata
Aristida adscenioides	Schizachrium exile
Ctenium elegans	
Hyparrhenia dissoluta	

It has been suggested by the writer that inselberg formations should be protected, so as to reduce the rate of water streaming off these rocks and hills and causing destruction in the plains below, so that tree growth on the inselbergs may act as wind breaks, and finally that fuel-wood can be cut, on rotation, on these hills. In the Jos Highlands in Northern Nigeria, at the writer's suggestion, some areas have already been reserved and planting of exotic species for fuel has already been begun.



(A.F.A. LAMB).

Farmland in the main valley of the Kazaure Hills.



Experimental plot at Kazaure
showing the vegetation completely cleared
in January, 1938, and below the same area
in which there is only grass and other-
wise no recolonization of the vegetation.

SUB-FORMATION 5b. HILL-SCRUB SAVANNA.

This edaphic climax is restricted in size owing to the comparatively flat nature of the terrain in which there are relatively few eminencies or hills. It is related to the savanna woodland and has much in common with the low-scrub savanna which succeeds farming operations or other clearings in savanna, and which is a seral stage only, in savanna woodland. A number of species are common to both hill-scrub savanna and scrub-savanna, but while the latter exhibit progressive ecological succession, the hill-scrub species are restricted in their growth and final form, owing to their exposed position, the shallowness and poorness of the soil, and the exposure of the soil to insolation, which restricts natural regeneration.

The floristic composition varies largely on the different types of hills, and on the hills in the different vegetational belts, those in the Guinea zone being infinitely richer than those in the pre-Saharan zone. A good scrub savanna may be found on the quartzite type of hills such as occur at Kazaure in northern Kano Province, as opposed to the degraded combretaceous scrub found on the lateritic hills in the pre-Sudan and pre-Saharan Zones in Niger Colony.

The vegetation on these hills is frequently heavily exploited for fuel since better vegetation is left than on the farm land areas of the valleys and plains. When the vegetation is wholly or partially destroyed a degraded scrub-vegetation succeeds, since the natural vegetation is in a state of delicate equilibrium owing to the physical and climatic factors. When the roots are grubbed out then grass only, results in the first few years, and, as it has been proved by the writer by experiments in the Kazaure hills, there is no natural regeneration or recovery by the shrubs in a short period of seven years. Improvement of the vegetation by /

by sowing of indigenous seeds or planting of cuttings, has also been proved to be quite ineffective; densification and general improvement can only be obtained by complete protect:ion from man, animals and fire. Farms are rarely made on these hill slopes, largely because of the poorness of the soil, but the vegetation is cut almost continuously for fire wood. Experiments made in the Kazaure hills proved that lines of stones and small boulders put in along the contour lines at one yard intervals, restrict the rapid run-off of rain water, retard erosion and in some cases build up strips of soil immediately above the lines of stones. Photographs are included to show the types of hill vegetation in the Kazaure area and the lack of it on lateritic hills in the Zinder region.

A number of hills in the Kano and Katsina provinces have been reserved at the suggestion of the writer, so that fuel may in the next decade, be obtained from the hill-scrub cut on rotation.

The vegetation on the hills and small plateaux in Niger Colony do not have the floristic range of those in the Sudan Zone, but exhibit a poorer, more scanty type of scrub consisting of Acacias, Combretum micranthum and other xerophilous species. Nor are these areas exploited for fuel to the same extent as further south, since there is a smaller population, which can obtain fuel from the vegetation on the plains, on which there is less extensive farming. On the flat-topped ironstone hills the soil is frequently lateritic with a surface covering of water-washed pebbles, showing obviously, surface soil is continuously being lost. The soil has become more and more unprotected from erosion and insolation and vegetational recovery has become impossible. Combretum micranthum, which will grow on nearly solid lateritic concretions and the cracks therein, is /

is found almost pure with only a few herbaceous colonizers such as Cassia singueana and Cassia obovata.

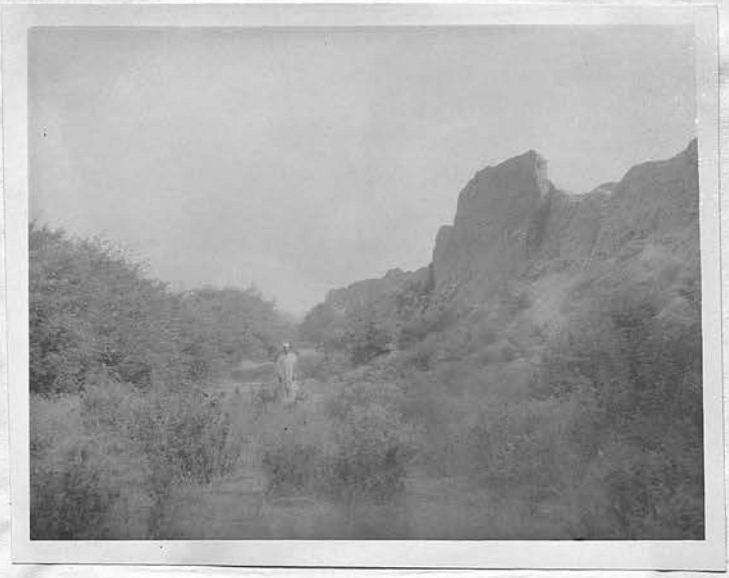
Grass species are even restricted on those hills and Andropogon gayanus is frequently absent; the commonest grasses are Aristida adscensionis and Pennisetum pedicellatum. Andropogon, however, may be found in profusion amongst hill scrub on the hills, in the southern Sudan zone and in the Guinea zone.

The following species are found in this climax:-

Bauhinia thonningii	ED.a.	Acacia ataxacantha	f.
Anogeissus schimperi	ED.o.	Acacia macrostachya	f.
Boswellia dalzielii	ED.o.	Boscia angustifolia	o.
Lannea acida	ED.o.	Cassia singueana	f.
Lannea barteri	ED.o.	Cassia obovata	o.
Prosopis africana	ED.o.	Combretum aculeatum	f.
Scleroearya birrea	ED.o.	Combretum verticillatum	f.
Bauhinia rufescens	D.o.	Dichrostachys glomerata	f.
Annona senegalensis	o.	Feretia canthioides	o.
Combretum micranthum	a.	Fluggea virosa	r.
Acacia albida	o.	Guiera senegalensis	f.
Acacia seyal	o.	Tephrosia bracteolata	r.
Acacia senegal	o.	Ziziphus mauritiana	o.

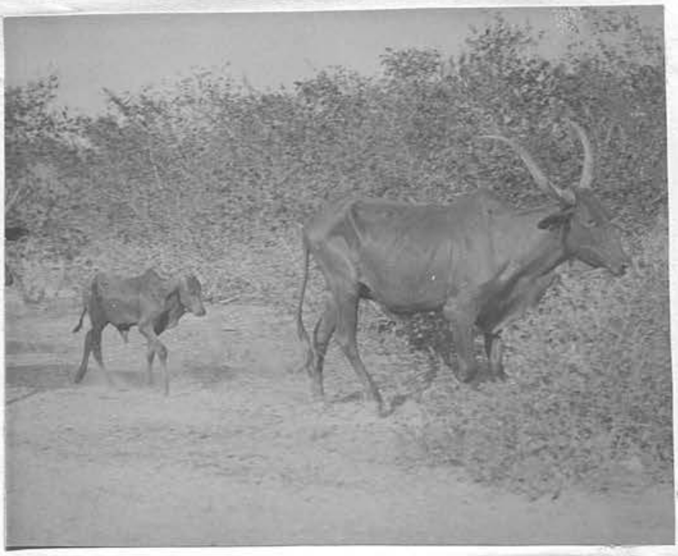
The following enumeration of an area of hill-scrub one acre in extent, was made in Daura Emirate of Katsina Province:-

SPECIES	Two inch Diameter Classes						Total	Percentage
	0-2:	2-4:	4-6:	6-8:	8-10:	10-12:		
Combretum micranthum	70	10	1				81	24·543%
Acacia macrostachya	31	6	2				39	11·817
Kaudahantsi	18	8	2	1			29	8·787
Combretum verticellatum	20	1	1				22	6·666
Guiera senegalensis	21						21	6·363
Cassia singueana	19						19	5·757
Acacia ataxacantha	13	1					14	4·242
Acacia seyal	14						14	4·242
Lannea barteri	4	5	2	1	2		14	4·242
Boscia salicifolia	11	1	2				14	4·242
Bauhinia thonningii	8						8	2·424
Lannea acida	3	2	3				8	2·424
Grewia mollis	7						7	2·121
Marlee	6	1					7	2·121
Prosopis africana	3			1	2		6	1·818
Annona senegalensis	4						4	1·212
Boscia angustifolia	4						4	1·212
Feretia canthioides	4						4	1·212
Boswellia dalzielii		3					3	·909
Acacia albida	1		1				2	·606
Acacia senegal	1	1					2	·606
Dichrostachys glomerata	2						2	·606
Fluggea virosa	2						2	·606
Tsabagi	1						1	·303
Albizzia chevalieri	1						1	·303
Tephrosia bracteolata	1						1	·303
Ziziphus mauritiana	1						1	·303
	270	39	14	3	4	-	330	99.990 %



Example of the vegetation in the town wall ditch at Kano. Vegetation consists mostly of Acacia sieberianna.

Scattered degraded scrub on the hill Dutsin Bidawa, Zinder.



Combretaceous scrub in the neighbourhood of Daura. The cattle belong to the Fulani cattle people.

An example of low inselberg in Katsina Emirate.

It will be seen that the largest numbers are recorded for the Combretums, Acacias, Guiera and Cassia singu-;eana and that the species which prefer a better and deeper soil such as Bauhinia, Boswellia and Lannea are smaller in number. Dichrostachys is rare because of the lack of shade, it is really a shade-demanding thicket species and therefore cannot live in open hill-scrub.

The above enumeration is typical of the Sudan zone; those areas in Niger Colony in the pre-Sudan and still less, in the pre-Saharan zone, exhibit neither the numbers or the floristic composition of the climax from which these figures were recorded.

Sub-formation 5c. Combretaceous Scrub.

Combretaceous scrub is an edaphic climax usually associated with a very degraded type of soil or with lateritic plains. It consists largely of Combretum micranthum; it often occurs as a consociation with but occasional relict species, indicating a better type of vegetation in the recent past. Although it has something in common with scrub-savanna it is not an association within savanna woodland; since it in no way fulfils the rôle of a soil improver, it forms an edaphic climax and as such is treated as a separate sub-formation. It is an indicator of poor soil and, as such, appears when land becomes degraded, as so much farmland has become degraded, by over-exploitation in the Western Sudan in recent decades.

The sub-formation occurs extensively in Sokoto, Katsina and Kano provinces of Nigeria, but does not occur in the area of the Chad sands in north-eastern Kano province, or near Niguru in Bornu province, wherein the deep sandy soil is /

is unsuited to Combretum micranthum. It is found in Niger Colony in the vicinity of Niamey, extensively round Tahoua, in the area between Dosso and Gaya, and also in south-Central Niger Colony between Tessawa and Zinder.

Extensive areas occur round the towns of Katsina and Daura, and it is worthy of note that Dr. Barth made no mention of it in his description of the vegetation since 1851 in the Western Sudan, although he refers to the areas as "covered with brushwood"...... "that brushwood is always a proof of cultivation having been carried on at no distant period", by which he meant the farm-scrub and low scrub-savanna of fallow-land. Nowhere did he refer to the poor combretaceous scrub of degraded farmland. The areas round Sokoto, Katsina, Daura and Kano indicate that they have long been subjected to exploitation of the land for farming, (or the vegetation for fuel collection,) and from which the soil has deteriorated.

There is no doubt that some of those areas have supported a higher type of vegetation and therefore a better soil at one time, shown by the fact that trees of better type are found, such as Lannea barteri, Sclerocarya birrea, Bauhinia thonningii, Entada sudanica, Commiphora africana and Cassia arereh; in one area a large healthy Albizza chevalieri was observed.

It is uncertain how quickly this sub-formation can be formed; the Emir of Daura who in 1944, is over seventy years of age, records that the combretaceous scrub round Daura has been there for at least forty years and that the area formerly consisted of good farmland. As the area in the vicinity of the town would probably be used for farming over a /

a period of two or three centuries, it is still impossible to say how long the degraded scrub has taken to colonize the ground from the time that it was untouched natural wood-:land savanna. It has certainly evolved into the large areas it now covers in the ninety years since Barth visited the region between 1850 and 1855.

This sub-formation can, in fact, be taken as one of the few undoubted soil indicators of a forestry soil as opposed to an agricultural soil. It is interesting to record however, that when real soil hunger intervenes the farmer will, as he has had to do near Daura, cut the Combretum scrub to farm the soil; the pre-treatment is longer and heavier manuring is necessary however, than in the case of the Bauhinia-Guiera association of good fallow land.

The following distinctive associations have been recorded by the writer in the Central Western Sudan:-

i) Combretum - Dichrostachys - Acacia association
ii) Combretum - Terminalia - Acacia association
iii) Combretum - Bauhinia association
iv) Acacia - Combretum association.

i) Combretum - Dichrostachys - Acacia Association

This association is found on the widely distributed sandstone plateaux, covered by protective layers of lateritic rock, and whose common height in any one area, shows a former level of the plain. These plateaux are found from south-west of Gaya, eastwards to Tahoua and to the Zinder area: they are very distinctive features of the regions in which they occur. Their flora, too, is distinctive, the commonest species being Combretum micranthum, Dichrostachys glomerata and Acacia macrostachya. It is certain that these hills were at one time covered by sandstone, and that the geological stratification is sandstone overlain by lateritic rock and concretions, /

concretions, which are exposed today, and which were, in turn, formerly under sandstone. This lateritic rock probably dates from Tertiary times. The surface soil is lateritic and water-washed pebbles are a common feature. The lateritic rock is being gradually disintegrated by erosion, and the sandstone, as Brynmor Jones has pointed out, will in time form good soil.

The following species occur on these plateaux:-

Combretum aculeatum	ED.f.	Ziziphus mauritiana	D.f.
Bauhinia thonningii	ED.o.	Acacia macrostachya	a.
Commiphora africana	ED.o.	Acacia ataxacantha	f.
Entada sudanica	ED.o.	Cassia singueana	f.
Lannea barteri	ED.o.	Combretum verticellatum	f.
Sclerocarya birrea	ED.o.	Boscia angustifolia	o.
Securidaca longipedunculata	ED.o.	Bauhinia rufescens	o.
Cassia sieberiana	ED.r.	Grewia mollis	o.
Cassia arereh	ED.r.	Ximenia americana	o.
Combretum micranthum	D.a.		
Dichrostachys glomerata	D.a.		
Guiera senegalensis	D.f.		

The characteristic grasses are Andropogon gayanus, Eragrostis tremula, and Pennisetum pedicellatum.

ii) Combretum - Terminalia - Acacia Association.

This is a much more extensive association than that already described. It occupies large areas of the relatively level plains of south-west Niger Colony and of western Sokoto province in Nigeria. It occurs south-east of Dosso and across the Nigerian frontier. It occurs south of Tahoua in country which is boldly undulating, with valleys separated by long, gently sloping hills. There the surface soil is lateritic and it would appear that a previous and much /

much better soil has been eroded, - hence the extensive occurrence of Combretum micranthum. There are farms in the valleys, which naturally contain a better soil than that of the hill crests; grass occurs frequently in tufts.

Occasional relict species such as Sclerocarya birrea, Cassia sieberiana, Commiphora africana and Bauhinia thonningii are evidence of a better type of vegetation in former decades.

The following species occur in this association;-

Bauhinia thonningii	ED.f.	Dichrostachys glomerata	D.f.
Balanites aegyptiaca	ED.o.	Terminalia avicennioides	D.f.
Sclerocarya birrea	ED.o.		
Cassia sieberiana	ED.r.	Cassia singueana	f.
Commiphora africana	ED.r.	Boscia angustifolia	f.
Lannea acida	ED.r.	Guiera senegalensis	o.
Acacia ataxacantha	D.a.	Leptadenia lancifolia	o.
Combretum micranthum	D.a.	Ximenia americana	o.
Ziziphus mauritiana	D.a.	Acacia albida	r.
Combretum verticellatum	D.f.	Calotropis procera	r.

iii). <u>Combretum - Bauhinia association</u>

This is an interesting association, which the writer believes is intermediate between farm scrub with its Bauhinia-Guiera association and the poorer types of combre-:taceous scrub, that it is, in fact, a seral stage, the association exhibiting retrogressive succession from fallow-land scrub to degraded scrub, because of the unwise over-exploitation of the soil in farming operations.

The association does not appear to be extensive and the area from which the enumeration recorded below was taken, is one of the few the writer has observed. The figures were obtained from an area of Combretaceous scrub near the forestry plantations in Katsina, on ground on which there has been restricted farming for the last thirty five years/

years because of its proximity to the Government station. The composition of the area is interesting in that there are so many Bauhinia and Guiera, showing that the soil is still fairly good, and that there is a large number of Dichrostachys, which denotes lack of densification, as yet, of the scrub. It will be noticed that there are a large number of relict species such as Albizzia chevalieri, Cassia sieberiana, Commiphora africana, Stereospermum kunthianum, Sclerocarya birrea and Parkia oliveri. The area consisted of young scrub and no species were above the 0-2 inch class.

The enumeration gave the following results:-

Enumeration - Combretaceous Scrub.

Katsina Area - One Acre.

SPECIES	Number in 0-2 Inch class	Percentage
Combretum micranthum	311	35·871%
Bauhinia thonningii	123	14·163
Guiera senegalensis	98	11·303
Dichrostachys glomerata	88	10·149
Cassia arereh	59	6·805
Anona senegalensis	47	5·420
Acacia machrostachya	38	4·381
Cassia singueana	38	4·381
Ximenia americana	26	2·987
Acacia ataxacantha	8	·921
Cassia sieberiana	7	·807
Securidaca longipedunculata	6	·680
Ziziphus mauritiana	5	·576
Grewia mollis	2	·230
Heeria insignis	2	·230
Sclerocarya birrea	2	·230
Stereospermum kunthianum	2	·230
Albizzia chevalieri.	1	·115
Bombax buonopozense	1	·115
Commiphora africana	1	·115
Parkia oliveri	1	·115
Vitex cuneata	1	·115
	867	99·939

iv) /

iv) Acacia - Combretum Association.

There is a fourth specialized type of scrub which occurs in the long undisturbed, hard-baked and hard-trodden soil of town-wall ditches, occurring throughout the Sudan and pre-Sudan zones. The larger towns such as Zinder, Kano, Katsina, and Daura still have the old town walls built of sun-baked clay and mud, which served as their outer defences up to the beginning of this century. They are not now kept in repair except at the town gates for the sake of historic interest. The walls are graudally being broken down by climatic action but the large ditches, often thirty feet wide and twenty feet deep remain, although they are gradually being silted up.

In these town ditches there is a wealth of scrub vegetation and where they are undisturbed by cattle or wells or children, dense thickets are formed. The soil is very poor indeed but is not barren by any means; the ditches hold water in the wet season and a poor type of vegetation, consisting of xerophilous species, and a wealth of grasses and weeds may flourish.

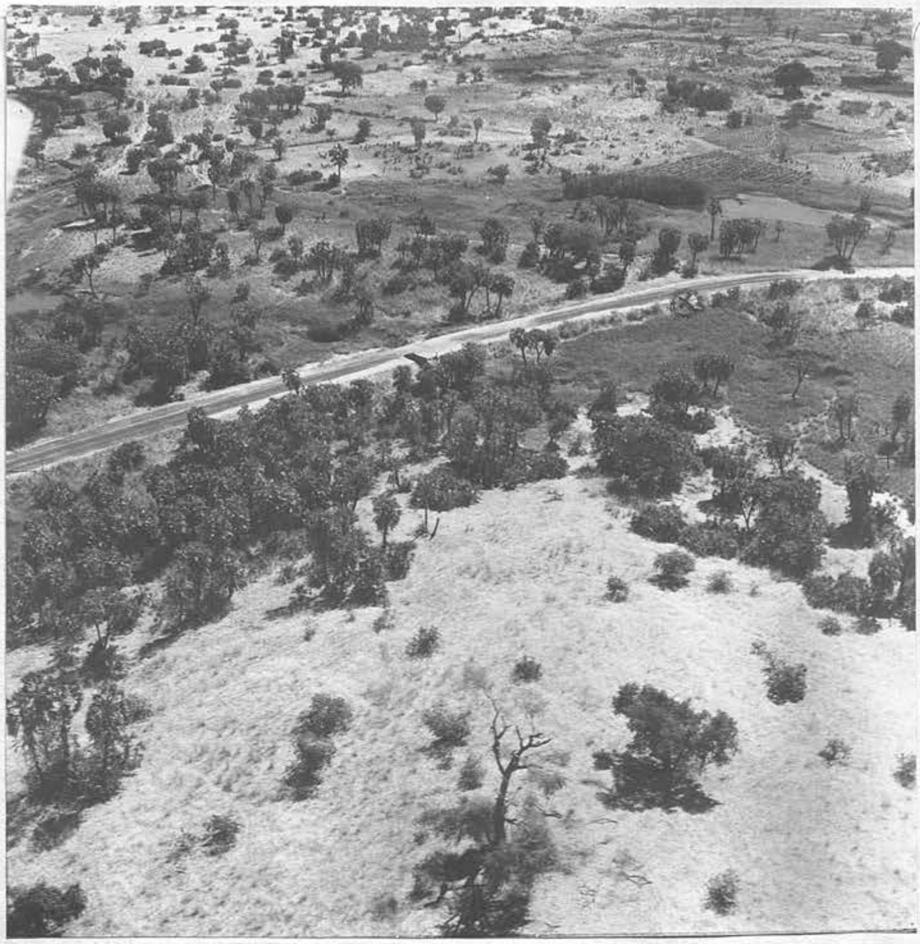
The vegetation consists of an Acacia-Combretum association which is not without interest. The preponderant species is usually Acacia ataxacantha, which frequently occurs as a consociation and which, in some areas, is quite impenetrable. Cattle frequently graze in the wider portions of these ditches and they undoubtedly assist in the natural regeneration of some of the species.

No enumeration has been made of this type of scrub, but the following list illustrates all the species which occurred in the town-wall ditch round the native town of Daura in July of 1940, the commonest species being Acacia /

Acacia ataxacantha, Combretum micranthum and Cassia tora.

Acacia ataxacantha	a.	Pennisetum pedicellatum	f.
Acanthospermum hispidum	a	Acacia arabica	o
Cassia tora	a.	Acacia sieberiana	o.
Combretum micranthum	a	Amorphophallus dracontioides	o
Acacia seyal	f	Aristida stipoides	o
		Capparis tomentosa	o
Balanites aegyptiaca	f	Grewia mollis	o
Boscia angustifolia	f	Ricinus communis	o
Leptadenia lancifolia	f	Rogeria adenophylla	o
		Smilax kraussiana	o

This association is not merely of academic interest but is of some importance from the economic point of view, in that the weed Acanthospermum flourishes in such situations. The cattle browse through the town ditches and Acanthospermum fruits are carried by the cattle onto the farm and fallow land. Acanthospermum then colonizes areas with a pure crop of the weed, preventing grass growth (which would be available for grazing), which is not abundant and is indeed below the requirements of the cattle, sheep and goats in some areas. From the point of view therefore of welfare and development the Acanthrospermum should be cleared from this association in these town ditches.



Aerial photograph of the Hyphaene stand seen in the lower photograph and showing the same patch of swamp and the same sand-dune.

Pure Hyphaene thebaica, north of Matamaye. Sand dunes in the background. Lying water on the left.

A mosaic built up from three aerial photographs of the river Maradi and the road from Maradi to Jibiya in Nigeria. The vegetation consists of orchard woodland. A tributary of the river Maradi can be seen below the motor road.

CHAPTER 12

FORMATION 6. WEST AFRICAN ORCHARD WOODLAND SAVANNA.

This formation lies for the most part north of latitude 13° and is therefore more plentiful in Niger Colony than it is in Nigeria, where it occurs in northern Sokoto, Katsina and Kano provinces. It is however less common today in Nigeria than in the past, since much of it, growing on the agricultural type of soil, has been destroyed in farming operations, except where the population is relatively small, as in Gumel Emirate of Kano province; in Nigeria patches occur in northern Katsina and Sokoto Emirates and larger areas in Gumel Emirate. There is no doubt that where there were formerly hundreds of square miles of this formation in Nigeria there are now but tens of square miles. It is regrettable that such areas have been destroyed and that a larger percentage has not been protected; but it should be appreciated that with the coming of peaceful conditions and the great increase of population in the last twenty years, the native peoples must have the land which is sufficiently good for agriculture, to produce the necessary food for them to enjoy a reasonable existence. Some Orchard-Woodland has been reserved in Northern Nigeria but it is by no means extensive.

The formation is not extensive from north to south, but it does cover a wide range from west to east. The southern boundary in Niger Colony runs from near Kaya north-west of Fadan Gourma, eastwards through the Niamey-Tillaberi area to Maradi and south-east of Zinder, where the Manga grass country is reached. The northern limit follows approximately the 300 mm. isohyet from north of Bentia on the Niger /

Niger to Gangara on the road from Katsina to Agades, and to Gouré north-east of Zinder. The greater part of the formation, in effect, lies within the pre-Sudan vegetational zone.

A number of associations occur in the formation and they themselves vary according to the climate and physiographic factors. The following were recorded by the writer:-

(i) Anogeissus - Bauhinia Association: - Birnin Konni area.
(ii) Tamarindus - Prosopis Association:- Southern Tessawa district.
(iii) Sclerocarya - Bauhinia Association:- Northern Tessawa district.
(iv) Commiphora - Bauhinia Association:- Southern Gangara district.

A description of each is as follows:-

(i) <u>Anogeissus - Bauhinia Association.</u>

This association is most marked in the Birnin Konni area, and it gives an indication of the former vegetation in northern Sokoto province, (which is intensively farmed), in which few large trees have been left and which, in the dry season, exhibits an expanse of bare, soft sand which is more desert-like than parts of the desert itself. Never-the-less the soil is still fertile and with heavy dressings of farm-yard manure and village sweepings, good crops are still obtained; it is doubtful how long this can be carried on before the soil deteriorates and Combretaceous scrub, which has already covered large areas, will supervene.

In the Birnin Konni district this association has a depth from north to south of approximately 30 miles. Much of the country is farmland, but the population is not sufficiently high, completely to destroy the orchard woodland. The country is undulating, the soil is sandy and fertile and the rainfall is approximately twenty-four inches per year.

The /

The tree vegetation in the climax woodland averages twenty-five feet high with a fairly close espacement. The contrast between the almost treeless expanse of Godabawa in Nigeria and the woodland of Birnin Konni is most striking. Aerial photographs of the Birnin Konni area from 14,000 feet stress ~~rather~~ the amount of farm and fallow land close to the town, but the areas of woodland can be distinguished in small portions, which increase greatly at some eight to ten miles from the town, where the rural population is much smaller.

The following species were recorded in this association:-

Anogeissus schimperi	ED.a.	Ziziphus mauritiana	D.f.
Bauhinia thonningii	ED.a	Cassia singueana	f.
Balanites aegyptiaca	ED.f.	Acacia ataxacantha	o.
Combretum verticillatum	ED.f.	Acacia seyal	o.
Sclerocarya birrea	ED.f.	Bauhinia rufescens	o.
Lannea barteri	ED.o.	Combretum micranthum	o.
Tamarindus indica	ED.o.	Ximenia americana	o.
Guiera senegalensis	D.f.		

(ii) Tamarindus - Prosopis Association.

This association was recorded in 1939, over a restricted area north of the riparian and swamp formations in southern Tessawa district. The former vegetation round Tessawa has been almost completely destroyed (as will be seen from the aerial photographs), by the farmers, in an area which is relatively highly populated. The ground is gently undulating and there is evidence of former "banks" of the rivers of the Quaternary period. The soil is light and sandy but is a fertile one. The average height of the vegetation is fifteen feet. The species indicate that the association /

association is quite a good one with good specimens of Anogeissus, Sclerocarya, Lannea and Securidaca. The soil is a good agricultural one as well as a good forest soil, and it will no doubt be used by farmers in the future as the population increases. Meanwhile the tree vegetation does much to protect the soil and generally to improve the condi- :tions in the region. The area is much used by the nomadic and settled Fulani cattle people for the grazing of their herds.

A larger number of species were recorded in this association than in the previous one and it is probable that this is caused by the fact that the area lies in a wide depression which has collected good soil over long years, in an area that was a riverain area in a previous age.

The following species were recorded:-

Anogeissus schimperi	ED.f.	Combretum verticillatum	D.f.
Balanites aegyptiaca	ED.f.	Dichrostachys glomerata	D.f
Bauhinia thonningii	ED.f.	Guiera senegalensis	D.f.
Diospyros mespiliformis	ED.f.	Ziziphus mauritiana	D.f.
Prosopis africana	ED.f.	Acacia arabica	o.
Sclerocarya birrea	ED.f.	Acacia seyal	o.
Tamarindus indica	ED.f.	Annona senegalensis	o.
Acacia albida	ED.o.	Bauhinia rufescens	o.
Lannea acida	ED.o.	Cassia singueana	o.
Lannea barteri	ED.o.	Securidaca longipedunculata	o.
Hyphaene thebaica	ED.l.		

(iii) /

Pure Sclerocarya birrea in orchad woodland on the road from Takieta to Tessawa.

(iii) Sclerocarya - Bauhinia Association.

This association occurs from approximately Tessawa, north to the southern limit of the pre-Saharan zone, some twenty miles further north. This is a very narrow and distinctive belt and its exact counterpart does not seem to occur on the road from Birnin Konni to Tahoua, nor from Gaya to Niamey; it appears therefore to be rather restricted in distribution. The soil is sandy but fairly fertile; the tree vegetation grows at a reasonably close espacement, as can be seen from the photograph taken a little north of Tessawa. Consociations of Bauhinia thonningii, Sclerocarya birrea and Commiphora africana were recorded. An association of Sclerocarya and Guiera was also observed. This is quite an important association since it improves the soil as well as protects it. Ample grazing and browsing is afforded to the cattle and livestock in general.

If the climax vegetation is destroyed for farming it is succeeded by the ubiquitous Bauhinia-Guiera association, characteristic of fallow land. Grass is common if not abundant and the commonest species is Andropogon gayanus. In the climax growth there are few species in the herb layer and very few, if any, on the ground layer.

The following species were recorded in this association:-

Bauhinia thonningii	ED.a.	Acacia arabica	f.
Sclerocarya birrea	ED.a.	Boscia angustifolia	f.
Balanites aegyptiaca	ED.f.	Cassia singueana	f.
Commiphora africana	ED.f.	Combretum verticillatum	f.
Anogeissus schimperi	ED.o.	Acacia albida	o.
Hyphaene thebaica	ED.o.	Acacia seyal	o.
Lannea acida	ED.o.	Annona senegalensis	o.
Prosopis africana	ED.o.	Bauhinia rufescens	o.
Tamarindus indica	ED.o.	Cassia arereh	o.
Vitex cuneata	ED.o.	Diospyros mespiliformis	o.
Guiera senegalensis	D.f.	Leptadenia lancifolia	o.
Combretum micranthum	D.o.	Ziziphus spini-christi	r.
Dichrostachys glomerata	D.o.		

(iv) Commiphora - Bauhinia Association.

The orchard woodland savanna formation is very distinctive in the pre-Saharan zone and stretches on the road from Tessawa to Agades, from twenty to ninety miles north of the former.

The Commiphora-Bauhinia association is the com-:monest in this area; there is little numerical variation in the species but the height of growth visibly decreases as one goes northwards. The area is mostly flat, but low weathered sandstone rocks and small escarpments occur in the northern portion. The soil is sandy and is fairly fertile; the lack of sufficient rainfall is the limiting factor in agriculture and it is in this stretch that the last of the non-irrigated farming occurs, approximately 100 miles north of Tessawa. The northern limit of ordinary farming is indicated on the map on agriculture included in this paper.

Commiphora africana is the commonest species in the area and Bauhinia thonningii, although abundant on the whole, begins to disappear towards the northern boundary of the formation. Commiphora and Acacia arabica form consociations in places. Acacia arabica, Anogeissus schim-:peri, Mitragyna inermis and Ziziphus mauritiana form an association in the region of the small swamps.

Eventually the association is reduced to scrub and grass about eight feet high. Andropogon gayanus is still the commonest grass.

The following species, with the heights of some indicated, were recorded in this association:-

Commiphora /

Commiphora africana	ED.a.	Combretum verticillatum	o.
Acacia albida	ED.f.	Leptadenia spartium	o.
Acacia arabica	ED.f.l.	Maerua crassifolia	o.
Sclerocarya birrea	ED.f.		
Anogeissus schimperi	ED.o.l.	Ziziphus spina-christi	o.
Prosopis africana	ED.o.	Bombax buonopozense	r.
Mitragyna inermis	ED.r.l.		
Tamarindus indica	ED.r.		
Bauhinia thonningii	D.a.		
Entada sudanica	D.r.		
Acacia seyal	f.		
Balanites aegyptiaca	f.		
Bauhinia rufescens 15'	f.		
Cassia singueana 8'	f.		
Guiera senegalensis 15'	f.		
Ziziphus mauritiana	f.		
Boscia angustifolia	o.		
Calotropis procera	o.		
Combretum micranthum 7'	o.		

CHAPTER 13

FORMATION 7. WEST AFRICAN DRY PALM STANDS.

Palm stands in the Central Western Sudan consist of Borassus aethiopum the Fan Palm, Hyphaene thebaica, the Dum Palm and Phoenix dactylifera or Date Palm, which is extensively cultivated for the sale of dates.

The Fan Palm is not common as it is in the Northern Guinea Zone, but occurs spasmodically in the Sudan zone from Gaya on the Niger eastwards to Kano. It is usually found in the neighbourhood of swamps or rivers or where there is a suitably high water table. It is not found, generally speaking, except by accident, in the dry sandy soils on which Hyphaene will grow. It is only found in Niger Colony in the south-western portion near the River Niger.

Good stands, of which photographs are included, occur in the Jibiya area of Katsina Emirate near the River Jibiya, and in river country east of Kano in regions in which there are shallow valleys in which telluric moisture is available. The palm is occasionally found in almost pure stands with surprisingly good natural regeneration. The stems are in very great use in building both native houses and government buildings. Every effort, therefore, is being made to protect them by controlled felling, as the Sleeping Sickness Service Department in Nigeria are opposed to complete reserva-:tion of riverian areas with the possibility of increasing the Tsetse fly numbers and the incidence of Trypanosomiasis.

Borassus are also invaluable in that they act as shelter belts in these areas and also, where they occur on river banks, they contribute very largely to binding the river banks and preventing the loss of valuable farmland.

The Borassus Palms may be almost pure, but there is usually a certain amount of small scrub and grass present, the /

Stands of Borassus flabellifer in association with Acacia campylacantha in the Jibiya Forest Reserve.

Pure stand of Borassus flabellifer with natural regeneration, in the Jibiya forest reserve.

Riparian woodland on the River Jibiya
and within the Jibiya Forest Reserve.
Species consisting of Borassus, Acacia
campylacantha, Hyphaene, Anogeissus schimperi,
and Tamarindus indica.

Photograph of part of the Jibiya forest reserve
and ,in the foreground,.young Hyphaene thebaica
on the present year's farmland.

the number of species depending on the closeness of the palms and the character of the soil. If the palms are felled for palm-scantlings or for farming or tobacco production and the area is abandoned, a covering of grass and herbs and possibly some scrub appears in due course. In a short time young Borassus appear, either from natural regeneration or from sown seeds, with an accompanying growth of grass, herbs and scrub. This is followed at a later stage by Borassus of good size. A pure stand of Borassus with a ground-cover of grass and herbs with some scrub, completes the cycle. If there is no natural regeneration, and no steps are taken by sowing of seed artificially to regenerate the area, then the second stage of grass and herbaceous growth will proceed directly to grassland and degraded scrub.

It may be of interest to record that because of Borassus reserves not being permitted by the Nigerian Government, the Native Authorities are being encouraged, in certain areas, by the Forest Department to create Communal Forest Areas of these palm stands, wherein the palms are protected, only exploited under permit and the area made available for restricted farming.

Hyphaene thebaica is found extensively in the Central Western Sudan and occurs from the southern limit of the Sudan zone northwards, in suitable localities, to the Desert zone. It is common from north of Fadan Gourma to Tilliberi, (where it is very common), eastwards to Sokoto, Kano and Nguru. Many pure stands occur over extensive areas. The palm occurs in areas in which there is surface water, sub-surface water or where telluric moisture is available. It occurs singly in dry areas where there is adequate soil moisture. It is not found, for instance, in dry areas of orchard-woodland savanna. It occurs frequently in /

frequently in riparian and swamp woodland. The range is, in fact, unexpectedly wide from north to south, and it is found to be common along the dried-up river courses in southern Aïr; east of Agades it was found to be quite luxuriant, dependant, of course, on telluric moisture. Along the banks of the River Agades, thirty miles north of Agades on the road to Iferouane, the pure Hyphaene form a typical "palmerie". It can also stand soil with evidence of salt and is in fact, for a palm, extremely tolerant.

Pure stands of the Dum Palm are therefore not uncommon and scattered palms are even common in dry woodland on sites with adequate supplies of water.

A most interesting ecological succession can be observed in areas of pure Hyphaene thebaica in which farming operations have been undertaken. When a palm-stand area is chosen for farming the palms are felled and the young natural regeneration is cut back to ground level, together with any scrub-~~savanna and thorn-~~scrub which may be on the area. Farming operations may then go on for three or four years or more. At the end of the final harvesting an area of exposed soil is left. It is followed after a few months by the shoots of young Hyphaene, and by low-scrub and thorn-savanna. It is important to note that mature Hyphaene will not coppiec but that regrowth occurs from young palms which have not been allowed to form the trunk. In Katsina province the young leaves of the palm are cut on the farmland, collected and burned so that the ash can be mixed with the soil; this very greatly assists in retain-:ing the soil fertility.

In some areas such as in the neighbourhood of the swamps at Nguru, Calotropis procera (the Dead Sea apple), appears sometimes forming a pure crop, of which an instance was /

Hyphaene thebaica stand with natural regeneration
south of Nguru.

was recorded north of Tessawa by Barth in 1850, when he wrote...."then followed a tract of country entirely covered with the monotonous Asclepias gigantea".

If the area on which there has been good stands of Hyphaene, is left with little natural regeneration after farming operations and no seed have been sown artificially, then the succeeding vegetation will consist of low-scrub savanna and thorn-scrub with occasional palms. If, on the other hand, the ground has been over exploited and there is no natural or artificial regeneration of Hyphaene, then retrogressive succession occurs through degraded scrub-savanna and thorn scrub to the final stage of sparse grass and low degraded scrub.

The cycle is as follows:-

Hyphaene thebaica and grass
Low scrub-savanna, thorn-scrub and grass
or Calotropis procera, scrub and grass
↓
Coppice of Hyphaene
Hyphaene natural regeneration
Scrub-savanna, thorn-scrub and grass
↓
Hyphaene scrub and thorn-scrub, savanna and grass
↓
Hyphaene, scrub remnants and grass.
Grassland and degraded scrub.

Raphia vinifera occurs in the southern Sudan zone; it usually requires, however, to be propagated artificially, under very difficult conditions and it is therefore uncommon. It can, nevertheless, be grown in certain areas and excellent stands occur in the cultivated gardens, (which are supervised /

Hyphaene thebaica and natural regeneration in an area with a high water-table, to the south of Nguru.

Dum palms in a low lying area north of Magariya. Charcoal kilns on the left - prepared mostly from Prosopis africana.

Dum palm stand and natural regeneration in the area North of Dankama on the road from Katsina to Tessawa.

Farmland north of Kazaura in an area with a high water table with numerous Hyphaene.

supervised by the Forest Department), at Sokoto in Nigeria. Raphia requires a good supply of water and accompanying shelter, and is found naturally, furthest north, along the river banks of the Northern Guinea zone. It is exploited largely by the native for the rachis of the large palm leaves; the rachis is used in the construction of houses, huts and other buildings in the northern Guinea zone. It should be grown artificially much more widely, and it is probable that it could be grown in the neighbourhood of perennial river swamps in the Gaya - Kano latitude.

The Sleeping Sickness Service in Nigeria is opposed to reservation of Raphia stands since tsetse fly occur so frequently in their shade; this has been overcome in certain areas in Katsina Province in Nigeria, by protecting the individual Raphia and allowing its exploitation on permit only, over a period of two weeks at the beginning and end of the rainy season in April and October. In this way it is considered that the tsetse if present, are not infective and that if the natives are bitten by fly they are, therefore, not infected; whereas if the natives are carriers, the fly which become infective have died before the natives again enter the palm stands.

The Oil palm Elaeis guineensis does not occur in the area under review.

CHAPTER 14

FORMATION-TYPE IV TROPICAL THORNLAND

Before proceeding to describe the formations in this formation-type it is considered advisable to clarify the terms thorn-woodland, thorn-savanna and thorn-scrub used in this paper. The definitions are as follows:

Thorn Woodland - An aggregation of thorn trees at or near their maximum height, growing at sufficiently close an espacement to form a closed or almost closed canopy and having little herbaceous or grass growth.

Thorn Savanna.- Vegetation consisting of thorn trees irrespective of their height, growing with an espacement to allow of a ground flora of shrubs, herbs and continuous or almost continuous grass growth.

Thorn Scrub - Vegetation consisting of thorny species with a height varying from a few inches to a few feet, irrespective of espacement and of ground flora, in which, however herbs and grass, often in tussocks, are usually present.

FORMATION/

Camels browsing on Acacia seyal; in Hadejia Emirate.

Live branches of Acacia seyal having been partially broken by graziers to provide green feeding for their stock.

Consociation of Acacia seyal in Hadejia Emirate.

FORMATION 8 - WEST AFRICAN THORN-WOODLAND.

There are few areas of thorn-woodland as defined above, in Nigeria; the area of true thorn-woodland lies some distance to the north of the Nigerian frontier.

The only areas of true thorn-woodland in Nigeria consist of Acacia seyal. These are neither extensive nor common and occur mostly in the south-eastern portion of the area under review, in northern Hadejia Emirate. This formation is by no means stable for this Acacia is subject continuously to lopping and topping, and sometimes wholesale felling to provide fodder for the goat. A good stand of Acacia seyal woodland was observed to have been reduced in eleven months to a vague skeleton of its former self. A photograph is included showing the damage that is done by lopping of Acacia seyal. At the suggestion of the writer it was introduced into the local forestry rules that when lopping is done one good leader must be left on each tree and it is already obvious that complete destruction of Acacia stands can thus be prevented.

At its best Acacia seyal forms a pure stand of thorn-woodland with a height of twenty-five or thirty feet, with a closed canopy and a clean floor.

Small patches of pure Acacia arabica can also be observed forming a small stand of thorn-woodland but this is rare.

In central Hadejia Emirate there are some close-growing small stands of Acacia albida, consisting mostly of holed, over-mature, rotten trees which are in danger of falling. There is no natural regeneration. At first sight these appeared to be remnants of former natural thorn-woodland, but the writer finally decided that they are relics of trees introduced by farmers and spread largely by goats and cattle which/

which eat the pods and excrete the undigested seeds. The trees are prized by the native for the pods which are good cattle fodder, and have been protected by the farmers.

When thorn-woodland has been destroyed by the farmer and the ground is finally abandoned, then low-thorn scrub colonizes the area. It consists of the Acacias suited to the area with Ziziphus mauritiana, Balanites aegyptiaca and Dichrostachys glomerata; Bauhinia thonningii and Guiera senegalensis may also occur. If the area is left untouched it may progress through thorn-scrub to thorn-savanna, event-:ually to form thorn-woodland again. If, on the other hand, it is heavily exploited for fuel, browsed, lopped and topped for cattle fodder, then the vegetation is likely to follow retrogressional succession through degraded thorn-scrub and scrub-savanna to the final stage of intermittent grass and very degraded low thorn-scrub, with an exposed soil, no natural regeneration and with a rare likelihood of vegetational improvement.

In Niger Colony thorn-woodland can nowhere be said to be common, there are only restricted areas, in suitable sites, in which the vegetation can be classed as climatic thorn-forest or thorn-woodland.

Pure and almost pure stands of Acacia nilotica occur at Aderbissinat, where, because of the proximity of the seasonal swamp, the water-table remains high, for this region, even during the long dry season. A consociation of Acacia nilotica was also recorded north of Efinateus on the road from Tahoua to In Gall, approximately on the same latitude as Aderbissinat.

Thorn-woodland consisting of Acacia seyal occurs over restricted areas and stands were observed on the

Tessawa/

Tessawa-Gangara road and also north of Efinateus. Thorn-woodland of Acacia raddiana occurs sporadically and patches of it were recorded near Agades, south of which it is found in association with Commiphora africana, Maerua crassifolia and Boscia senegalensis. In Thorn-woodland other thorny species such as Balanites aegyptica, Zizip hus mauritiana and ~~non-thorny~~ species such as Boscia senegalensis, Commiphora africana and Maerua crassifolia are found.

An interesting Acacia nilotica-Balanites association occurs at Aderbissinat in the neighbourhood of the Aderbiss-:inat Lake; Acacia nilotica, which is a moisture loving species, occurs as a consociation in the immediate vicinity of the lake. A little to the north of the town Acacia nilotica, Acacia raddiana and Balanites aegyptica are found in association. Commiphora, which is so common north and south of the town does not occur in these associations. The thorn-woodland is most striking in an area of orchard-woodland, and its occurrence is entirely dependant on water being available in some quantity. A photograph of one of the wells at Aderbissinat is included showing pure Acacia arabica in the background.

The Acacia - Balanites association is also found in the Efinateus area in approximately the same latitude, although it was not recorded by the writer in the Niger valley on the road from Niamey to Gao.

FORMATION /

Windblown Acacia laeta on the road from Zinder to Takieta. Observe the shallow roots and the Acacia seyal in the background.

Road junction of the road from Zinder to Takieta and from Takieta to Kano. Compare with aerial photograph.

The rest house and surrounding vegetation at Takieta, showing the scattered nature of the vegetation. This should be compared with the ground panoramic ground photograph. Guiera scrub and coppiced Bauhinia occur in the foreground. Tamarindus and Acacia albida are seen at the back beyond the rest house.

FORMATION 9. WEST AFRICAN THORN SAVANNA.

Thorn-savanna is fairly extensive in the area under review, it is not however common in Northern Nigeria except in localized areas such as north-western Katsina Emirate and in the Hadejia region; it is small in area compared with the ubiquitous savanna-woodland of the Sudan and Guinea zones. Nevertheless it is quite an important formation since it gives soil protection, some return to the soil, and, which is most important, grass for the cattle and goats and browse for the latter and camels which come south to Nigeria, as transport animals, in large numbers during the trading season in the dry months of the year.

The ground-floor is frequently covered with good grass, some scrub and some herbaceous growth. A number of Acacias occur gregariously, varying according to habitat, and small pure stands can be seen of Acacia arabica, Acacia macrostachya and Acacia seyal.

The following species are found:-

Acacia albida	f.	Dichrostachys glomerata	f.
Acacia arabica	o.l.	Ziziphus mauritiana	f.
Acacia campylacantha	o.		
Acacia nilotica	o.l.		
Acacia senegal	o.		
Acacia sieberiana	f.		
Acacia seyal	a.		
Balanites aegyptica	f.		

Great damage, unfortunately, is done to this formation by lopping and topping for cattle browse.

If thorn-savanna is carefully protected, and provided the soil is sufficiently good, it will progress to thorn-woodland. On the other hand, if it is seriously damaged or destroyed /

Thorn woodland south of Maradi which includes Acacia seyal, A. arabica, A. Ataxacantha, Balanites aegyptica, Celtis integrifolia, Bauhinia thonningii and Cassia tora.

Ground photograph of the above area, showing thorn-woodland south of Maradi. the following species occur in this region: Acacia arabica, A. ataxacantha, A. seyal, Balanites aegyptica, Bauhinia thonningii, Celtis integrifolia and Cassia tora.

destroyed it is succeeded by low thorn-scrub, scrub-savanna and grass. With unfavourable conditions or lack of pro:tection it will be succeeded by thorn-scrub, then scrub-savanna and finally degraded thorn-scrub and inter:mittent grass.

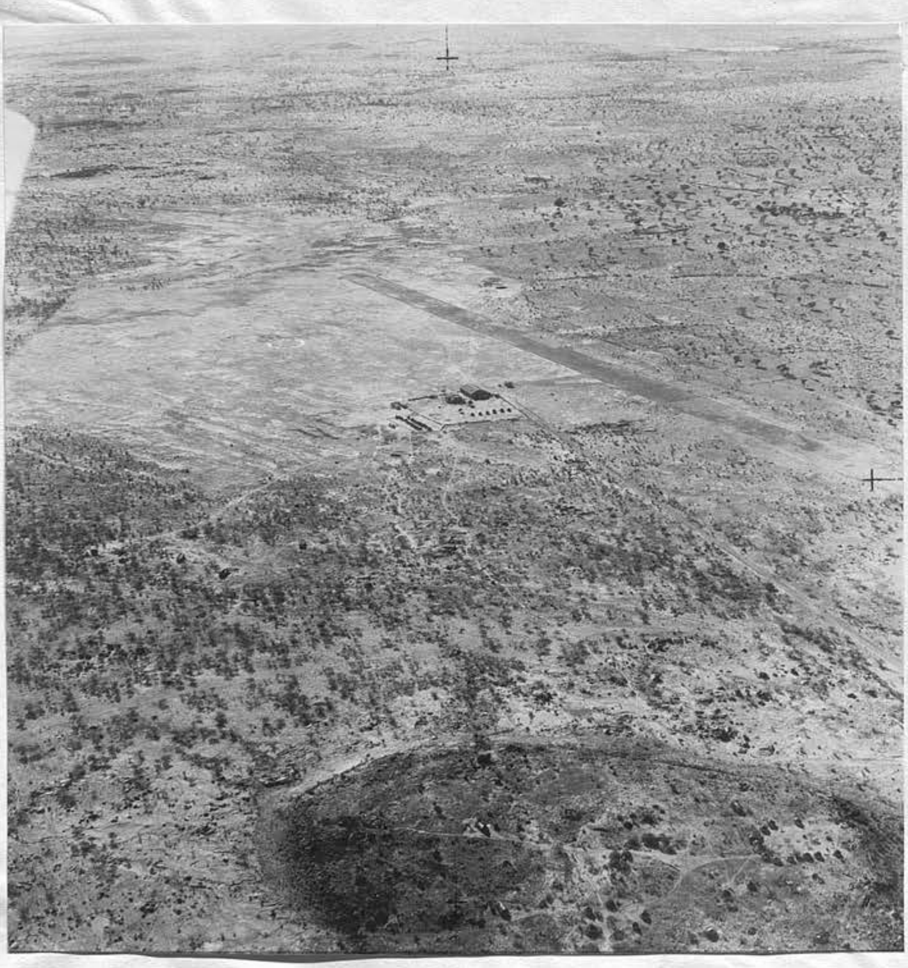
In Niger Colony the thorn species occur at varying espacements depending upon the suitability of the habitat; the silvicultural dominants being from about eight feet to their optimum growth. The formation has a ground flora which is sparse.

The thorn-savanna formation is extensive in the western Sudan and covers some thousands of square miles. It is of importance since it protects and improves the soil, although the improvement may be only slight, but it does prevent soil deterioration and consequent vegetal retrogression; its value is great since it provides fodder for cattle, sheep, camels and goats.

The non-scandent Acacias occur in the thorn-savanna. In the southern area Acacia arabica (and Acacia nilotica in moister areas), and Acacia seyal are commonest; between the latitudes of Zinder and Aderbissinat, Acacia laeta is common, occurring as a consociation or in association with Acacia seyal; north of the latitude of Gangara, Acacia raddiana occurs in association with Acacia seyal and Acacia arabica and further north it is found as a consociation.

The northern fringe of thorn-savanna occurs approximately on the line from Bentia on the River Niger to Efinateus and Aderbissinat; there is a wide ectone and the thorn-savanna merges gradually into the formation thorn-scrub.

An /



Zinder aerodrome from the hill Dutsia Bidawa. Thorn scrub in foreground.

An Acacia raddiana - Balanites - Ziziphus associa-:tion occurs on approximately latitude 15° 50' and runs from Bentia eastwards to Aderbissinat. It is extensive therefore, from east to west, but it occurs in no great depth; it is however valuable as a continuous belt of protective vegetation south of the desert line. Permanent non-irrigated farming is impossible, therefore it is not destroyed by farmers; the population is scanty, therefore it is not destroyed for fuel; it is, however, browsed to a certain extent by stock, but not sufficiently intensively to affect its growth and distribution.

The espacement averages fifteen feet and the trees are from five to fifteen feet high. The following species were recorded in this association on the road from Katsina to Agades and from the latter to Tahoua:-

Acacia raddiana	D.a.	Maeura crassifolia	D.f.
Balanites aegyptiaca	D.a.	Boscia senegalensis	f.
		Ziziphus mauritiana	f.
Commiphora africana	D.f.	Calotropis procera	r.

Aerial and ground photographs are included to illustrate thorn-savanna and also the tension zone between it and the formation thorn-scrub.

FORMATION 10. WEST AFRICAN THORN-SCRUB.

This is an inextensive formation which is usually found in areas of thornland which have been heavily ex-:ploited for farming, and which are lying fallow and recovering as far as they can, or on areas which have been heavily lopped and topped for cattle browse or for fuel. The height varies from a foot or less to about eight feet.

If /

If thorn scrub is protected it is succeeded by thorn savanna provided the climatic and edaphic factors are suitable. Acacia seyal responds most stirkingly to such protection.

Edaphic factors may limit Acacias to scrub height and this is exemplified on the hard clayey soils in the region of seasonal swamps, and is also shown in the case of the foot high Acacia raddiana seen in the small surface drainage channels in the desert area. Pure stands of Mimosa pigra may also be found on the edge of seasonal ponds and in the Sudan zone along seasonal river-banks.

An example of pure Acacia sieberiana was found on the boundary between the Daura and Kazaure Emirates in Nigeria, in the region of an extensive seasonal swamp. The area is now reserved and it will be interesting to see its ecological development.

Acacia macrostachya is also found pure in this region and it almost invariably occurs as an edaphic climax on poor dry soils, which carry a few relict species of a higher type, showing that ecological retrogression has occurred in recent decades. The Acacia are about eight feet in height, and appear, in this area, to have reached their maximum growth. Specimens of Combretum micranthum and Dichrostachys glomerata are also found in this area.

In Northern Nigeria the thorn scrub therefore provides some of the cattle fodder; the cattle are, on the whole, well fed and healthy although they suffer at times from inadequacy of drinking water. Since this terrain is gently undulating and not hilly, there does not appear to be the danger of over-grazing with consequent soil exposure followed by accelerated soil erosion such as is found in East Africa.

In /

In addition to the importance of goats and cattle in supplying human food, their skins and hides form an important source of revenue to the cattle people and to the country; this is fully recognised by the Nigerian Government which has done much, through the Veterinary Department, to improve the health, as well as the strains of the cattle and goats by castration, selective breeding, innoculation against rinderpest and in other ways. It is obvious therefore that adequate pasturage and browse must be provided; grazing and browsing should not be condemned as depredation, but should be regulated where necessary.

Thorn-scrub is extensive in Niger Colony and in the French Sudan and is found roughly north of latitude 16°, the southern limit running from Ansongo on the River Niger eastwards to north of Efinatus and Aderbissinat. The thorn-scrub was first recorded at Abellama on the road north to Agades and at sixty five miles south of In Gall on the road to Tahoua. It occurs just south of Ansongo on the Niger. It is protected from farming since it is north of non-irrigational farming but it provides fodder for stock and camels. The vegetation is sparse and varies in height from six to eight feet on its southern boundary to less than one foot in the desert area, where it was recorded by the writer both in the Bagzan area of the Aïr Mountains and north of Tabankort on the route from Gao to North Africa.

The following association was recorded from the Abelamma area:-

Acacia raddiana - Commiphora - Maerua Association

This association occurs from a little north of Aderbissinat to the Cliffs of Tigueddi, which form the southern boundary of the Sahara on this longitude. The vegetation quickly changes from south to north to a more open and stunted type /

Natural regeneration of Acacia albida in the vicinity of Zinder on an area in which their destruction has been prevented.

type; whereas the height on its southern boundary is about ten feet, near the cliffs it is sparse and the average height is about six feet, Acacia raddiana predominating. Acacia laeta also occurs in the association.

The area is gently undulating, the soil is a deep soft sand and there are occasional small fixed dunes and patches of sandstone outcrops; the vegetation is, on the whole, sparse and the grass is tussocky. In certain areas there are patches of pure grass steppe. There are occasional patches of pure Acacia raddiana.

Photographs of this type of vegetation are included.

The following species occur in this association.

Acacia raddiana	D.a.	Balanites aegyptiaca	D.o.
Maeura crassifolia	D.a.	Cadaba farinosa	o.
Boscia senegalensis	D.f.	Salvadora persica	o.
Commiphora africana	D.f.	Calotropis procera	r.
Acacia laeta	D.o.		

SUDAN DALLOL VEGETATION.

The vegetation of the Sudan zone dallols is not unlike that found in riparian or swamp woodland. The dallols usually consist of shallow valleys of varying width, they may be completely dry or they may consist of seasonal swamps or of perennial swamps, it is only in the height of the rains that the latter may have flowing water.

The lower portion of the Dallol Maouri was visited by the writer at the portion between Gaya and the Nigerian frontier and at this point it consists of a shallow valley some six hundred yards wide which is dry in the dry season and consists of a series of seasonal swamps in the rainy season. It is typical of the dallols of the Sudan zone and the same vegetation is found in the lower Dallol Bosso and incidentally, in some of the former rich valleys which formed tributaries of the River Hadejia in Quaternary times in Gumel Emirate in Nigeria. In the Dallol Maouri, Borassus aethiopum was found to be the preponderant species; species of Khaya senegalensis and the Guinea zone Parkia oliveri also occur. The following species were recorded by the writer:-

Borassus aethiopum	ED.a.	Bauhinia thonningii	D.f.
Khaya senegalensis	ED.l.	Guiera senegalensis	f.
Parkia oliveri	ED.o.	Combretum micranthum	o
Prosopis africana	ED.o.	Ficus platyphylla	o
Acacia ataxacantha	D.f.	Vitex cuneata	r.

The commonest grass is Andropogon gayanus

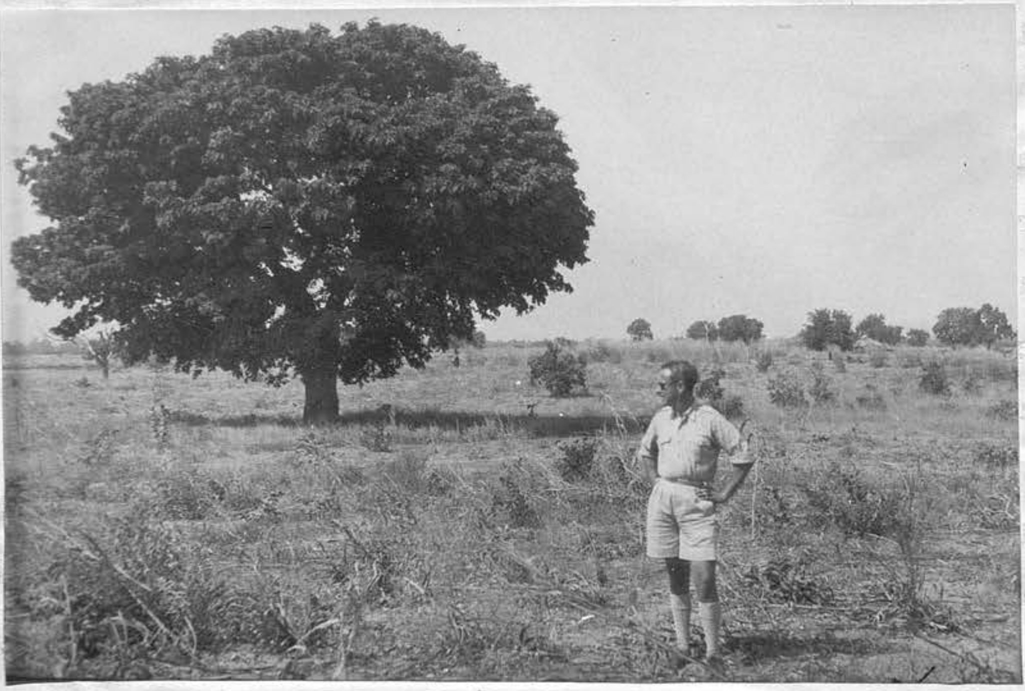
PRE-Sudan /

PRE-SUDAN DALLOL VEGETATION.

The best examples of the dallol vegetation in the pre-Sudan zone were seen in the dallol south of Tessawa on the road to Gazawa and in the dallols south of Zinder on the direct road south to Kano. The former consists of a wide valley in which there is a wealth of Hyphaene thebaica palms and fairly thick thorn-woodland; the 'banks' of the dallol consist of sand dunes which are indicated on Barth's map and are about eight hundred yards apart at the narrowest point. Barth mentions the vegetation of this valley but does not seem to have realized it was a dallol. Ground photographs showing the general vegetation, as seen from the east bank, are included and one aerial photograph shows the valley and the village of Gazawa. The Dum palms occur nearest to the edges of the valley and constitute close-growing palm-stands at this point. The soil in the valley is hard and clayey in the dry season and supports only a poor type of vegetation. The area is water-logged in the wet season and the French road engineers have required to build a new road a little above the plain level and to dig drains along each side; the old road which the writer followed in April of 1939 en route Agades, followed close to the right bank, but it was found difficult to keep up in the rains.

Thus on the edges of the valley occur pure stands of Hyphaene and in the centre of the dallol the vegetation consists of thorn-woodland and thorn-savanna. There are some pure stands of Acacia laeta, Acacia seyal and of Acacia arabica and various associations of the thorn species occur, the commonest of which is an Acacia laeta-Balanites association.

The /



An example of a large Khaya senegalensis in one of the dallols south of Zinder.

The following species were observed in the Tessawa Dallol in the neighbourhood of the Acacia laeta - Balanites association:-

Acacia laeta	ED.a.	Commiphora africana	D.o.
Balanites aegyptica	ED.a.	Acacia arabica	D.o.
Bauhinia rufescens	ED.f.	Leptadenia lancifolia	o.
Hyphaene thebaica	ED.f.		
Acacia seyal	ED.f.		

A photograph of the Acacia - Balanites association is included.

In the dallols south of Zinder, the preponderant species is again Hyphaene but the most surprising sight is large specimens of Khaya senegalensis which, although they are only about forty feet in height as mature trees, have large flourishing crowns and a girth of six and seven feet. They are obviously dependent on telluric moisture and are relict species of a vegetation which was considerably richer than that of the existing vegetation today. A photograph of one of the Dry-zone Mahoganies taken on the road to Zinder is included.

PRE-SAHARAN DALLOL VEGETATION.

The best examples of this type were seen on the road from Tessawa to Agades and from In Gall to Tahoua; on the latter data were obtained from the vegetation of the Petit Tadiss Dallol which runs from near Efinateus to a little north of Tahoua. The dallol is most distinct, the banks again consist of fixed sand dunes or banks, and the valley varies from half a mile to over a mile wide over part of its length. It is very obviously a valley in which in Quaternary times a tributary of the River Niger flowed first to /

to join the Dallol Maouri, later to flow into the Niger, having risen in the Aïr Mountains. The floor of the valley, (which the road now follows), is almost flat, the soil is hard and clayey in the upper reaches and soft and sandy in the lower part of the valley in which farming is carried on. The banks vary from 80 to 100 feet high. The first non-irrigated farms begin seventy miles north of Tahoua. The vegetation consists of scattered thorn-savanna; consociations of the Acacias occur (Acacia laeta, Acacia seyal and Acacia arabica), and associations of the Acacias with Balanites are common. Celtis integrifolia and Mitragyna inermis were found, rather surprisingly, on one seasonal marsh.

The following species were recorded from the Petit Tadiss Dallol seventy miles north-east of Tahoua.

Acacia arabica	ED.a.	Acacia laeta	D.a.
Acacia nilotica	ED.f.	Bauhinia rufescens	D.f.
Balanites aegyptiaca	ED.f.	Boscia angustifolia	f.
Bauhinia thonningii	ED.f.	Acacia seyal	o.
Combretum verticillatum	ED.f.	Leptadenia lancifolia	o.
Celtis integrifolia	ED.r.l.	Salvadora persica	o.
Mitragyna inermis	ED.r.l.	Combretum micranthum	r.

Photographs of this dallol are included.

SAHARAN DALLOL VEGETATION.

The Tilemsi Dallol and the Dallol Timmer'soi are the largest of the desert dallols in this area. The former runs from the Adrar Des Iforhas and the mountains near Kidal to Gao, and the latter from the Hoggar Massif and the Air Mountains to join the Dallol Bosso.

The writer travelled for over a hundred miles along the valley of the Tilemsi Dallol on the journey northwards across the desert; it is surprising to see how far north the Acacia vegetation persists in this valley. There /

There is in fact telluric moisture on which the Acacia and grass vegetation is entirely dependent, for the average rain:fall is less than five inches per annum and rain may not fall for some years.

The vegetation consists of the Acacias of which Acacia raddiana is the preponderant species, with occasional Acacias and occasional specimens of Boscia salicifolia, Cadaba farinosa, Maerua crassifolia and Salvadora persica. The grass is tussocky and stunted and is frequently absent.

The vegetation in the lower portion of the dallol near Gao consists of open thorn-scrub with a height of five or six feet and the motor track winds through rather scattered scrub. The vegetation becomes more stunted as one proceeds northwards and becomes more and more scattered and intermittent until the tree vegetation disappears and there are merely widely scattered tussocks of grass.

A photograph is included which gives an indication of the thorn scrub in this dallol fifty miles north of Gao.

The following species occur in the Saharan dallols.

Acacia raddiana	a.	Boscia salicifolia	o.
Acacia laeta	f.	Cadaba farinosa	o.
Salvadora persica	f.	Cassia obovata	o.
Maerua crassifolia	o.	Balanites aegyptiaca	o.
Ziziphus mauritiana	o.		
Acacia seyal	o.		

Open farmland plain west of Hadejia showing the tree vegetation destroyed on farmland and forest in the middle distance.

CHAPTER 15.

FORMATION-TYPE V. - TROPICAL GRASSLAND.

The formations West African Savanna, West African Grass Steppe and West African Marsh Grassland occur in the formation-type of tropical grassland in the area of the Central Western Sudan; meadow and mountain grassland (in its accepted sense), do not occur in the area. The grass which occurs in the Aïr Mountains is not true mountain-grassland but is the desert type of grass growing in favour:able sites in the mountain area and does not compare, for instance, with the mountain-grassland occurring on Cameroon Mountain or in the highlands of East Africa.

Formation 11. West African Savanna.

Savanna can best be described as Xerophilous grassland with isolated trees or shrubs, and that definition must constantly be borne in mind when considering grassland vegetation either academically or in the field.

Savanna is very restricted in Northern Nigeria, the component tree and shrub species vary throughout the area, depending upon whether it occurs in woodland savanna, orchard-woodland savanna or in thornland. The writer has seen few areas of savanna in Northern Nigeria and their occurrence appears to be artificial, due to the destruction of the vegetation by man for farming, cattle grazing and browsing and possibly also to fire over some centuries. Savanna occurs naturally when the soil is unable to support more than very scattered trees and shrubs and it is occasionally seen on the more elevated portions of upland plain from which the good soil has been washed and carried to /

to the shallow valleys below. In Nigeria such areas are used for grazing but the tree vegetation has suffered (although the grass has benefited), from the deliberate and often indiscriminate grass firing carried out over centuries by the cattle-owning Fulani. Few trees and shrubs remain on the area and there may be as few as one or two trees only per acre. Experiments are now being carried out in chosen areas in Northern Nigeria to ascertain the effect of controlled firing and one of the experiments was laid down by the writer in Katsina in 1939; it will be described in some detail under the chapter on experiments. Some results have already been obtained. The commoner grasses in this formation are Andropogon gayanus, Andropogon exilis, Andropogon pseudapricus and Schizachyrium exile.

The writer considers that in general, in Niger Colony, savanna is found on the latitude of the plain between the Cliff of Tigueddi and Agades, eastwards to the In Gall area, thence to the region of Bentia on the river Niger, where it occurs further south than in the Aïr region.

The tree and shrub vegetation consists almost entirely of Acacias and in Central Niger Colony the preponderant species is Acacia raddiana. The grass is often intermittent, tussocky and short in the dry season, although it can be reasonably luxuriant during and immediately after the wet season; the uninterrupted stretches of fine grass represent areas of grass steppe (which is described next), within the Savanna formation.

The ground is occasionally bare or covered with stones of various sizes and shapes and are often water-washed.

Associations of Acacia raddiana and Acacia seyal are not uncommon and consociations of the former are frequent. The trees may be in small clumps or scattered singly.

It is rather surprising to find that the narrow savanna belt occurs further to the south in this region of the Niger than it does in the region of the Cliffs of Tigueddi. Its position does not appear to be influenced however by the River Niger. In the Ansongo area, itself south of the latitude of Agades and these Cliffs, savanna as such, has disappeared, the area consists of grass steppe at the best and exhibits more generally, desert conditions. The savanna area occurs in the region of Bentia and to the immediate south.

The following species occur in the savanna formation in Niger Colony:-

Acacia raddiana	D.a.	Ziziphus mauritiana	o.
Acacia seyal	f.	Cassia obovata	r.
Boscia salicifolia	o.	Calotropis procera	r.
Commiphora africana	o.		
Maerua crassifolia	o.		

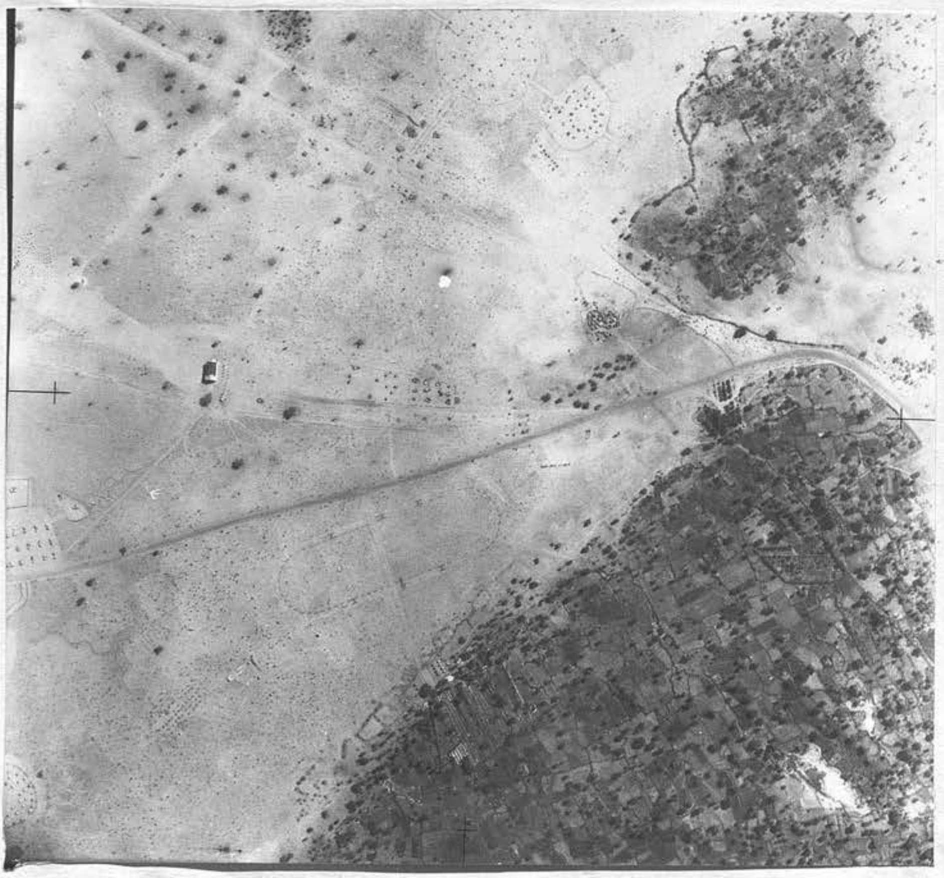
The following grasses occur in this formation:-

Andropogon gayanus	Cenchrus setigerus
Andropogon pseudapricus	Cenchrus ciliaris
Aristida adscensionis	Ctenium elegans
Aristida mutabilis	Eragrostis ciliaris
Aristida stipoides	

Ground photographs are included to illustrate this formation and aerial photographs indicate how sparse the vegetation is on the ground. It will be noted that from ordinary photographs there appears to be more vegetation than is actually on the ground.

Formation 12 /

Fixed sand dunes West of Myrria. Grass and very scattered Acacia albida.



The oasis of Myrria from approximately 6,000 feet. The dark tone of the moist soil can be seen. The sandy soil with a light covering of grass and few trees can be observed in the bottom left-hand corner of the photograph. Pure sand without any grass covering can be seen on the various paths leading to the different houses.

FORMATION 12. WEST AFRICAN GRASS STEPPE

This formation consists of Xerophilous grassland without trees or shrubs; it should be noted, however, that patches of intermittent grassland, which are due to edaphic or biotic factors and which occur within the savanna woodland, or thornland or even in the grassland formation-types, can:not truly be described as grass steppe.

True grass steppe is very restricted in area in Northern Nigeria. Small areas occur in Kano and Hadejia Emirates of Nigeria; in the former pure grassland occurs where the soil is unsuited to tree vegetation in areas where there appears to have been soil deterioration; in Hadejia Emirate areas of grass steppe occur on fixed sand-dunes which were formed when the area, now known as Northern Nigeria, endured desert conditions. The sand-dunes of Hadejia Emirate form a very interesting feature of the area. They are, in some ways, reminiscent of the long low sand-dunes found in the northern Sahara today, and while they may only be some thirty to fifty feet high and about one hundred yards wide they run, on occasion, for a distance of some five or six miles. The dunes are now fixed by grasses and are rarely, if ever, used for farming. Grass steppe occurs on many of these dunes, and these areas constitute the only true grass steppe of the area.

Other areas of grassland in the area have been caused by destruction of the tree vegetation for fuel or for farming, and by browsing and grazing; firing has also hastened vegetational retrogression. This type of grassland provides /

provides good grazing and is therefore of importance to the native.

The commonest species in this formation in Northern Nigeria is Schizachyrium exile, which is used for fodder and for making grass roofs; other species are Andropogon pseudapricus and Monocymbium ceresiiformis.

Excellent examples of the formation grass steppe occur over wide areas in Niger Colony and they constitute the penultimate stage before the tussocky and intermittent grass of the semi-desert. Areas of grass steppe were examined by the writer north of the Cliffs of Tigueddi, in the area between Agades - Teguidda N'Tesemt and In Gall and in the region between Gao and Tabankort, en route to Reggan and North Africa. Grass steppe is found south and west of Agades, westwards approximately be-:tween latitudes 17° and 18° to the Gao-Tabankort area. It is in fact found further north in the latter area due to the influence of the Niger and to telluric moisture in the Tilemsi Dallol. The grass becomes short, although it continues to be widespread and more or less continuous, on the northern fringes of the formation.

Grass steppe is of importance since it protects the soil from erosion and insolation; it is valuable for grazing and for building purposes. The grasses are, of course, completly desiccated even in Northern Nigeria, before the middle of the dry season (i.e. in January), nevertheless they provide valuable fodder.

It is probable that the grazing can be improved in these areas where there is still a high cattle population and experiments have been carried out by the writer in the Katsina area. These experiments and the results obtained are described later.

One of the most striking areas of grass steppe in /

in the area of the Central Western Sudan occurs on the sand dunes to the east of Myrria, on the road from Zinder eastwards to Lake Chad. The sand-dunes in the neighbour:hood of Myrria are not unlike those already described in Hadejia Emirate, only they occur on a much larger scale. The country consists of undulating hills which are not unlike the English Downs; the valleys are wide and fairly deep with only gentle slopes. The area was without doubt one of desert sand-dunes in a previous geological age.

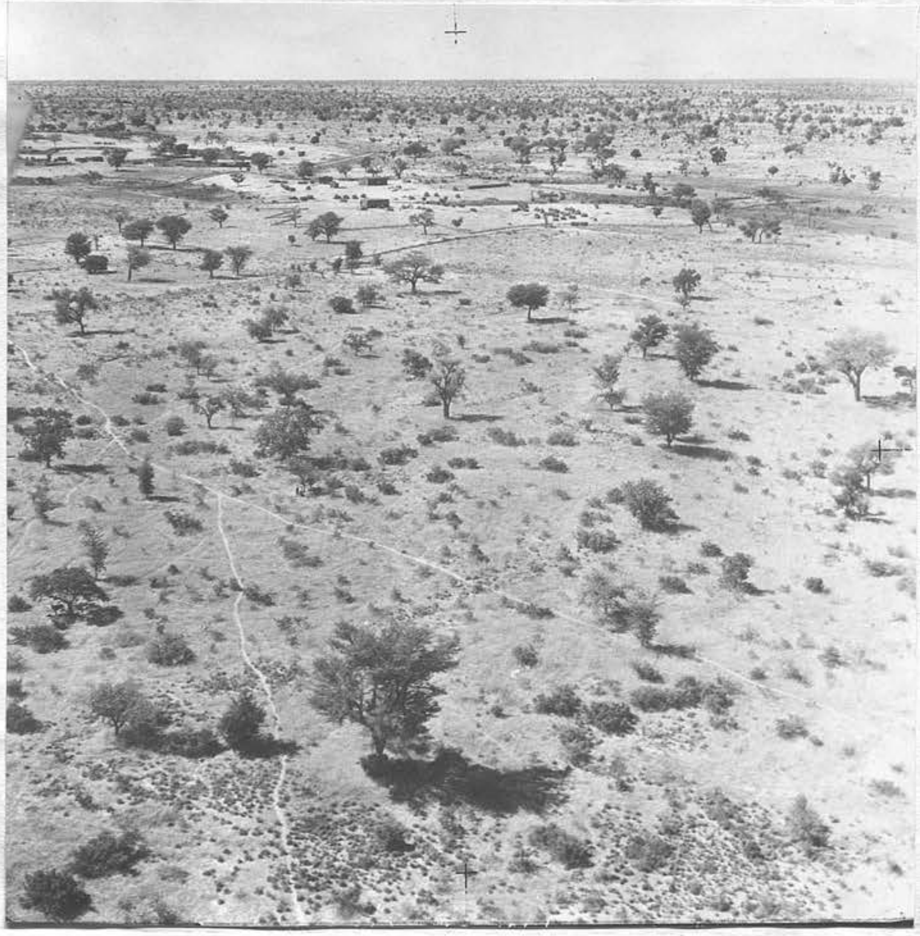
The soil is light and sandy, there is little or no tree vegetation and true grass steppe conditions are exemplified. The grass protects the soil from accelerated erosion, from wind erosion and from insolation. The soil appears to be too light for farming and no agricultural activities were seen anywhere in the area. The grass consists largely of Andropogon gayanus. A ground photograph of the area is included and aerial photographs taken from 14,000 feet illustrate the lack of vegetation on these dunes. The grass provides useful grazing for the Myrria cattle and is therefore of considerable value.

The following grasses occur in this formation:-

Aristida adscensionis	Eragrostis pilosa
Aristida mutabilis	Eragrostis tremula
Aristida pallida	Eremopogon foveolatus
Aristida pungens	Lasiurus hirsutus
Andopogon gayanus	Latipes senegalensis
Chenchrus biflorus	Pennisetum mollissimum
Chenchrus prieurii	Sehima ischaemoides
Cymbopogon proximus	Urochloa lata
Eragrostis ciliaris	Urochloa trichopus
Eragrostis gangetica	

Photographs are included of the sand-dune grass steppe within the Myrria region east of Zinder and of this formation between Agades and In Gall. Aerial photographs are /

Marshland at Matamaye, farmland with scattered trees consisting of Acacia, Prosopis, Hyphaene and Bauhinia and Guiera scrub.



Matamaye from the south, showing the area of swampland. The scattered trees on farmland can be seen. The tracks in the foreground lead to the well in the lower right hand quarter of the photograph.

are included of the Myrria sand-dune country and of Agades, both of which demonstrate the vegetation of the region.

FORMATION 13. WEST AFRICAN MARSH GRASSLAND.

Marsh grassland is very inextensive in the area under review; not unnaturally it occurs in the southern portion and in restricted patches along the River Niger. It is found only in the vicinity of seasonal or perennial swamps in low-lying ground in the vicinity of the rivers or large dallols and in basin-like depressions.

Good examples of marsh grassland are found in Daura Emirate in Nigeria, in an area which consists of a large depression at the foot of a series of hills, into which the former rivers of the present day dallols flowed, prior to running further eastwards across Gumel Emirate to join the River Hadejia, flow~~i~~ing finally into Lake Chad.

The marsh grassland consists of tall rank grass which grows, even in water, for a large part of the year, but it is usually found in a soil which retains a high degree of moisture throughout the year. Photographs of the Daura marsh-land are included to show the type of grass vegetation.

Marsh grassland is also found along the large rivers in Sokoto province and, like the Daura area, it is useful in providing grazing for cattle, sheep and goats.

In Southern Niger Colony areas of marsh-grass occur on the banks of the seasonal lakes which, however, are of very short duration, for they quickly dry up in the dry season.

Marsh /

The Bende dallol north of Magariya showing the grass Typha australis in some profusion in the valley.

Part of the swampland at Matamaye. The Hyphaene denote a high water table. The light sandy soil on the farms and in the foreground is clearly seen.

Marsh grasses, some of which grow to a height of six and eight feet also occur along the ancient river valleys, and examples of this was seen in the Bende dallol north of Magariya on the road to Zinder. This is Typha australis which is a tall reed with light stems and it grows in some profusion. A photograph of this dallol north of Magariya is included.

Marsh grassland occurs in the dallols immediately to the south of Zinder and also near the oasis at Myrria. Aerial photographs of the Myrria vicinity show, by the dark patches, the moist areas in that region and the less dark areas indicate grassland of which a certain percentage is under cultivation.

Marsh grassland occurs in the lower portion of the Dallol Maouri and the Dallol Bosso and, of course, in suitable areas on the Niger itself, north to the latitude of Ansongo; thereafter true marsh grassland was not observed by the writer. The aerial photograph of Gao, taken from 14,000 feet, does not show areas along the Niger with anything approaching the formation marsh grassland.

It should be remembered that swamp-woodland and swamp-thornland contain species of swamp grasses, and ex-:amples of these were seen on the road from Katsina to Agades, south of Gangara, and at Aderbissinat, 128 and 200 miles respectively, north of the Nigerian frontier. Swamp-grassland was also observed north of Efinateus on the Birnin Konni - In Gall route. The most luxuriant swamp vegetation, including marsh grassland, was observed on the River Niger between Gaya and Say, south of Niamey.

Some of the grasses, of which Andropogon gayanus is the most important, mentioned under savanna and grass steppe, are usually observed in the neighbourhood of swamp grassland.

The /

The following species occur in marshland in Northern Nigeria and in Niger Colony, and in the latter they are found to occur far north of the Nigerian boundary.

Echinochloa colona   Paspalidium geminatum

Echinochloa stagnina

Andropogon gayanus

Echinchloa colona is a valuable fodder grass at all stages and is at times abundant in inundated meadows. Echinochloa stagnina resembles wild rice; it constitutes rich fodder for cattle and horses and the grain is edible. The stems are used for thatching and the succulent submerged stems are rich in sugar. Paspalidium geminatum is a creeping or floating grass with a hollow, spongy stem; it constitutes valuable fodder. It is worthy of note that the grasses of the pre-Saharan and Desert zones are even more valuable to the native than those of the woodland and forest areas; invaluable, in fact, as the grasses are in the southern areas, they are used in innumerable ways by the dwellers in the desert and the semi-desert and are, indeed, of no little importance in the life of the peoples of these regions.

CHAPTER 16.

C. DESERT

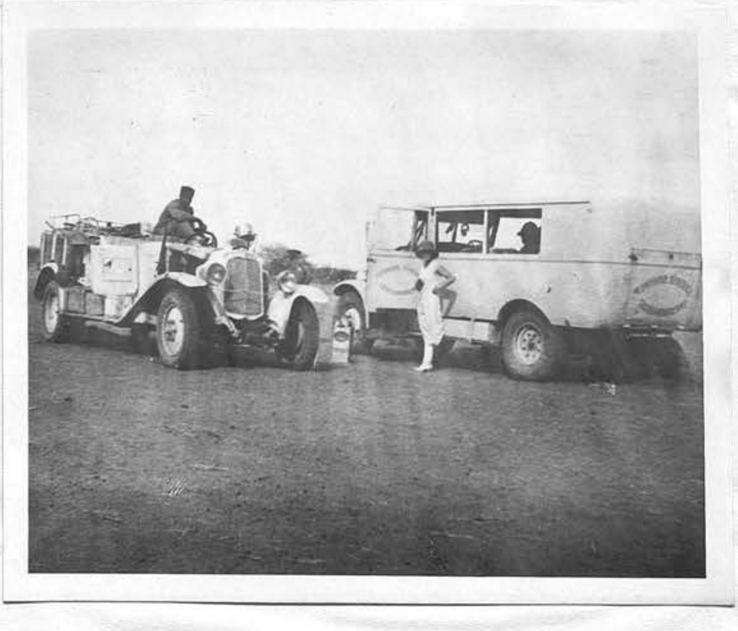
FORMATION-TYPE VI-TROPICAL DESERT

The general conception of the term desert is usually so vague and inaccurate that it is worth quoting the definition as recorded by Schimper, who writes (p.163), as follows: "Desert, the third leading type of climatic formation, originates when, on account of too great drought or cold, climatic conditions are hostile to all vegetation; the types of both woodland and grassland then become stunted and their differences become obliterated, for the struggle between them ceases. The soil is then monopolised by such woody or herbaceous plants as can still contend successfully against the inclemency of the climate."

Schimper later (p.605) goes on to write: "The amount of rainfall naturally differs in these various desert districts, but it never exceeds 300 mm., and usually remains much lower. .... In the Sahara the atmospheric precipitations are irregular, though taking place chiefly during spring. .... But owing to the smallness of the rainfall such maxima and minima have no practical significance; the vegetative periods depend upon the heat, which increases the injurious effects of drought and therefore brings plant-life to a state of rest at the time of its maximum. The atmospheric dryness acts in the same manner as the heat, and is usually much greater in the deserts than in woodland and grassland districts; its maximum is attained in summer". Later Schimper points out that one must ...."distinguish between two œcological groups of desert plants, the one the existence of which depends directly upon rain, and the other in which it depends upon the presence of subterranean water."

Few /

Thorn scrub consisting mostly of Acacia raddiana at Gao. The building in the middle distance is the Mosque.



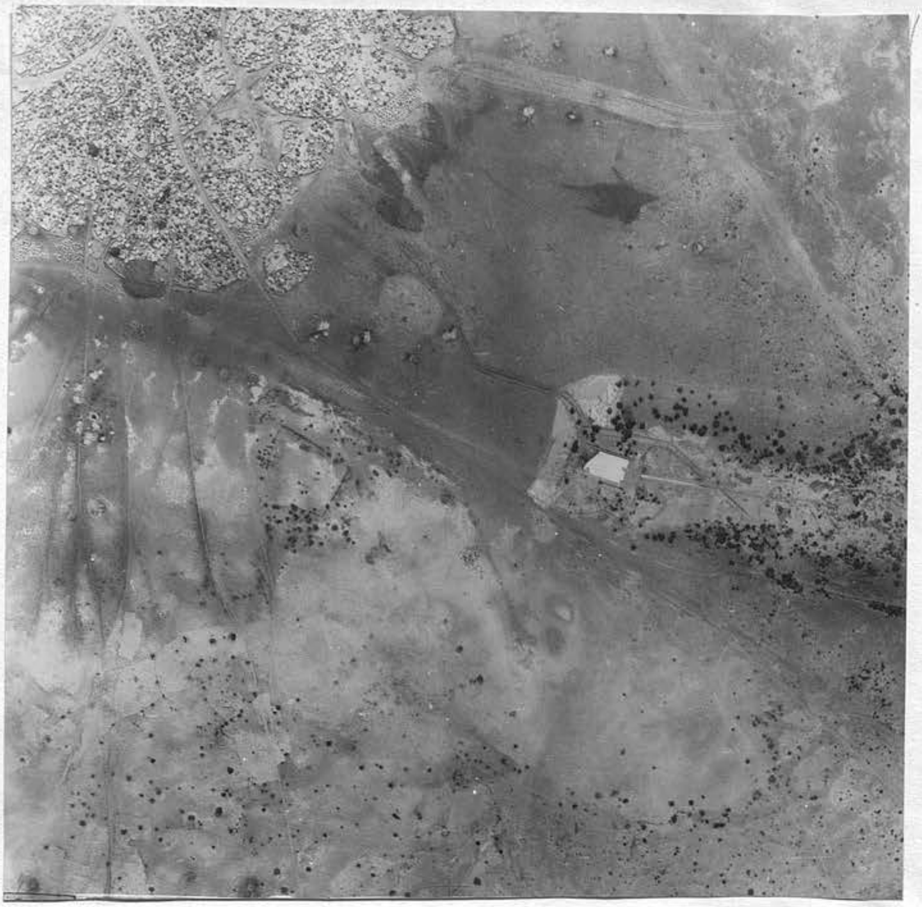
Semi-desert approximately 50 miles north of Gao on the road from Gao to Bidon Cinq.

Few comments are required on these trenchant observations. It is pointed out that, in actual fact, the southern boundary of the Saharan Desert in the portion of the Central Western Sudan under review is along the 200 mm. isohyet. The atmospheric precipitations however in the southern Sahara occur, not in the spring, but towards the end of the summer months, that is in August. Schimper's point regarding the two ecological groups is stressed throughout this paper, and, especially north of the 150 mm. isohyet, the more striking areas of vegetation are,-(as indeed are those in the pre-Saharan, pre-Sudan and Sudan zones),-de:pendent upon telluric moisture as opposed to atmospheric precipitation.

In effect the desert zone lies, in the area under review, north of the 200 mm. isohyet, and while the semi-desert zone may be said to lie between the 200 mm. and 150 mm. isohyets, the true desert occurs north of the 150 mm. isohyet.

FORMATION 14. WEST AFRICAN SEMI-DESERT.

It must be stressed again that definitions of the vegetational types must be borne in mind in the field, and the definition of semi-desert requires constantly to be kept in view or misleading deductions are made and recorded. Schimper states (p.163) the following: "Transition forms between desert on the one hand, and woodland and grassland on the other, are termed semi-deserts". The writer is of the opinion that recent French botanists have not adhered to, or have not agreed, with the above definition, for areas of thorn savanna and thorn scrub have, in recent years, been designated as semi-desert. It is obvious from careful study of the thornland vegetation from near the River Niger eastwards to the Agades area, that the formation-type tropical thornland occurs in general north to the 200 mm. isohyet although there are /



Tahoua from about 14,000 feet showing a ridge of combretaceous scrub on the right.

Ansongo and the River Niger, the scrub vegetation of semi-desert can be seen at the top of the photograph. Sand dunes can be seen on the right.

are some areas south thereof which have the appearance of desert conditions, but these are isolated areas, possibly as a result of biotic influences within the thornland area.

Schimper's definition of semi-desert is sound and correct, but it must be realized that by the term 'woodland and grassland', vegetation consisting of thorn scrub and grassland is implied.

Semi-desert therefore, in the opinion of the writer, consists of areas in which the vegetation, although it may be stunted and intermittent, consists of trees, shrub and herbs, but not in the profusion in which they are found in the climatic-climax of the formation thorn-scrub, or in any type of vegetation in the formation-type Tropical Thornland.

The southern boundary of the semi-desert in the In Gall region begins at the Cliffs of Tigueddi. The line is clear cut and there is, at this point, no ectone or tension zone. On the tableland south of the cliffs the vegetation consists of thorn-scrub and intermittent grass, as can be seen from the photograph taken a little south of the cliffs. In the wide valley north of the cliffs, the vegetation consists of intermittent low thorn-scrub with little or no grass and the vegetation is that of the semi-desert. Photographs taken from the top of the Cliffs of Tigueddi demonstrate this point.

The semi-desert (a term which can be applied to a considerable area of the Sahara) is, in fact, no barren waste, but one in which some trees, shrubs and grass occur, though not with the continuity or the luxüriance of the Climatic Dry Woodland.

It may be of interest to record Schimper's remarks (p.616) on the Aïr region. He writes: "In the tropical Sahara, between 16° and 20° N. - in Aïr, for instance - the character of the vegetation is different, and on the whole less /

less meagre than in the north of the Sahara. The hills, it is true, are entirely devoid of plant life, but in the wadis, where subterranean water accumulates the trees attain large dimensions. They are, however, usually small-leaved and thorny, therefore of a xerophilous stamp. To them there belong, in particular, Acacia seyal, Del., Maerua rigida, R.Br.,⊠ Ziziphus spina-christi, Willd., Balanites aegyptica, Del., and the palm Hyphaene thebaica. A species of Stapelia grows on the rocks. The granitic sand of the former water-courses in the wadis is overgrown by Panicum turgidum, Forsk., but grasses are otherwise rare."

Schimper paints a true picture of Aïr, but the writer would point out that while it is true that the hills appear to be devoid of plant life, there is, in reality, tree and scrub vegetation of a kind on the slopes of some of the hills, and that while trees occur in the valleys where telluric moisture is available, there is also intermittent low-scrub vegetation in the open plains and in the wide valleys of Aïr; none is non-xerophillous. The valleys of Aïr and the other hilly or mountain areas are, in fact, not typical of the major portion of the semi-desert which occurs on the vast plains; there the vegetation is even more sparse, stunted and intermittent, and this was seen by the writer in the Tabankort area north of the Niger bend. There the vegetation consists of stunted thorn-scrub, consisting almost entirely of Acacia raddiana, with only intermittent tussocky grass. Aerial photographs of the environs of the Agades landing ground and in the neighbourhood of Gao show how restricted the vegetation is. Ground photographs of both areas give an idea of the poorness of the general vegetation.

The following species were recorded by the writer in the Aïr Mountains and in the typical semi-desert of the Gao-Tabankort region:-

Acacia /

⊠ Maerua crassifolia (Syn. M. rigida R. Br.)

Acacia raddiana	a.	Cadaba farinosa	o
Boscia senegalensis	f.	Calotropis procera	o
Hyphaene thebaica	f.	Cassia obovata	o
Maerua crassifolia	f.	Cassia tora	o
Salvadora persica	f.	Commiphora africana	o
Acacia arabica	o.l.	Leptadenia spartium	o
Acacia ataxacantha	o.l.	Ziziphus mauritiana	o
Acacia seyal	o.		
Balanites aegyptiaca	o.		

It may be of interest to record that Aubréville in his Niger Colony Forestry Expedition, records the following in addition to the above list in the Bagzan Mountains, which were not covered so extensively by the writer:

Anogeissus lieocarpus ⊠	Grewia flavescens
Bauhinia rufescens	Dichrostachys glomerata
Bauhinia thonningii	Ficus salicifolia
Boscia salicifolia	Ficus teloukat
Cordia garaf	Tamarindus indica
Diospyros mespiliformis	
Grewia betulifolia	

The occurrence of these species, commonly met in the Sudan and pre-Sudan zones, seems to indicate that those in Air are relict species from a time when conditions in that region were more humid than they are today.

SUB-FORMATION 14a. WEST AFRICAN DESERT PALM-STANDS.

The date palm, Phoenix dactylifera, forms a very distinctive feature of the oases of the desert area, and, as such, the palm-stands must be considered part of the desert vegetation and are included therefore, in the formation-type Tropical /

⊠ Anogeissus schimperi Hochst. Ex. Hutch. and Dalz.

Tropical Desert rather than under the formation West African Dry Palm-Stands in the formation-type Tropical Savanna Woodland. The desert palm-stands are thus included in the Desert division rather than that of the division Climatic Dry Woodland, and since they form, in effect, part of the formation semi-desert, they are included as a sub-formation of it.

The date palms are very highly prized by the desert peoples. They occur, in most places, where there is sufficient telluric moisture although, of course, in the Northern Saharan they occur along the large seasonal rivers. It is essential for the palm to have available soil moisture and for the crown to exist in a dry or almost dry atmosphere. It does not grow well ~~for instance~~ in the Sudan zone, (as for instance in the Kano area), with its relatively higher humidity.

Phoenix dactylifera is grown commercially in Niger Colony on a very large scale, and its cultivation, protection and exploitation play a very important part in some of the larger oasis of the desert area, and produce a large revenue. The best example seen by the writer was the 'palmerie' at In Gall, where many hundreds of date palms are cultivated. The 'palmeries' are of comparatively recent commercial exploitation, and it is of interest to record that Barth makes no record of a date palm stand at In Gall which he mentions although he did not visit it himself, yet it cannot be assumed that there was none at that time.

The cultivation of the date is a specialized occupation and the natives tend the palms most carefully. The palms are usually grown in the area close to a river bed where they have available root moisture and the crowns have a dry atmosphere. Date palm stands occur in the oases of the true desert area and are found, amongst other places in Agram, /

Agram, Aïr, Djado, Kaouar and Tibesti. Abadie records that there are as many as 10,000 date palms at Agram and 100,000 at Kaouar.

The treatment of Phoenix is interesting; the fertilization of the date palms is carried out artificially in January and February; sometimes the pollen from the male flower is introduced by hand into the female flower; often, however, the male flower is placed between two branches at the top of the female palm and fertilization is effected by the action of wind and insects. When the fruits are formed they are protected by coverings of plaited fibres, (taken from palm leaves), to protect them from birds, insects and rain. The gathering of the fruits begins in July, but the main crop consists of the dates allowed to dry on the palms and it is gathered in September. Those from In Gall and Djado are considered to be of a very high standard commercially. With regard to the exploitation of the palm output Abadie records that one date palm will produce from forty to eighty kilograms of dates, that the life of a palm is from sixty to eighty years and at Kaouar, for instance, each palm is worth from five to ten francs.

Phoenix dactylifera are grown in the Sudan zone both in Niger Colony and in Northern Nigeria, but the conditions are not entirely suitable, the humidity throughout the wet season is too high, and first class dates are rarely obtained. Efforts have been made to increase the date palms in Northern Nigeria, but as they can only be propogated from suckers which are neither easily obtained or trans-:planted, no great success has as yet been achieved.

The date palms are valuable in the economic life of the desert dwellers and as such are of very great importance.

FORMATION /

FORMATION 15. WEST AFRICAN TRUE DESERT.

The writer cannot resist quoting Schimper in this connection also, who follows his views on semi-desert with the words (p.153): "The desert, on the contrary, is oecologically an open formation. Most seeds do not germinate in it, and seedlings frequently succumb to the inclemency of the climate. Others prolong their miserable existence. Many plants die and their places are not re-:occupied. There are always many spaces to be filled in the desert." He adds as a footnote "Very sparsely stocked stations in climatic districts suitable for woodland or grassland must not be confounded with climatic deserts. "....

True desert provides probably one of the best examples of climatic climax for it is wholly unaffected by biotic and other unnatural influences. The vegetation is, at the best scanty, and over large areas it is absent, nor is there any sign of any life whatsoever. Seeds from existing vegetation may germinate if climatic conditions chance to become favourable, but the seedlings or plants usually die. Few retain life in order eventually to produce the poorest type of xerophilous vegetation, whose life is at best a mere existence. In the open exposed desert in which infinitesimal rainfall occurs in a long series of years or no rainfall occurs and there is no telluric moisture, the occurrence of vegetation is usually impossible.

On the other hand it should be borne in mind that in sheltered valleys within the desert, where some rainfall, however small, may occur, or where there is intermittent flow of river water, as in the valleys running southwards to the River Niger from the Hoggar Massif, or where telluric moisture /

The desert city of Agades, showing thorn scrub in the distance and open sand beyond the town.

The foothills of the Bagzan Mountains, 35 miles north of Agades on the road to Iferouane. The scrub and tree growth consists almost entirely of Acacia raddiana.

The River Agades 30 miles north-east of the town of Agades. Riparian thornland on the banks of the river. The vegetation consists of Acacia arabica, Acacia ataxacantha, Ziziphus mauritiana and Hyphaene thebaica. Drift river crossing in the foreground moisture is inexplicably present, then vegetation may spring up from the seeds lying dormant in the sand. The resulting vegetation may have but a short life which may be a matter of days only.

The poorest of grass vegetation may help to fix the sand and prevent serious sand movement. Bagnold in 'The Physics of Blown Sand and Desert Dunes' (p.183) presents one attitude to the study of vegetation when he states: "Physically, vegetation can be regarded as a special kind of surface roughness." He goes on to write (p.184): "Hence unlike a pebble or rock surface vegetation cannot increase the rate of sand flow over it relatively to that over bare sand - rather the reverse...... Again, as long as the vegetation is alive, the surface on which it grows cannot even become fully charged with sand, for the grass grows higher as the sand accumulates." These remarks refer to the Libyan Desert, but apply equally to the Sahara which is one and the same desert area.

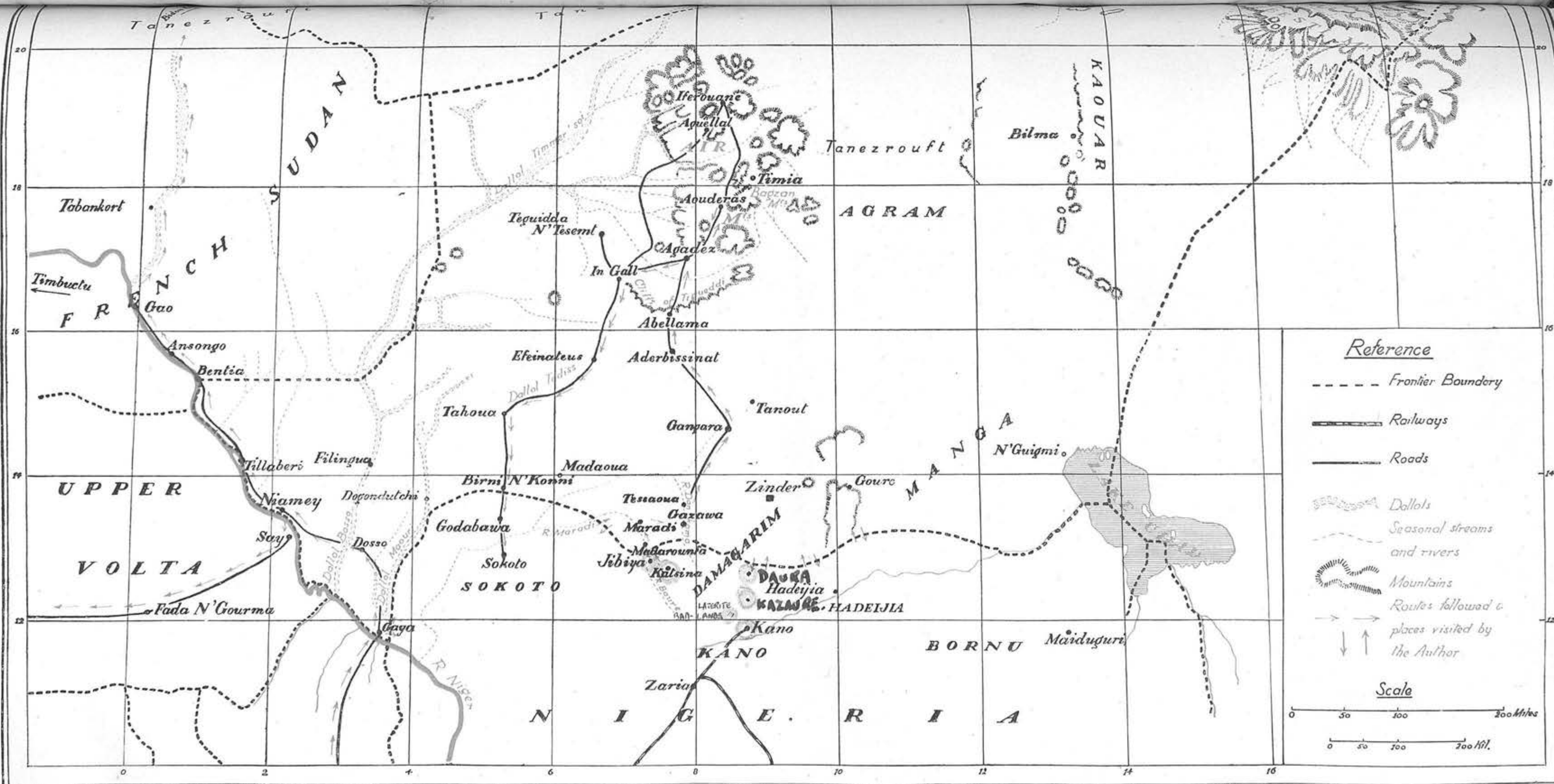
Schimper's footnote (p. 153) that sparsely stocked stations must not be confounded with climatic deserts is invaluable advice, for it is dangerously easy to classify areas of apparently induced desert conditions (on a small scale), as being semi-desert or even desert. It is desirable to examine such an area envisaging what the ecological succession would be were the area to be protected from man, animals and from firing. Areas of farmland for instance in Bornu Province of Nigeria, which have produced ground-nuts (Arachis hypogaea Linn.), over the full cycle of years have apparently little if any vegetation whatsoever, and they may present a picture of desert conditions more desert-like than parts of the desert itself.

Areas /

Areas of true desert were examined in the Bagzan mountains of Aïr, but the area is relatively small compared with the semi-desert of that region. It is only on the more exposed upland plains and on the mountains themselves that true desert conditions obtain, where there are indeed 'many vacant spaces'.

True desert conditions are found north of latitude 18° and the best example was seen by the writer in the western Tanezrouft (whichis the Tamachek or Taureg word for the land of thirst), north of Gao and Tabankort in the north-east portion of the French Sudan. Here one sees only a stretch of sand, possibly covered with water-washed pebbles and stones, and in which there is no sign of life, no suspicion of xerophilous vegetation, no insect life, no animal life, no bird life. This is the final phase, the Tanezrouft, the Tauerg's land of thirst, Abadie's "desert dans le desert."

FORESTRY RESEARCH IN NORTHERN NIGERIA.



MAP OF EXPERIMENTAL AREAS.

SUPPLEMENTARY PAPER ON FORESTRY RESEARCH IN NORTHERN NIGERIA.

Prior to the desiccation investigations in the Sokoto and Kano-Katsina forest circles there had been little systematic forest research in the northern Emirates of Nigeria, although a number of forest officers had carried out experiments on their own, the result of which, for the most part, were rarely published, nor were they readily available for young forest officers.

The writer began a series of experiments and recorded all the data of silvicultural and ecological interest during the term of the desiccation investigation and thereafter when in charge of forestry in Katsina and Kano Provinces.

A number of results were recorded in his two departmental reports (1) on the desiccation investigation in Kano and Katsina Provinces and in various papers in the Nigerian Forester, which is now called Farm and Forest. Results of his observations were also included in his two Institute papers (2) published by the Imperial Forestry Institute, Oxford. Owing to the fact that the major part of the writer's military service was spent in the northern Emirates of/

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(1) (a) The Sylvan Conditions and Land Utilization in Northern Kano and Katsina Provinces Part I 1938, W.A. Fairbairn.
(b) The Sylvan Conditions and Land Utilization in Northern Kano and Katsina Provinces Part II. 1940. W.A. Fairbairn.

(2) (a) Ecological Succession due to Biotic Factors in Northern Kano and Katsina Provinces of Northern Nigeria. W.A. Fairbairn. Imperial Forestry Institute Paper No. 22. 1939.
(b) Classification and Description of the Vegetation Types of Niger Colony French West Africa. W.A. Fairbairn. Imperial Forestry Institute Paper, No. 23, 1943.

of Nigeria he was able to examine various experiments from time to time between 1940 and 1943; and in the October of 1943 he was again posted to the Kano-Katsina circle, and was able to carry out further investigations and record definite results from experiments begun seven years before.

The following subjects were studied amongst others:-

Treatment and control of the weed Acanthospermum hispidum.

Rate of regrowth of hill-scrub savanna.

Rate of regrowth of combretaceous scrub.

Rate of regrowth of Guiera senegalensis.

Rate of river bank and gully erosion at Kazaure.

Effect of late firing and early firing on grassland.

River bank erosion and its control.

Rate of regrowth of vegetation protected on lateritic bad-lands

Rate of formation of lateritic concretions.

The effect of various types of vegetation on wind force.

The results of the above experiments from which definite data have been obtained and from which, in some cases, definite legislation has already been effected, are now described. The experiments made, the observations carried out and the results obtained are described in turn, and the deductions which have been made are recorded in each case.

1 /

1. TREATMENT AND CONTROL OF THE WEED ACANTHOSPERMUM HISPIDUM.

Experiments[(1)] were initiated by the writer in the Northern Provinces of Nigeria for the control of the Star-bur, Acanthospermum hispidum. This invasive weed is said to have been introduced from South America to Egypt during the war years 1914-1918 with fodder for horses and mules, and to have spread across to the Western Sudan in the intervening years. It is, however, known as the Star-bur in South Africa and occurs in Senegal, the Gold Coast and in Northern and Southern Nigeria, so the story of its introduction from South America via Egypt, must be regarded with some caution.

Whatever its origin, there is every indication that Acanthospermum may become a very serious pest in the Western Sudan. It is spreading with alarming rapidity and may seriously upset the rural economy of the area, for it can cover pasturage areas so thickly as to prevent cattle from grazing satisfactorily on them.

In an endeavour to find an economic method of at least checking if not eradicating the Star-bur, a series of plots was laid down along one boundary of the plantation area at Katsina*. It was proposed to apply such obvious methods of control as cutting, grubbing, firing and chemical treatment; and then to try the ecological method of approach, and endeavour to reduce the vitality of the weed by the introduction of shade, since it is a strong light demander.

Chemical treatment by applying a strong solution of copper chloride proved only partially successful, and Acanthospermum sprayed with this solution was killed within twenty-four hours; after some weeks, however, new growth appeared /

(1) Vide Nigerian Forester, Vol.1, No. 2, Nov. 1940.
* Since duplicated at Kano

appeared. This method is not being pursued for the present, as it is obviously not an economic one.

A series of experiments with the introduction at different espacements, of cuttings of indigenous tree species was also started, but with the perversity so often shown by cuttings in the Katsina area these did not take and that experiment has so far been a failure.

The experiments from which the best results were obtained were, fortunately, those using methods which there is some possibility of applying extensively in the field, but no definite conclusions can be drawn until they have been replicated on a variety of sites and over large acreages. It is hoped that further experiments on these lines will be made at Agricultural Stations also.

The plots laid down at Katsina were 225 square feet in area and treatments were as follows:-

I. Control. (Demarcated 1.5.40).

II. Herbaceous vegetation cut to ground level and cut material removed. (Completed 7.5.40).

III. Herbaceous vegetation cut, and ground dug over to a depth of two feet; the vegetation removed and the roots grubbed out. (Completed 8.5.40).

IV. Herbaceous species cut and the whole burned <u>in situ</u>. (Completed 8.5.40).

V. Herbaceous growth left for early firing in October of each year.

Up to the time of writing definite results have been obtained from the five plots. In July of 1940 (the middle of the rainy season in Katsina), a record was made of the herbaceous species occurring in each plot; the object being to observe the state of the vegetal growth and, in the area (III) from which the vegetation had been completely removed, to record the invading species.

A /

A full enumeration was then made in quadrats of nine square feet in plots I, II, III and IV, with the following results.

	I	II	III	IV
Acanthospermum hispidum ...	125	28	14	Nil
Cassia tora	42	1	1	32
Pandiaka heudelotii ...	34	-	-	4
Corchorus olitorius ...	6	3	34	10
Cucumis melo	1	3	1	2
Merremia angustifolia ...	1	-	-	-
Digitaria debilis	3	-	6	3
Pennisetum pedicellatum ...	258	-	4	-
Amaranthus viridis ...	-	-	1	-
Tribulus terrestris ...	-	-	7	1
Dactyloctenium aegyptium ...	-	4	5	-
Cynodon dactylon	-	-	1	-
Peristrophe bicalyculata ...	-	5	-	1
Pennisetum hordeoides ...	-	50	-	-
Commelina nudiflora ...	-	8	-	6
Totals	470	102	74	59

Taking the quadrats as accurately representative of the plots - which of course they could not be in spite of every endeavour to locate them in typical areas - the following totals were obtained of the number of Acanthospermum in each plot and the percentage it constitutes of all the species enumerated. Actually, though the Quadrat in Plot IV was free of Acanthospermum, there were a few in one small corner of the plot.

/

		No. per plot.	Percentage
Plot I	Control	3,125	26·8
Plot II	Vegetation cut and re-:moved	700	27·4
Plot III	Vegetation cut and re-:moved, roots grubbed and ground dug to depth of 2 ft.	350	18·9
Plot IV	Vegetation cut and burned *in situ*	Nil	Nil

On present indications, therefore, the best re-:sults may be expected from cutting and burning Acanthospermum. It is noteworthy that, where the Star-bur occurs on farmland in the vicinity of Katsina it is hand-weeded by the farmers, and this has the effect of reducing it considerably.

The writer is of the opinion that the method likely to be adopted finally for the control of the weed over large areas will be a combination of several treat-:ments, according to a programme such as this:-

1. Early weeding in May and June, or cutting and burning in the case of large areas.
2. Cutting and burning in late November.
3. Cutting and burning in April of any of the weed left.

At a later stage experiments were made with con-:tinuous weeding of Acanthospermum while immature or in flower, before actual seeding took place. Good results were obtained by this method, which is, in actual fact, adopted by the farmers in cleaning operations on the farms.

The experiment was then carried a stage further and the ecological approach attempted. It was realized from observations in the field that Cassia tora (which is useful fodder for cattle and is used medicinally by the native), occurring in an area of Acanthospermum, appeared to give the necessary shade in order to reduce the density of the weed. Two further plots were then made in which the/

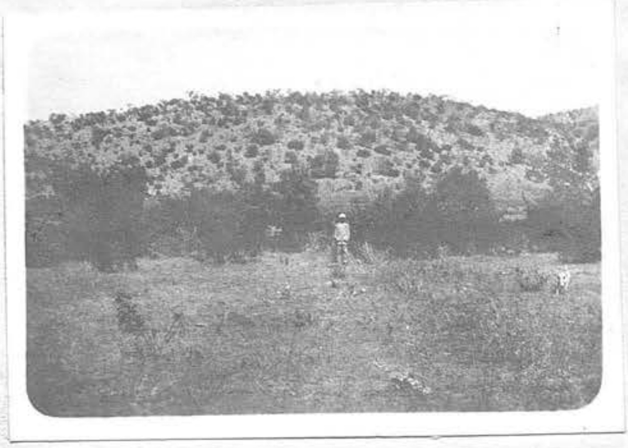
the herbaceous growth was cut to ground level and Cassia tora seed was sown broadcast on one and sown thickly in lines at six inches' interval in the second. The con-:ditions found in the field were duplicated. It was found that after three years the Acanthospermum under Cassia tora had neither the density or the strength of those in the con-:trol plot in which the conditions had not altered over three years.

It has been found that the weed is even more wide-spread throughout Northern Nigeria in 1944 than it was in 1937 and the time has arrived at which Government and the Native Administrations are required to take concerted action, in order that the weed be removed from farmlands before seeding time. While this is being done on farmland it is, however, allowed to spread on wasteland and the seeds are eventually carried to farmland again.

The writer examined areas of the weed in French Niger Colony and found that it was also a problem there; he discussed the question with the French Administrative officers at Zinder and Maradi and corresponded with the French Agricultural Botanist from Niamey, who stated while his Government were aware of the danger, nothing could be done to combat it in wartime because of the shortage of staff.

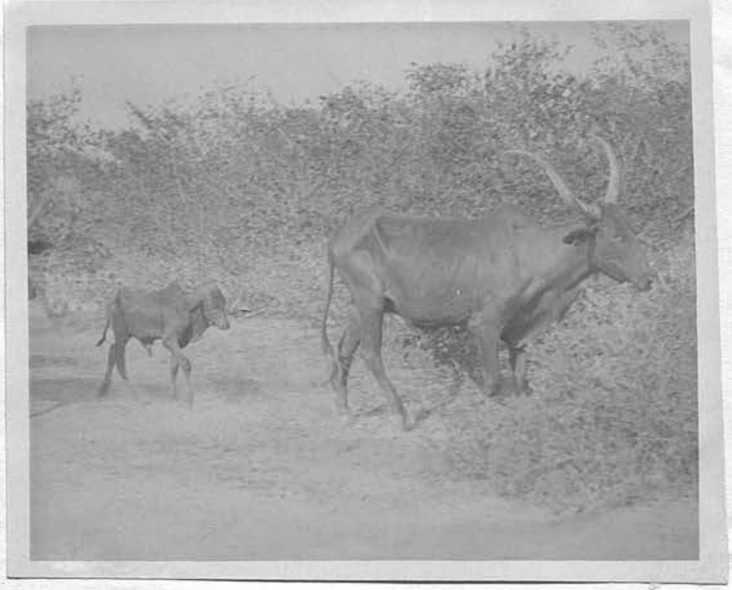
It is therefore demonstrated that effective measures on farmland include the early weeding of this pest, that where Acanthospermum is widespread on wasteland it should be cut and burned before seeding and if that is not possible its growth can be controlled by the broadcast sowing of Cassia tora seed.

2./



Hill scrub vegetation of the Kazaure Hills.

Hill scrub on the Kazaure Hills in January of 1944; the vegetation is a little more sparse due to exploitation for fuel, than in the above taken in December of 1937.



Combretaceous scrub at Daura. This should be compared with aerial photographs.

2. RATE OF REGROWTH OF HILL-SCRUB SAVANNA.

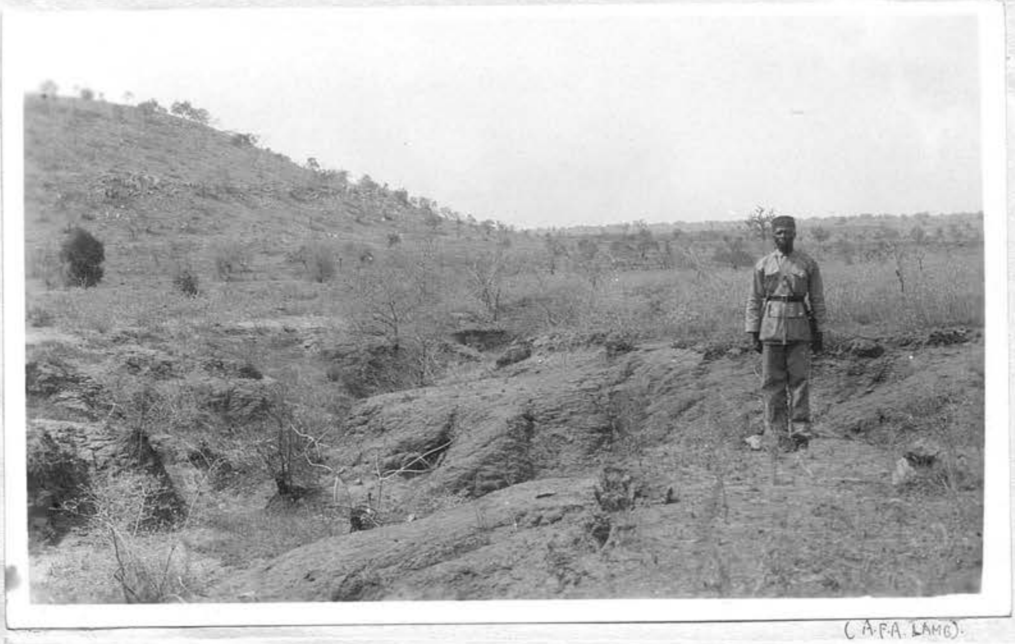
Three plots each consisting of 4356 square feet were made on hill slopes at Kazaure on 25th December 1937 with a view to ascertaining the rotation for fuel cutting. Inspection on 19th May 1940 showed that regrowth of Cassia singueana, Combretum verticillatum and Combretum micranthum had occurred and had reached the average heights of seven feet, five feet and four feet respectively. In January of 1944 the vegetation had recovered its original height of eight to ten feet and was in fact denser than the average vegetation on the hill side. Since the vegetation, is, however, protective in function, although the rotation could be laid down at seven years, it is recommended by the writer that it should be ten years.

3. RATE OF REGROWTH OF COMBRETACEOUS SCRUB.

A test plot (4356 square feet) was laid down at Daura on the 7th December 1937 with a view to ascertaining the rate of regrowth of combretaceous scrub and, where it is cut for fuel, what period of years the rotation should be. Observations on 7th June 1940 showed coppice of Acacia ataxacantha and Bauhinia thonningii had reached five feet, Combretum micranthum six feet and Guiera senegalensis three feet in height. Further observations made in January of 1944 proved that the vegetation on the plot had reached the same height of 8-10 feet as the former uncut vegetation, although it was not quite so dense. Therefore it is safe to state that a rotation of eight years can be used in cutting Combretaceous scrub for fuel.

Guiera consociation on fallow land in northen Katsina.

Guiera consociation on farmland on a light sandy soil near Kaita, 11 miles north of Katsina.



(A.F.A. LAMB).

Area in which the rate of erosion was measured at Kazaure.

Formerly severely eroded streambanks in the Kazaure hills. With protection of the vegetation the banks are now fixed and erosion practically eliminated.

4. THE RATE OF REGROWTH OF GUIERA SENEGALENSIS.

A plot measuring 4356 square feet was laid down on new fallow-land at Daura on the 7th December 1937 with a view to studying the rate of growth and densification of Guiera senegalensis. The area had been farmed in 1936. By the 4th November 1938 the growth had reached eighteen inches; by the 15th June 1939 it was three feet high and fairly dense; by 14th May 1940 it was five feet high and the growth was then dense. The plot was last examined in January of 1944 and the Guiera was found to be 10-12 feet high and so dense as to prevent easy passage through the plot. An aerial photograph of Daura shows this plot to the west of the road from Daura to Zinder. This proves that if such an area were to be cut on rotation for firewood that the rotation can be as low as six years.

5. RATE OF RIVER BANK AND GULLY EROSION AT KAZAURE.

A series of measurements were made on the 2nd of January, 1938, on the banks of a stream in the Kazaure Hills in order to measure the rate at which accelerated soil erosion takes place in this region.

A number of points were taken on two branches of the stream one of which was suffering from gully erosion. A series of points were marked on the banks so that the rate of erosion over a given period could be assessed. Inspection on the 7th of May 1940 showed that in a period of two years and four months the average width of bank that had broken down and disappeared was 2·5 feet and that the rate of erosion is therefore approximately one foot per year. The area was again inspected in March of 1944 and the observations confirmed the previous results.

Grass cut annually on fire trace.

Grass fully protected.

Grass early fired.

6. EFFECT OF LATE FIRING AND EARLY FIRING ON GRASSLAND.

The question of late and early firing of grassland has always been debatable and in order to obtain specific results for the Katsina area, five plots each one chain square were laid down in the Katsina plantations in an area of natural vegetation and grassland which had been protected for 16 years.

The vegetation consists mainly of Bauhinia thonningii, Guiera senegalensis in an area of orchard woodland savanna.

The following plots were laid down in April of 1939:-

I. Control:
II. Complete Fire Protection:
III. Early Firing:
IV. Late Firing:
V. Late firing followed by one year protection:

The following observations were recorded in August 1940:-

I. Control: A matting of tough dry grass in the dry season, and of tough fresh grass in the early rains. Tough tussocks of grass throughout the plot. Grazing fair.

II. Complete Fire Protection: As in control.

III. Early Firing: Strong tussocks of grass in the dry season, good growth of strong grass in the early rains.

IV. Late Firing: A matting of tough dry grass in the dry season; in the early rains, excellent growth of tender fresh grass and herbaceous growth. Grazing good.

V. Late firing and one year protection: Strong tussocks of dry grass in the dry season and good growth of fresh grass in the early rains.

It/

Portion of the river bank immediately North of the Jibiya forest reserve.

River bank protection on the river Jibiya within the forest reserve. Note how the vegeta:tion has fixed and protected the banks.

It is interesting to note that the grass on the fire traces in the plantations, which are cut in October of each year, produces the best of grazing grass, the tussocks of old grass being completely absent.

Photographs of the plot completely protected, that of the plot which has been late-fired and the grass on the fire trace are included.

Early firing of grassland has usually been advocated in the past as a means of preventing late fierce fires, with the consequent destruction of young tree growth. The Fulani grazers seem to prefer late firing of grassland for their cattle, but it should be borne in mind that the time of firing varies with differences in latitude and these notes refer to the Katsina area only.

The plots were examined in January of 1944 and the inspection confirms the observations made in August of 1940. The results are best from the plot which was late fired, which supports the views of the Fulani, who have long decades if not centuries of experience from which to judge.

7. RIVER BANK EROSION AND ITS CONTROL.

The writer's interest in river bank erosion was[1] stimulated by the rapid destructive action of the River Jibiya in Katsina Province. The river runs for a relatively short distance of about 50 miles before flowing northwards into French Territory and it was decided measurements should be made in one of the areas in which the river had done much damage, and that experiments on vegetational protection of the banks be attempted.

A/

(1) Vide: Farm and Forest, Vol. 11, No. 2. October, 1941.

River Jibiya. The Fan palm shows the starting point of the survey.

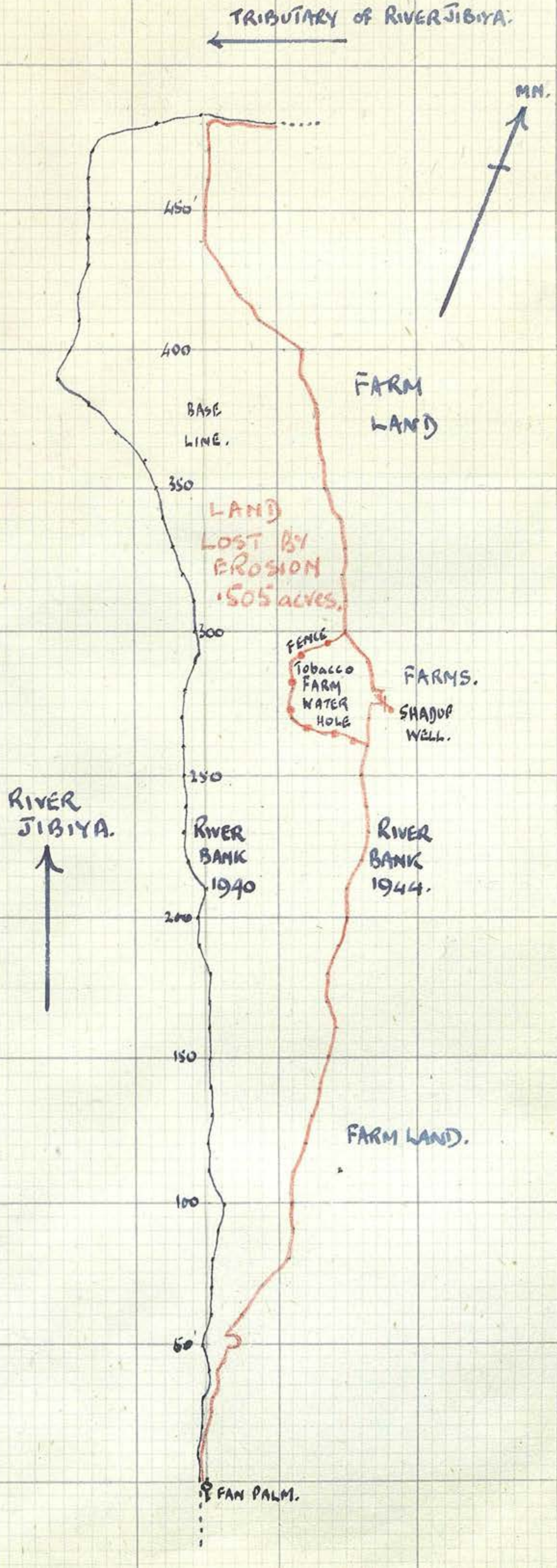
Portion of the river Jibiya at the beginning of the rains.

Part of the river bank on which the survey was made.

SURVEY OF RIVER JIBIYA BANKS
1940 AND 1944.

SCALE 1 INCH = 50 feet.

FARM LAND DESTROYED APPROXIMATELY ·505 acres.



A suitable area was chosen approximately one mile north of the Jibiya bridge where progressive damage had been taking place year after year, and an accurate survey was made in July of 1940 of 500 feet of the eastern bank of the river near the French boundary, so that a later survey would show the actual loss of land.

A second survey was made in January of 1944 and the results of the two surveys show how much the river has cut away valuable farmland in three years and six months. The surveys have been plotted on graph paper and are included with this note. It will be seen therefore that over this short period approximately ·5 acres have been lost over a mere 500 feet of bank. When it is considered that this is going on almost unrestricted over many hundreds of miles, it will be appreciated how important the problem is.

The local farmers pointed to places near the middle of the river where occasional tree stumps still remain to show what was farmland only in 1937; at this point the river is some 300 yards wide and the banks are scoured by its sinuous course. In contrast to this there is a straight stretch of the river about two miles south-east of the Jibiya bridge, where it runs through the Jibiya Forest Reserve. Here the width is approximately 80 yards and the ten foot high banks are completely covered with Imperata cylindrica and other grasses, as well as Mimosa pigra, Ipomea repens and other creepers. The banks are firmly fixed and there is no sign of erosion except where native paths have been made down to the dry season water-holes in the river bed.

Nature has fixed the banks controlled the river and prevented erosion. A few yards outside the reserve boundary the river banks are very broken, erosion is going on rapidly and farmland is being destroyed.

Experiments/

Lateritic plain north of Kano showing pairs of photographs, taken in 1940 and in 1944; the improvement in the vegetation can be seen.

Lateritic plateau 12 miles north of Kano.

Pairs of photographs, taken in 1940 and in 1944, of the vegetation at the base of the lateritic plateau, showing improvement with protection.

Experiments made in sowing indigenous seeds and planting of cuttings proved unsuccessful. Thus it is obvious that protection of the river banks from farming and fuel cutting is the most efficient, the cheapest and the easiest method of preventing such erosion.

A series of photographs are included which show the fixed banks with their wealth of vegetation in the forest reserve and the banks outside the reserve where erosion is taking place continuously with the loss of large areas of valuable agricultural land.

As a result of these observations (which were published in Farm and Forest Vol. 11 No. 2 of October 1941), the writer recommended that fifteen feet from the high water level of all streams and rivers should be protected from grazing, farming and fuel cutting, and this has been incor:porated in the Native Authority Forestry Rules for Northern Nigeria published in 1943.

Experiments were made in this area with regard to river training, but the light poles, lightly tied to:gether, and placed in the stream bed were too insecure to stand up to the fierce early flooding of the river. It is now realized that strong poles firmly driven into the sandy river bed would be more suitable, but the real remedy is conclusively proved to be protection of the river bank vegetation.

8. RATE OF REGROWTH OF PROTECTED VEGETATION ON LATERITIC BAD-LANDS.

There is a large number of areas of lateritic soil with but little vegetation throughout the northern emirates of Nigeria and in French West Africa, as already described in the thesis. These areas usually support a poor type of degraded/

Eroded lateritic plain 12 miles north of Kano, showing the regrowth after 3 years protec-:tion, of Guiera, Bauhinia and the grass Andro-:pogon gayanus.

Lateritic plain north of Kano showing pairs of photographs, taken in 1940 and in 1944; the improvement in the vegetation can be seen.

degraded scrub in which specimens of Combretum micranthum can be found at times even in the cracks and crevices of what appears to be pure lateritic concretions without any semblance of soil.

There is little doubt that some of these areas have been induced, (as in Daura for example), due to over-exploitation of the farmlands during the present century and their rehabilitation is one of the problems of the forest and agricultural departments.

The writer became interested in an extensive area of lateritic plains twelve miles from Kano on the road to Daura and has studied the vegetation on it from 1937 onwards. It is obviously an area which has had a shallow soil; it is on a slightly elevated plain, which has been over exploited until the good surface soil has been lost, first by lack of vegetational protection and later by sheet erosion.

A series of photographs were taken in January of 1940 and these are included in the paper.

Enumeration of a quadrat 10 yards square of the degraded scrub on the exposed lateritic plateau gave the following results in the 0-2 inches diameter class; none was larger than two inches in diameter.

ENUMERATION OF A QUADRAT OF 10 YARDS SQUARE OF LATERITIC BAD-LANDS: KANO - DAURA ROAD

Species	0-2 inch diameter class.
Guiera senegalensis	38
Combretum micranthum	6
Cassia sieberiana	4
Crotalaria obovata	2
Chrozophora senegalensis	1
	51

The/

Pairs of photographs, taken in 1940 and in 1944, of the vegetation at the base of the lateritic plateau, showing improvement with protection.

The following grasses also occured:-

Andropogon gayanus
Andropogon exilis
Pennisetum pedicellatum
Aristida sieberiana

As a contrast the enumeration of one acre of representative vegetation in a slight valley on the same area gave the following results:-

ENUMERATION OF 1 ACRE OF LATERITIC BAD-LANDS
ON THE KANO-DAURA ROAD

Species	Diameter Classes 0-2	2-4	Totals
Acacia albida	3		3
Acacia arabica	2	4	6
Balanities aegyptiaca	2		2
Bauhinia thonningii	3		3
Cassia obovata	1		1
Cassia singueana	7		7
Cassia tora	5		5
Dichrostachys glomerata	1		1
Diospyros mespiliformis	1		1
Leptadenia lancifolia	2		2
Solanum incanum	1		1
Ziziphus mauritiana	1		1
Ziziphus spina-christi	2		2
	31	4	35

The grasses Andropogon gayanus and Andropogon exilis were also present.

It is interesting to note that the following species are found at the immediate base of the minor escarpment of this plateau.

Parkia oliveri
Sclerocarya birrea
Diospryos mespiliformis
Butyrospermum parkii
Acacia arabica
Combretum micranthum
Tamarindus indica
Entada sudanica
Acacia ataxacantha
Bauhinia thonningii
Adansonia digitata
Calotropis procera
Ziziphus mauritiana.

The two photographs with crenelated edges in the first series, show the vegetation on the borders of the rich farmland/

farmland soil (wherein the above series of species were listed), immediately to the north of the ironstone plateau. These were taken in January of 1940. The other photographs of the lateritic area were taken in September of 1940.

The area was declared a communal forest area in 1941 and it was protected from cutting and firing and as far as possible from grazing. One part-time forest guard only could be afforded and the area was grazed intermittently, since one man could not patrol it the whole time. In spite of this the protection produced good results, the scrub improved in height and density and the second series of photographs (taken as nearly as possible from the same positions, in March of 1944) show the striking difference.

Thus it is proved that even on the most infertile lateritic ironstone a certain scrub vegetation can grow if the necessary protection is afforded it. It is obvious that if the vegetation can be improved the soil will in due course become rehabilitated and it will again be possible to use it in the growing of economic crops. The large areas therefore of lateritic ironstone which cover many hundreds of square miles in the Central Western Sudan can be improved by protection initially and can play an important part in the future in providing both grazing and farmlands in an area where an increase in both is highly desirable.

9. RATE OF FORMATION OF LATERITIC CONCRETIONS.

There have been differing views in regard to the rate at which lateritic concretions are formed and when the writer advanced the theory in 1940 that 'laterite' was in the process of formation in certain areas the theory was generally disbelieved; the writer had observed both in Daura and Katsina borrow-pits and depressions in which lateritic/

Lateritic concretions in borrow-pits at Daura.
Note the pencil and the camera case for
comparitive sizes.

lateritic concretions appeared to be forming although he had no record of the original formation of these borrow-pits.

It was observed that pits from which the soil had been dug to build the forestry house in Katsina about 1929 had already formed laterite on the surface and sides and it seemed that the laterite had been formed recently, but it was impossible positively to state this.

In the course of his military duties the writer saw in February of 1941 weapon pits and slit trenches being dug in light sandy soil in the neighbourhood of Daura. On his return to Daura in January of 1944 an examination of the former pits showed that laterization had taken place on the surface soil and that it had already reached a thickness of four to six inches. This was to be found true of a number of such pits which were dug in the vicinity of the Daura landing ground and was not exceptional in any one area.

From the observations made at Daura it seems that laterization is effected when the soil (in this case which has been heavily farmed in recent decades) is exposed and no protection is afforded it by vegetation. From those, on the other hand made at Katsina, where there is good agricultural soil in the vicinity of the borrow-pit, it seems obvious that the soil is not over-exploited and that it is the removal of the vegetal cover and consequent soil exposure that has allowed the lateritic concretions to form.

It is therefore obvious that the retention of vegetal covering can prevent laterization in soils which have not been over-exploited and that it can retard the formation of laterite in over-exploited soils. Once later-:itic concretions have been formed over large areas it is extremely difficult to introduce a better type of vegetation than/

than the combretaceous scrub which is the edaphic climax. Thus protection of all soils in agricultural areas is essential if the formation of lateritic concretions and retrogressive succession are to be avoided.

It is therefore proved conclusively that under certain conditions lateritic concretions can be formed in a period of three years and that it is being formed to-day.

10. THE EFFECT OF VARIOUS TYPES OF VEGETATION ON WIND FORCE.

It had been suggested that the vegetation in the northern Emirates of Nigeria had little effect on the wind force, the writer disagreed with this statement and carried out a series of experiments on the force of air currents in relation to shelter belts of different types, i.e. plantations, a single row of close growing trees, a double row of avenue trees, avenue trees with a thick Euphorbia hedge at the base, scattered trees and isolated trees.

Measurements were taken over a series of weeks in different conditions of weather, during average winds and in rain storms, so as to obtain as much data as possible. The measurements were only comparative and were recorded on four gauges, each depending on the effect of wind pressure on a piece of light tin, four inches square, lightly balanced with its lower edge on a V shaped notch, with a needle attached showing on the wind gauge-base, comparative measurements of wind forces. Even light puffs of wind were recorded by the gauges. All were adjusted, (before any experiment was begun), in relation to each other so as to record the same readings under the same conditions.

The/

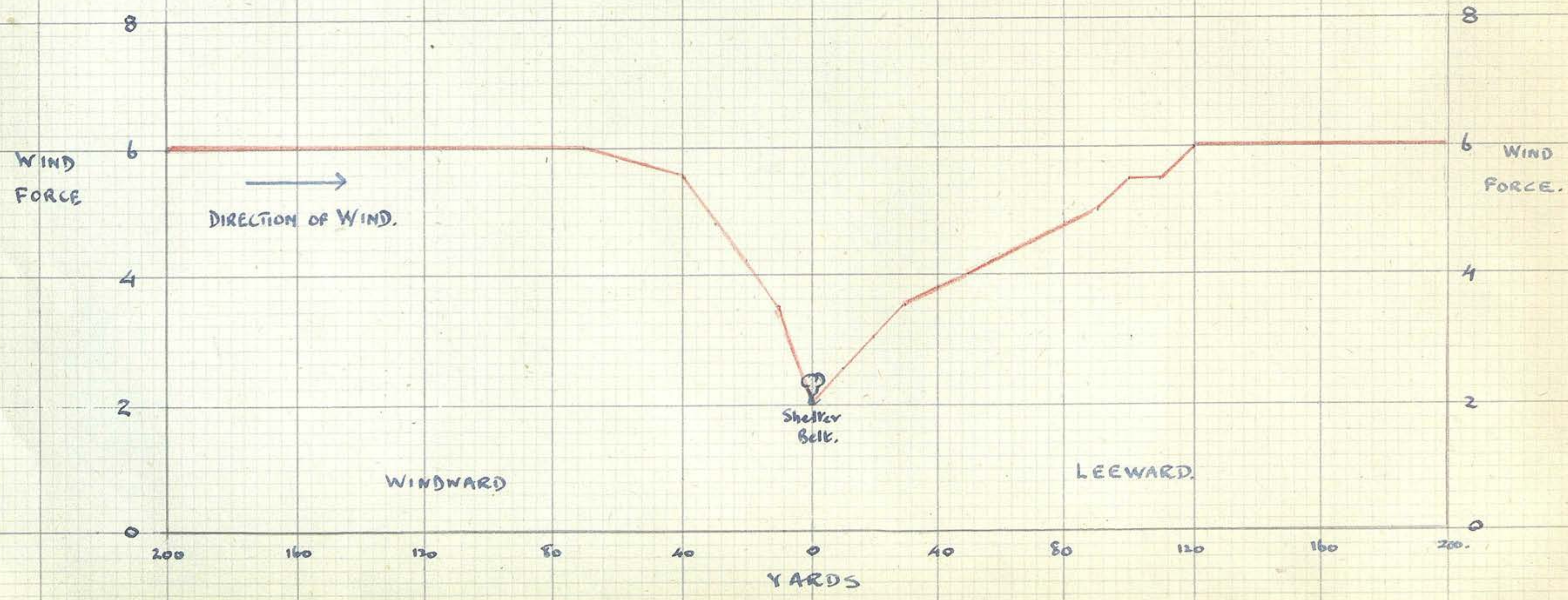
The measurements were generally taken at intervals of 10 yards for some distance to windward and to leeward of the obstruction, a control being retained at its base.

The accompanying graphs showing a series of these experiments illustrate how air currents are decelerated by the presence of vegetation of various kinds; it may be assumed that the undulating effect apparently induced in these currents by the various obstructions connotes a reduction in the force of the wind over the area effected.

The results proved that the force of the air currents is reduced by shelter belts, plantations, hedges and, at soil level, in the case of light winds even by grass only a few inches high.

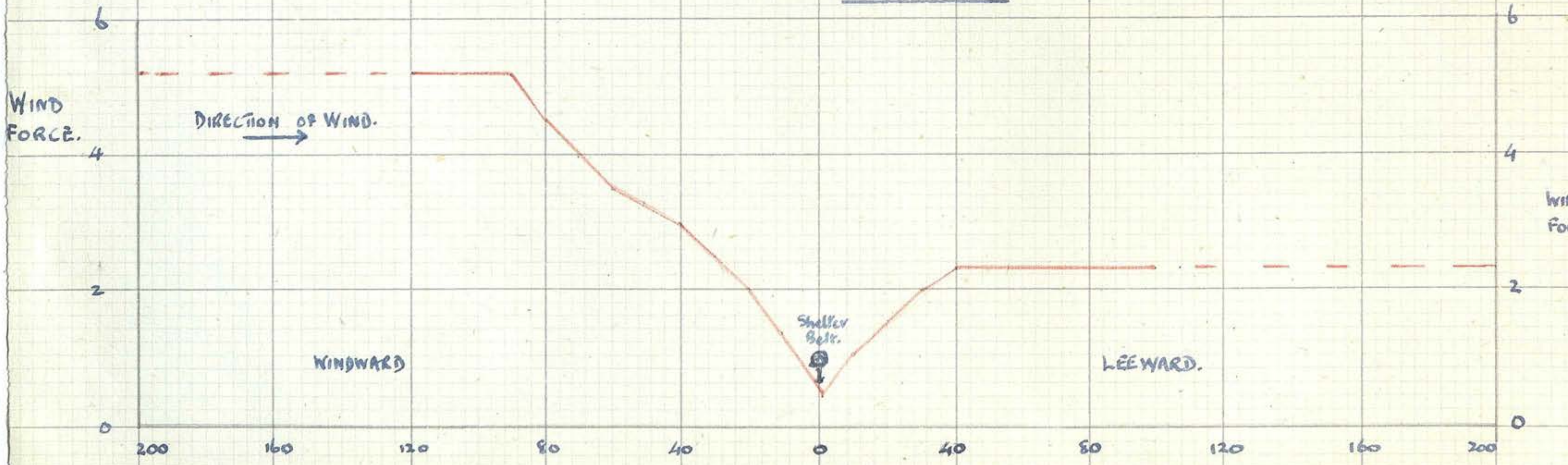
LIGHT SHELTER BELT.

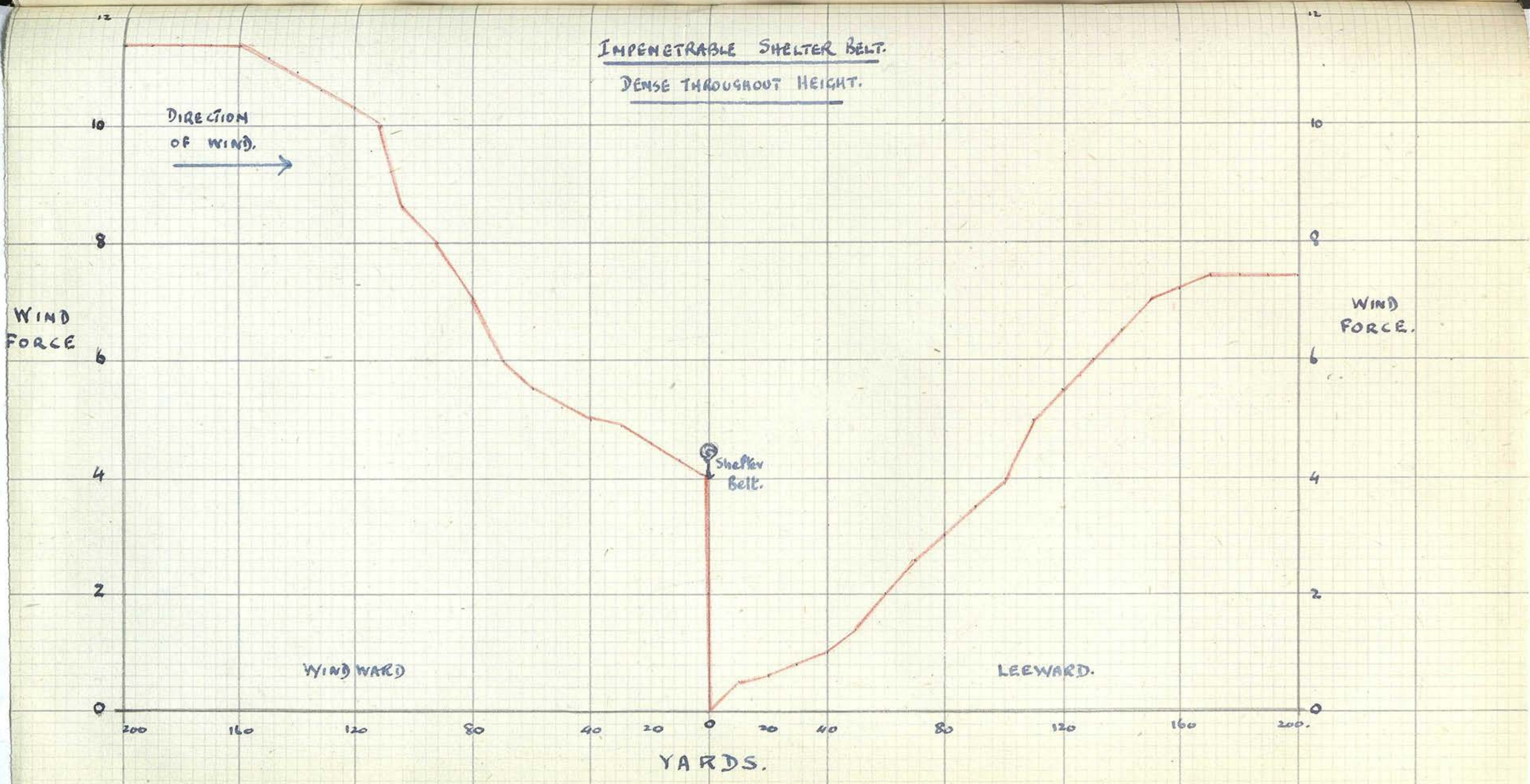
OPEN ABOVE AND BELOW.



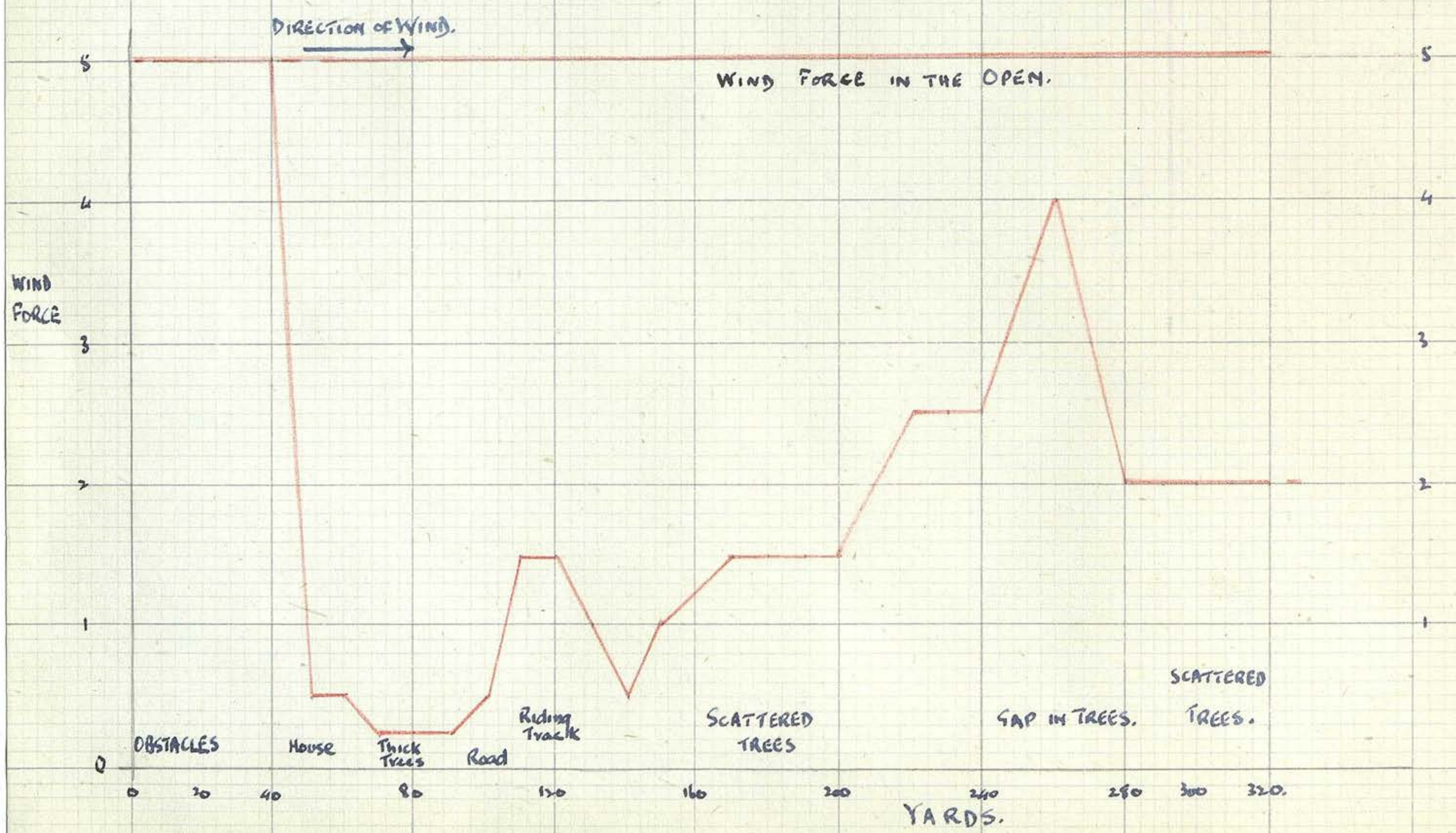
Medium Density Shelter Belt.

Medium Density Above.
Dense Below.

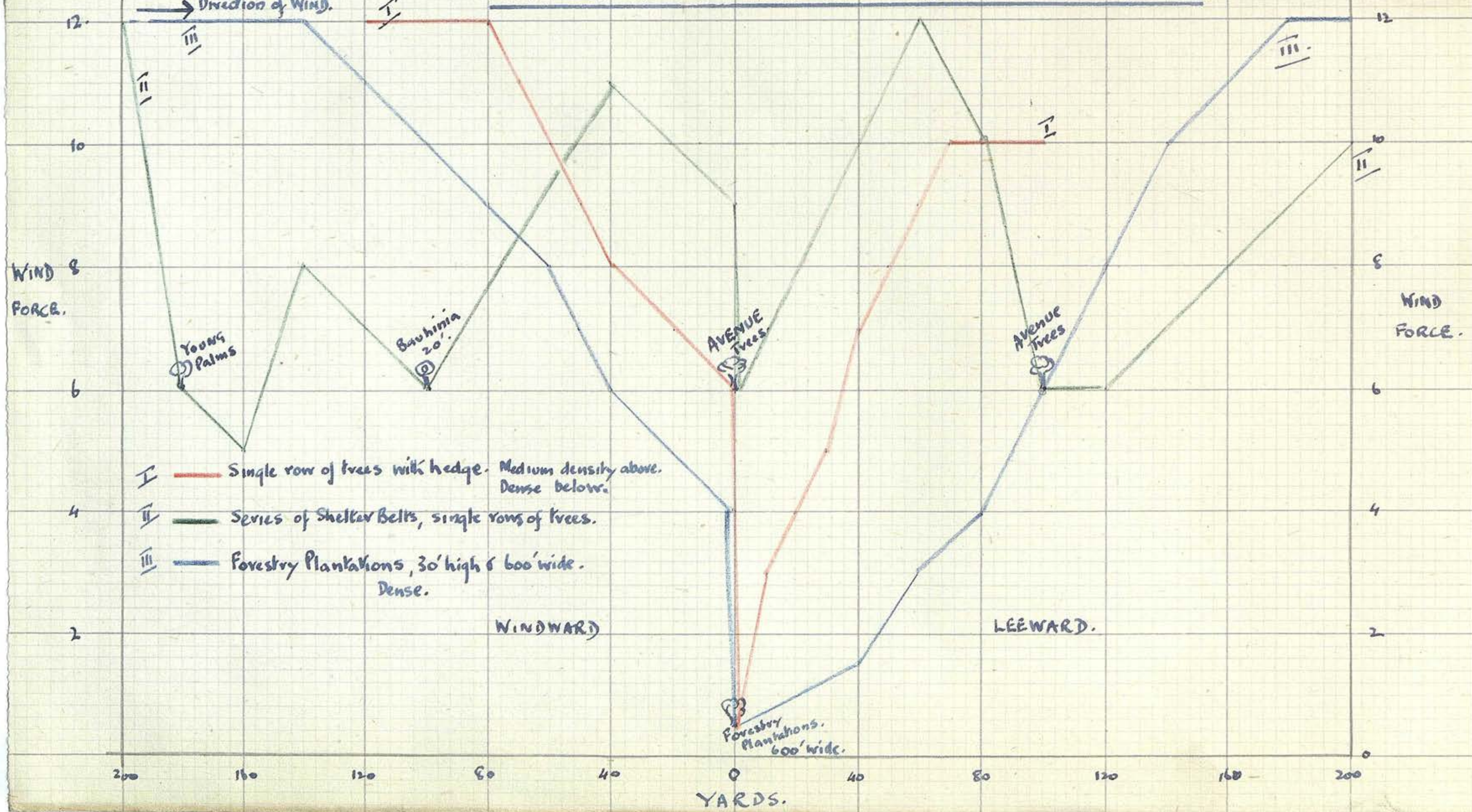



IMPENETRABLE SHELTER BELT.
DENSE THROUGHOUT HEIGHT.
DIRECTION
OF WIND.
WIND
FORCE
WIND
FORCE.
Shelter
Belt.
WINDWARD
LEEWARD.
YARDS.
12
10
8
6
4
2
0
200
160
120
80
40
20
0
20
40
80
120
160
200.

EFFECT ON WIND FORCE OF VARIOUS OBSTACLES.



EFFECT OF VARIOUS SHELTER BELTS AND WINDBREAKS ON WIND FORCE.



A series of enumeration statistics are also included as an appendix to this paper. Enumeration figures have not previously been recorded for the area under review except by the present writer in the Imperial Forestry Institute paper on French Niger Colony. They represent the complete enumeration, except in one case of a one per cent enumeration, of areas of representative vegetation. They are recorded in two inch diameter classes from 0 - 2" to 16 - 18" and 18" and over.

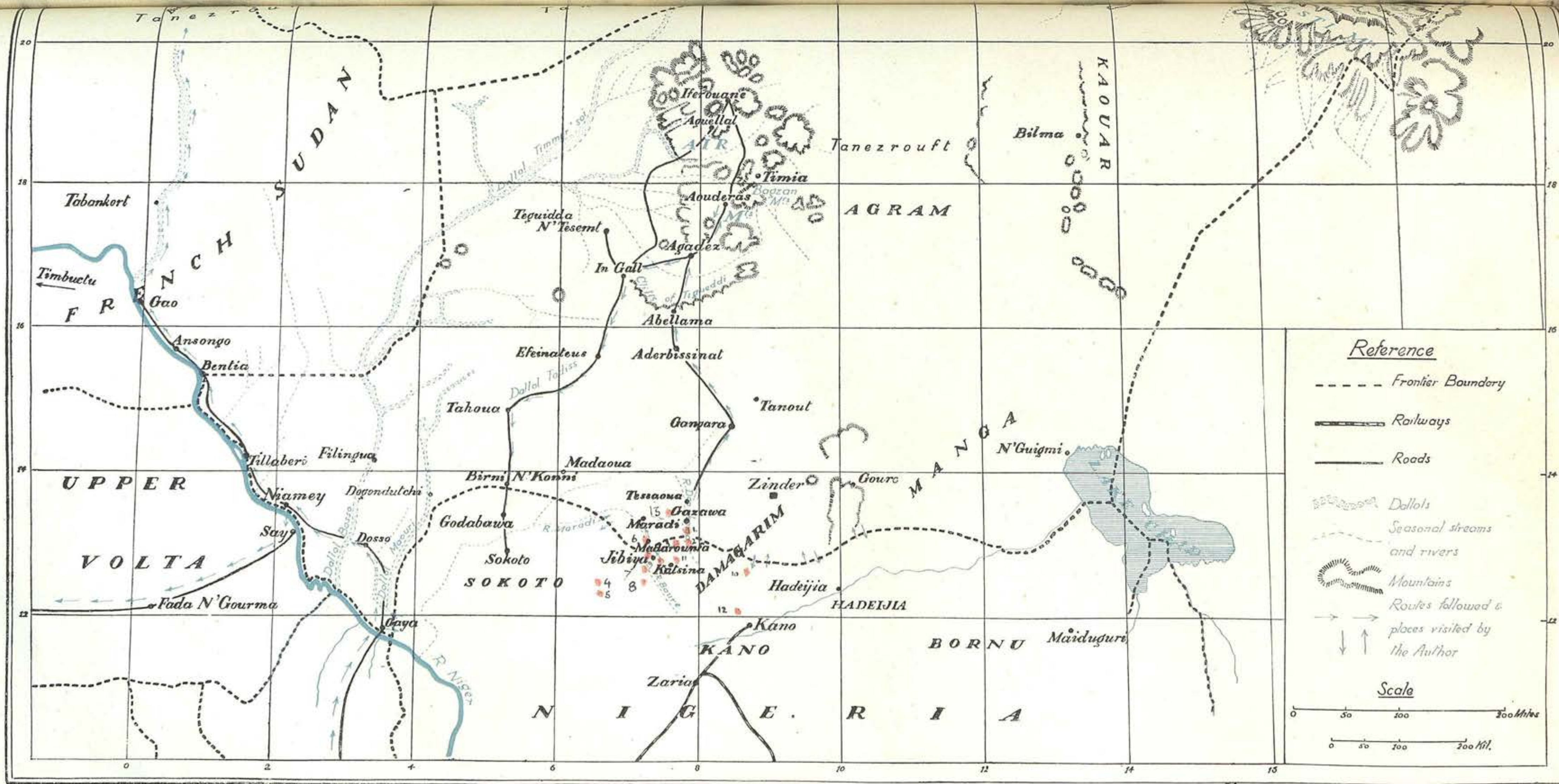
The enumeration of the following types of vegetation are recorded:-

1. Swamp Woodland
2. Riparian Woodland - Niger Colony
3. Riparian Woodland - Northern Nigeria
4. Savanna Woodland
5. River-bank Orchard Woodland Savanna
6. Dry Orchard Woodland Savanna
7. Hyphaene thebaica Palm-Stand
8. Borassus aethiopum Palm-Stand
9. Inselberg Vegetation
10. Hill Scrub
11. Combretaceous Scrub
12. Lateritic Bad-lands
13. Riparian Thornland

A P P E N D I X

oOo

ENUMERATION STATISTICS



MAP SHOWING ENUMERATION AREAS.

NUMBERS INDICATE THE ENUMERATION PLOT.

SWAMP-WOODLAND- SOUTHERN NIGER COLONY

100% ENUMERATION. CLASSIFIED SPECIES TESSAWA DISTRICT.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
ACACIA ARABICA	8										8	2
" ATAXACANTHA	6	2									8	ACRES
" SENEGAL	3										3	
" SEYAL	12	3				1					16	
" SIEBERIANA										1	1	
BALANITES AEGYPTICA	9	1									10	
CAPPARIS TOMENTOSA	1										1	
CASSIA SINGUEANA	4	1									5	
COMBRETUM MICRANTHUM	41	6									47	
CRATEVA ADANSONII						1	1	1			3	
DIOSPYROS MESPILIFORMIS	15	7	5	4	6	9	6	2	4	9.	67	
HIPPOCRATEA RICHARDIANA	11	2									13	
HYPHAENE THEBAICA				2		5	3	3			13	
MITRAGYNA INERMIS	3	4	3	3	6	5	3	2	1		30	
ZIZIPHUS MAURITIANA	2										2	
NOWN												
AL	115	26	8	9	12	21	13	8	5	10	227.	
AL UNKNOWN												
ND TOTAL												

RIPARIAN WOODLAND - SOUTHERN NIGER COLONY.

100% ENUMERATION CLASSIFIED SPECIES TESSAWA DISTRICT.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculate area c unit
ACACIA ALBIDA										1	1	2
" ARABICA	8								1		9	ACRES.
" ATAXACANTHA	16										16	
ANOGEISSUS SCHIMPERI		5			4	3	4			8	24	
CRATEVA ADANSONII	4		1		3	6	5			2	21	
COMBRETUM MICRANTHUM	3										3	
DIOSPYROS MESPILIFORMIS	17	4	7	12	9	9	8	5	3	10	84	
FICUS ITEOPHYLLA.										1	1	
FLUGGEA VIROSA	6	4	2								12	
HIPPOCRATEA RICHARDIANA.	12										12	
MITRAGYNA INERMIS	8	4	3			4	3			5	27	
TAMARINDUS INDICA					1	1					2	
ZIZIPHUS MUCRONATA.	15	5									20.	
NOWN												
TAL	89	22	13	12	17	23	20	5	4	27	232.	
TAL UNKNOWN												
AND TOTAL												

RIPARIAN WOODLAND - JIBIYA RESERVE - KATSINA -

1% Enumeration.

CLASSIFIED SPECIES

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculate area of unit
ACACIA ALBIDA.		0	1	0	[illegible]	3					5	
" ARABICA				0	1	0	1				2	2
" ATAXACANTHA	0	1									1	SQUARE
" CAMPYLACANTHA	0	1	2	9	1	3	0	1	1	5	23	MILES
" SIEBERIANA	-	1	4	2							7	
ANOGEISSUS SCHIMPERI	-	1	1	2	1	1	4	4	2	8	24	
BORASSUS FLABELLIFER	-					2	9	8	16	24	59	
DIOSPYROS MESPILIFORMIS	-	26	25	3	1	1	1			2	59	
FICUS GNAPHALOCARPA	-			2							2	
HYPHAENE THEBAICA	-	3	10	4	48	36	14	1	10	4	128	
LANNEA BARTERI	-					1					1	
TERMINALIA AVICENNIOIDES	-				1						1	
ANNONA SENEGALENSIS	-		2								2	
BALANITES AEGYPTIACA	-		2								2	
BAUHINIA THONNINGII	-	3	3	1	2	1	1				11	
ZIZIPHUS MAURITIANA.	-			3							3	
" " MUCRONATA.	-	11	4								15.	
UNKNOWN												
N I L.												
TOTAL		47	54	76	56	46	30	14	29	48	345	
TOTAL UNKNOWN												
GRAND TOTAL												

RIVER-BANK ORCHARD WOODLAND SAVANNA NORTHERN KATSINA.

100% ENUMERATION. CLASSIFIED SPECIES RUMA FOREST RESERVE.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
LANNEA ACIDA.				2		1					3	
ANOGEISSUS SCHIMPERI		3	7	7	2	2					21	1
LANNEA BARTERI.	2		1		1						4	
ACACIA SEYAL	6	5	1								12	ACRE.
TAMARINDUS INDICA			1								1	
DIOSPYROS MESPILIFORMIS	1	1									2	
HYPHAENE THEBAICA					1	1					2	
HYPHAENE coppice.	2										2	
ACACIA SENEGAL.	1										1	
GUIERA SENEGALENSIS	15										15	
COMBRETUM VERTICILLATUM	10										10	
XIMENIA AMERICANA.	15	6									21	
AMPELOCISSUS GRANTI.	3										3	
CROSSOPTERYX FEBRIFUGA.	2	1	1	1							5	
COMMIPHORA AFRICANA.	5	10	7	1	-	1					24	
FERETIA CANTHIOIDES	8										8	
BAUHINIA THONNINGII		1									1	
DICHROSTACHYS GLOMERATA.	3										3	
CAPPARIS TOMENTOSA.	8										8	
CASSIA SINGUEANA.	3	2									5	
SCLEROCARYA BIRREA.				1	4						5	
MAERUA CRASSIFOLIA	5										5	
BALANITES AEGYPTICA.				1							1	
BOSCIA SALICIFOLIA	1										1	
SECURIDACA		1									1	
LONGIPEDUNCULATA	x											
COMBRETUM ELLOTII	1	1	1								3	
BOSWELLIA DALZIELI		2	7	3	2	1					15	
ZIZIPHUS MAURITIANA	3	2									5	
GYMNOSPORIA SENEGALENSIS	1	1									2	
ANNONA SENEGALENSIS.	1										1	
RANDIA NILOTICA.	2	3									5	
OWN												
AL	98	39	26	16	10	6					195.	
AL UNKNOWN												
ND TOTAL												

DRY ORCHARD WOODLAND SAVANNA. NORTHERN KATSINA.

100% ENUMERATION. CLASSIFIED SPECIES RUMA FOREST RESERVE.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
LANNEA BARTERI							1				1	1
DIOSPYROS MESPILIFORMIS			3	1	2	1	1				8	
BOMBAX BUONOPOZENSE	2										2	ACRE
ANOGEISSUS SCHIMPERI	1			1				1			3	
BUTYROSPERMUM PARKII		1	3			1					5	
ACACIA SEYAL	4										4	
STERCULIA SETIGERA	1	1							1	1	4	
LANNEA ACIDA		1									1	
ACACIA SIEBERIANA				3			1			1	5	
FICUS PLATYPHYLLA.	1										1	
HYPHAENE THEBAICA	3										3	
ACACIA SENEGAL	1										1	
ENTADA SUDANICA.			1								1	
BAUHINIA THONNINGII	1	10	3								14	
SCLEROCARYA BIRREA			1	3	4						8	
COMBRETUM VERTICILLATUM	18	3	1		1						23	
" " " HYPOPILINUM	2	1									3	
GUIERA SENEGALENSIS	15										15	
RANDIA NILOTICA	1	1	2								4	
CASSIA SINGUEANA.	4										4	
BOSWELLIA DALZIELI					1	1					2	
STEREOSPERMUM KUNTHIANUM.	2										2	
FLUEGGEA MICROCARPA	1	-	0	-							1	
BALANITES AEGYPTICA.	[illegible]	1									2	
PSOROSPERMUM GUINEENSE	0	0	1								1	
AMPELOCISSUS GRANTII	8	[illegible]	0	-							8	
COMMIPHORA AFRICANA	5	1									6	
XIMENIA AMERICANA.	1	8	1								10	
GARDENIA ERUBESCENS.	3										3	
KNOWN												
TAL	75	28	16	8	8	3	3	1	1	2	145.	
TAL UNKNOWN												
AND TOTAL												

FOREST RESERVE No 9.

% ENUMERATION.

HYPHAENE THEBAICA PALM STAND.

KATSINA PROVINCE.

CLASSIFIED SPECIES

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
HYPHAENE THEBAICA	-	28	7	5	4	3	4	3	4	1	59	2
ACACIA ARABICA		1								1	2	ACRES.
PROSOPIS AFRICANA.										2	2	
BAUHINIA THONNINGII	65	54	28	9	5	4	3				168	
GUIERA SENEGALENSIS	48	36	22	2							108	
ANNONA SENEGALENSIS	49	22	5								76	
ZIZIPHUS MAURITIANA	2	1	1	1							5	
CASSIA SINGUEANA	4										4	
ACACIA SEYAL	-										-	
SCLEROCARYA BIRREA	1	1	1								3	
BAUHINIA RUFESCENS.	0	1			1						2	
UNKNOWN												
NIL												
TOTAL.												
TOTAL UNKNOWN. NIL												
GRAND TOTAL.	169	144	64	17	10	7	7	3	4	4	429.	

BORASSUS AETHIOPUM PALM STAND. NORTHERN KATSINA

100% ENUMERATION. CLASSIFIED SPECIES JIBIYA FOREST RESERVE.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
BORASSUS AETHIOPUM						4	16	20	6	2	48	1
HYPHAENE THEBAICA	8	2			6	2					15	ACRE.
CASSIA SIEBERIANA	43	38	2								82	
ANOGEISSUS SCHIMPERI	12			3		4	2				21	
FICUS GNAPHALOCARPA	2	1								1	4	
ACACIA SIEBERIANA	4				2		4				10	
ANNONA SENEGALENSIS	5										5	
BAUHINIA THONNINGII	6	1	1								8	
DIOSPYROS MESPILIFORMIS	15	5				2					22	
FLUGGEA VIROSA	21	2									23	
ACACIA ALBIDA						1					1	
TERMINALIA AVICENNIOIDES.	62	17	2			1	1				83	
ACACIA CAMPYLACANTHA	4	10				5	3				22	
CASSIA SINGUEANA ~~TERMINALIA~~	6										6	
ZIZIPHUS MUCRONATA	4	2									6	
ACACIA ATAXACANTHA	3	2									5	
~~PROSOPIS OBLONGA.~~	-											
MIMOSA PIGRA	18.										18.	
NOWN												
AL	209	80	5	3	8	19	26	20	6	3	379.	
AL UNKNOWN												
ND TOTAL												

INSELBERG VEGETATION - KATSINA.

00% ENUMERATION.

CLASSIFIED SPECIES

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
ACACIA ATAXACANTHA	8										8	
ADANSONIA DIGITATA										2	2	3
ANOGEISSUS SCHIMPERI				1			1	1	3	2	8	
BAUHINIA THONNINGII	1	1									2	ACRES.
BOMBAX BUONOPOZENSE						1					1	
BOSCIA ANGUSTIFOLIA	2										2	
" SALICIFOLIA		2			1						3	
CASSIA SINGUEANA.	8	2									10	
COMBRETUM MICRANTHUM.	6	2									8	
COMMIPHORA AFRICANA.	4			1							5	
CROSSOPTERYX FEBRIFUGA	2	3	4	1	1						11	
FERETIA CANTHIOIDES.	2										2	
FICUS VALLIS-CHOUDAE	6	2	2	4	2	2			3		21	
GUIERA SENEGALENSIS	1										1	
HYPHAENE THEBAICA	1										1	
LANNEA BARTERI		1				1			1	2	5	
MAERUA ANGOLENSIS	1										1	
SCLEROCARYA BIRREA				1							1	
STERCULIA SETIGERA	1	1									2	
STEREOSPERMUM KUNTHIANUM.	1										1	
NOWN												
NIL												
TAL	44	14	6	8	4	5	1	-	7	6	95.	
TAL UNKNOWN NIL												
AND TOTAL	44	14	6	8	4	5	1	-	7	6	95	

HILL - SCRUB. KATSINA PROVINCE

100% ENUMERATION. CLASSIFIED SPECIES DAURA EMIRATE.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
COMBRETUM MICRANTHUM	70	10	1								81	
ACACIA MACROSTACHYA	31	6	2								39	1
KANDARANTSI.	18	8	2	1							29	
COMBRETUM VERTICILLATUM	20	1	1								22	ACRE.
GUIERA SENEGALENSIS	21										21	
CASSIA SINGUEANA	19										19	
ACACIA ATAXACANTHA.	13	1									14	
ACACIA SEYAL	14										14	
LANNEA BARTERI.	4	5	2	1	2						14	
BOSCIA SALICIFOLIA	11	1	2								14	
BAUHINIA THONNINGII	8										8	
LANNEA ACIDA	3	2	3								8	
GREWIA MOLLIS	7										7	
MARKE	6	1									7	
PROSOPIS AFRICANA	3			1	2						6	
ANNONA SENEGALENSIS	4										4	
BOSCIA ANGUSTIFOLIA	4										4	
FERETIA CANTHIOIDES	4										4	
BOSWELLIA DALZIELI		3									3	
ACACIA ALBIDA	1		1								2	
ACACIA SENEGAL.	1	1									2	
DICHROSTACHYS GLOMERATA.	2										2	
FLUGGEA VIROSA	2										2	
TSABAGI	1										1	
ALBIZZIA CHEVALIERI	1										1	
TEPHROSIA BRACTEOLATA.	1										1	
ZIZIPHUS MAURITIANA.	1										1.	
NOWN												
TAL	270	39	14	3	4						330.	
TAL UNKNOWN												
AND TOTAL												

COMBRETACEOUS SCRUB. KATSINA PROVINCE.

100% ENUMERATION CLASSIFIED SPECIES KATSINA GOVERNMENT STATION.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
COMBRETUM MICRANTHUM	311										311	1
BAUHINIA THONNINGII	123										123	
GUIERA SENEGALENSIS	98										98	ACRE.
DICHROSTACHYS GLOMERATA	88										88	
CASSIA AREREH	59										59	
ANNONA SENEGALENSIS	47										47	
ACACIA MACROSTACHYA	38										38	
CASSIA SINGUEANA	38										38	
XIMENIA AMERICANA	26										26	
ACACIA ATAXACANTHA	8										8	
CASSIA SIEBERIANA	7										7	
SECURIDACA	6										6	
LONGIPEDUNCULATA	8											
ZIZIPHUS MAURITIANA	5										5	
GREWIA MOLLIS	2										2	
HEXERIA INSIGNIS	2										2	
SCLEROCARYA BIRREA	2										2	
STEREOSPERMUM KUNTHIANUM	2										2	
ALBIZZIA CHEVALIERI	1										1	
BOMBAX BUONOPOZENSE	1										1	
COMMIPHORA AFRICANA	1										1	
PARKIA OLIVERI.	1										1	
VITEX CUNEATA.	1										1.	
UNKNOWN												
TOTAL	867										867.	
TOTAL UNKNOWN												
GRAND TOTAL												

LATERITIC BAD LANDS — KANO PROVINCE

100% ENUMERATIONS. CLASSIFIED SPECIES — KANO DISTRICT.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
Acacia albida	3										3	1
Balanites aegyptica	2										2	ACRE.
~~Acacia arabica~~	2	4									6	
Cassia occidentalis	1										1	
Cassia singueana.	7										7	
Leptadenia lancifolia	2										2	
Dicrostachys glomerata	1										1	
~~Cassia obovata~~	1										1	
Bauhinia thonningii	3										3	
Diospyros mespiliformis	1										1	
Gardenia ternifolia	1										1	
Ziziphus spina-christi	2										2	
Ziziphus mauritiana.	1										1	
Cassia tora.	5										5.	
UNKNOWN												
TOTAL	31	4									35.	
TOTAL UNKNOWN												
GRAND TOTAL												

RIPARIAN THORNLAND. SOUTHERN NIGER COLONY

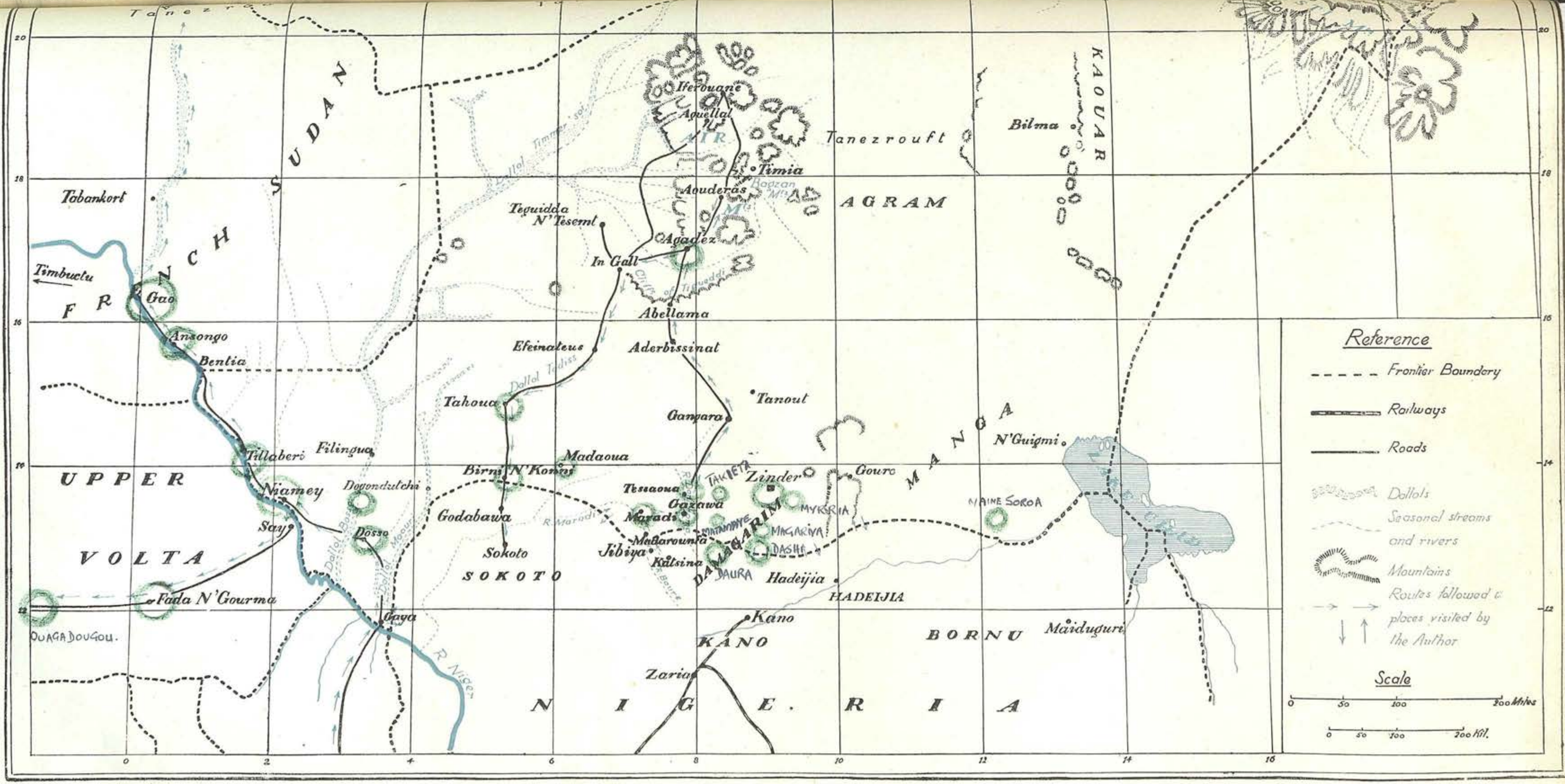
100% ENUMERATION. CLASSIFIED SPECIES TESSAWA DISTRICT.

SPECIES	CLASSES in 2" in Diameter 0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18 plus	Totals	Calculated area of unit
ACACIA ARABICA	2										2	1
ACACIA LAETA		9	17	9	1						36	ACRE.
ACACIA SEYAL				4	1						5	
BALANITES AEGYPTIACA	3	2	5	1	5		1				17	
BAUHINIA RUFESCENS			6								6	
COMMIPHORA AFRICANA	1										1	
HYPHAENE THEBAICA				1			4				5	
LEPTADENIA LANCIFOLIA.	3										3	
NOWN												
AL	9	11	28	15	7	-	5				75.	
AL UNKNOWN												
ND TOTAL												

THE IDENDIFICATION & EXAMINATION

OF

FOREST TYPES FROM AERIAL PHOTOGRAPHS.



MAP ILLUSTRATING AREAS OVER WHICH AERIAL PHOTOGRAPHS WERE TAKEN.

Zinder from the south showing the inselberg formations. The trees consist of Acacia albida and Ziziphus spina-christi.

The government station of Maradi, with the area of thorn-woodland consisting of almost pure Acacia arabica in the moist valley below the escarpment on which the station stands. Gully erosion on this escarpment is seen clearly.

THE IDENTIFICATION AND EXAMINATION OF FOREST TYPES FROM AERIAL PHOTOGRAPHS.

The series of aerial photographs which illustrates the forest types, the general vegetation and land utilization in the Central Western Sudan in the thesis, is the first to have been taken in Northern Nigeria and in French Niger Colony. The photographs were taken under service conditions and the most up-to-date methods of aerial photography were employed. The writer was engaged in the interpretation of these aerial photographs during a period of military service and was fortunate enough to secure this series.

The photographs were taken under perfect conditions for photography, and cover nearly all the types of vegetation of that part of the Western Sudan which is described in the thesis. The writer examined a portion of the area from the air and also travelled by air over large areas of similar country in Nigeria and throughout French West Africa from Nigeria westwards to the Gambia in April of 1944.

The use of aerial photography has progressed immeasurably since the War years of 1914-1918, when a certain amount of aerial photography was carried out. The value of aerial surveys and of aerial photography was early appreciated but real progress was retarded by the initial expense involved and by the lack of improvement being made in the technique of aerial photography. It was, however, used in India, South Africa and America in the twenties /

VEGETATIONAL CLASSIFICATION.

A. Edaphic Moist Woodland.

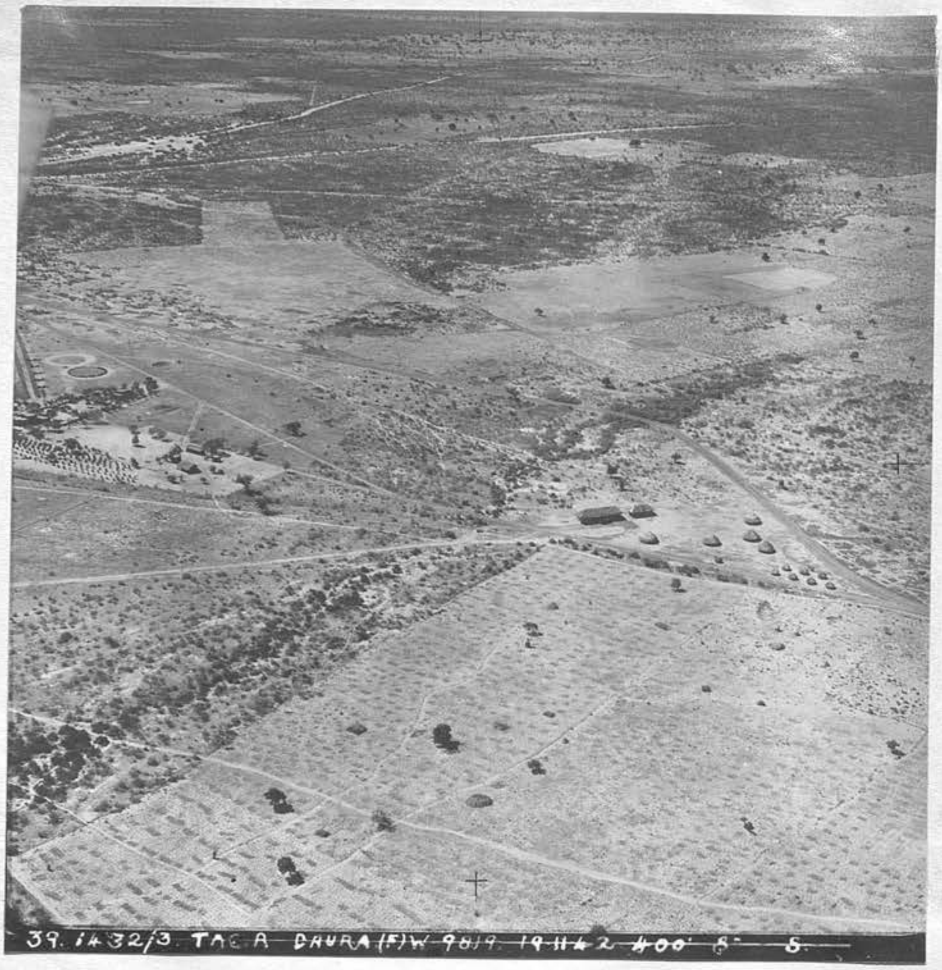
Formation-Type I.	Tropical Riparian Woodland.
Formation 1.	West African Riparian Woodland.
Sub-formation 1a.	Bamboo Brakes.
Sub-formation 1b.	Dallol Vegetation.
Formation 2.	West African Riparian Thornland.
Formation-Type II.	Tropical Swamp Woodland.
Formation 3.	West African Swamp Woodland.
Formation 4.	West African Swamp Thornland.

B. Climatic Dry Woodland.

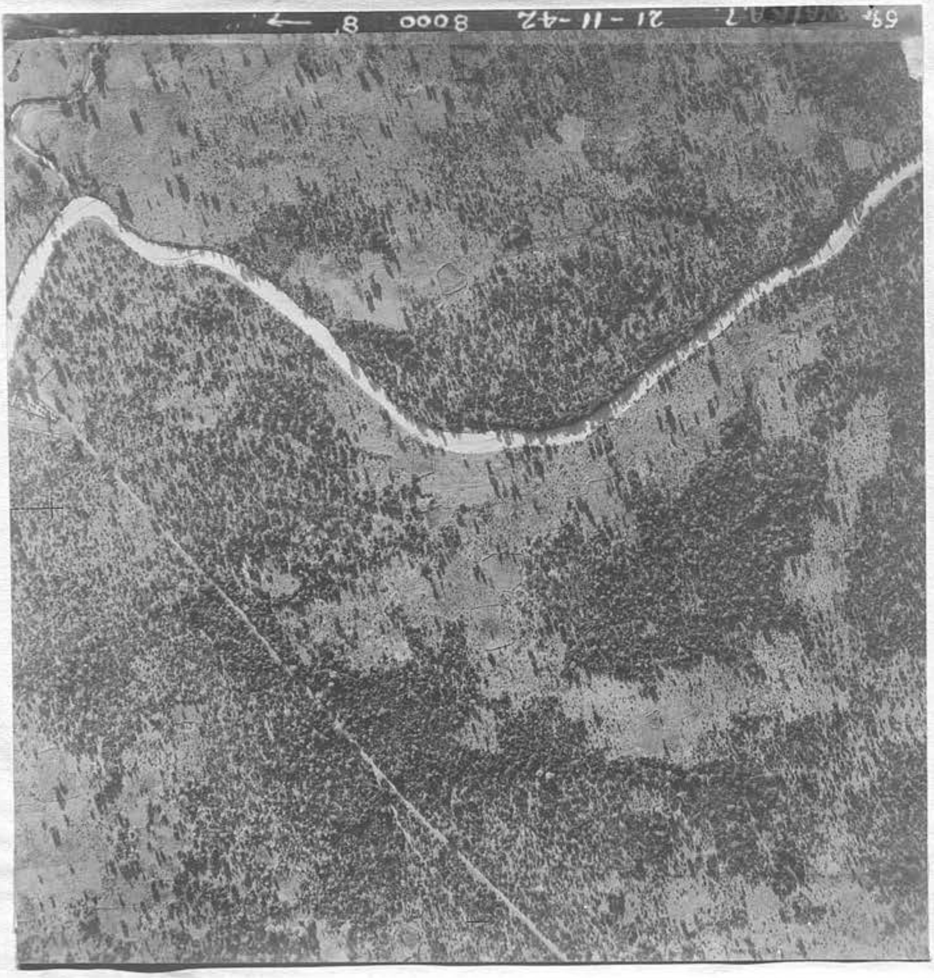
Formation-Type III.	Tropical Savanna Woodland.
Formation 5.	West African Woodland Savanna.
Sub-formation 5a.	Inselberg Vegetation.
Sub-formation 5b.	Hill-Scrub Savanna.
Sub-formation 5c.	Combretaceous Scrub.
Formation 6.	West African Orchard Woodland Savanna.
Formation 7.	West African Dry Palm Stands.
Formation-Type IV.	Tropical Thornland.
Formation 8.	West African Thorn Woodland.
Formation 9.	West African Thorn Savanna.
Formation 10.	West African Thorn Scrub.
Formation-Type V.	Tropical Grassland.
Formation 11.	West African Savanna.
Formation 12.	West African Grass Steppe.
Formation 13.	West African Marsh Grassland.

C. Desert.

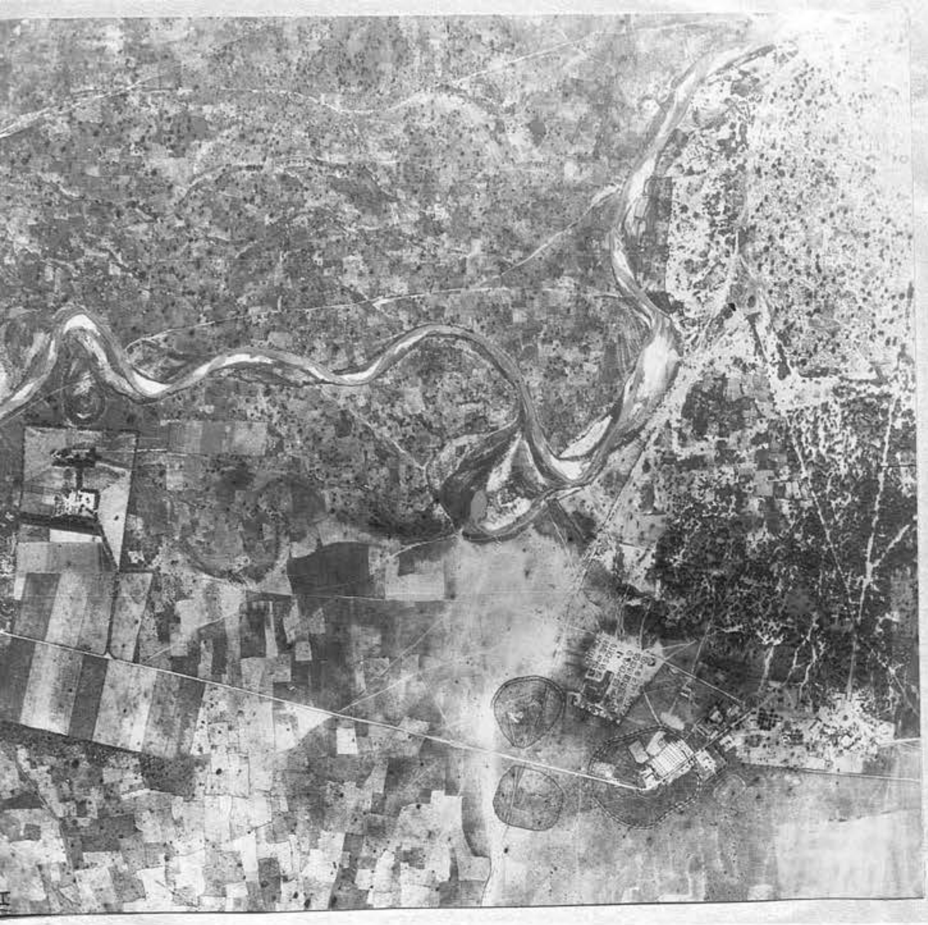
Formation-Type VI.	Tropical Desert.
Formation 14.	West African Semi-Desert.
Sub-formation 14a.	West African Desert Palm-Stands.
Formation 15.	West African True Desert.



Consociation of Combretum micranthum round Daura. The farm in the foreground is made in this scrub because of the land hunger in this area.



The River Maradi near Madarunfa bridge. The vegetation consists of fairly dense savanna-woodland with a number of thorn species. Part of the woodland, which has been more extensive in the past, has been cleared for farming.



Maradi from 12,000 feet, showing the Government station, the town, the course of the river and the Acacia woodland. The dark-toned areas of fallow-land are clearly seen.

Zinder from about 14,000 feet. The native town covers the top right hand quarter of the photograph. The dark toned area in the vicinity of the aerodrome consists of Acacia scrub and grassland. The hill Dutsin Bidawa is on the lower part of the picture. Inselberg can be seen on the right. The areas of farm and fallow-land can be seen. The black dots on the bottom right hand corner represent Acacia savanna.

twenties but it was not until after 1930 that sufficient progress had been made in light-reconnaissance aircraft and in the construction of cameras to make aerial photography a commercial proposition.

It has now been demonstrated that specialized forest aerial surveys can be made at less cost, which attain the same results as a survey on the ground, although preliminary reconnaissance work in the field is obviously necessary.

Immediately prior to 1939 the use of aerial surveys in Nigeria was seriously considered by the Nigerian Government; the writer studied some aerial surveys while the matter was under consideration and examined a large number of aerial photographs in relation to forestry and general land-use.

Estimates in Nigeria regarding the cost of enumeration surveys on the ground showed that while ground surveys cost a few shillings over £5 per square mile, the aerial surveys, taken at approximately 6,000 feet cost £5 per square mile. The one per cent enumeration surveys were made by enumerating traces one chain wide, through the forest at intervals of one hundred chains and recording all the information available on these line transects. This included an enumeration and girth measurement of the tree species, examination of the ground flora, the soil, topography in general and any other information available. The method proved interesting and gave valuable results, but information nevertheless, which was quite incomplete. Compared with aerial photography which can indicate the conditions (though with obvious limitations), over the whole area, the balance is greatly in favour of aerial survey.

The /

The benefit which forestry can derive from aerial photographs has been described at length in America (where it had already reached a very high standard prior to 1939), and in our own scientific papers. The Oxford Forestry Memoir (1) by Mr. R. Bourne on aerial surveys in relation to forestry is of interest.

It is obvious that a very great deal of information can be obtained by the examination of forests and land in general from the air, especially over areas where, for reasons of the density of the vegetation or the flatness of the terrain, ground examination is rendered difficult. All aerial photography and survey, however, must be supported by reconnaissance on the ground, and interpretation of the aerial photographs must be made by persons who know the area and its vegetation well, and who have, in addition, studied the region from the air.

The writer travelled by air over some 2,000 miles throughout northern Nigeria and French West Africa, and has examined a number of the areas on the ground. In December of 1943 and in January of 1944 special visits were made to southern Niger Colony to take ground photographs of some of the most interesting points photographed from the air, and both types of photographs have been incorporated in this paper for the purpose of comparison. Knowing the area and having examined part of it from the air he was able to identify the forest formations, subformations and, in some cases, the associations on the ground and also to study their area and distribution.

The /

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(1) Aerial Survey in Relation to the Economic Development of New Countries, with Special Reference to an Investigation carried out in Northern Rhodesia. R. Bourne, 1928. Oxford Forestry Memoir No. 9.

Thorn-woodland with occasional farm clearings on the road from Madarunfa to Maradi. Drainage channels and areas of swamp with swamp-woodland can be seen below the road.

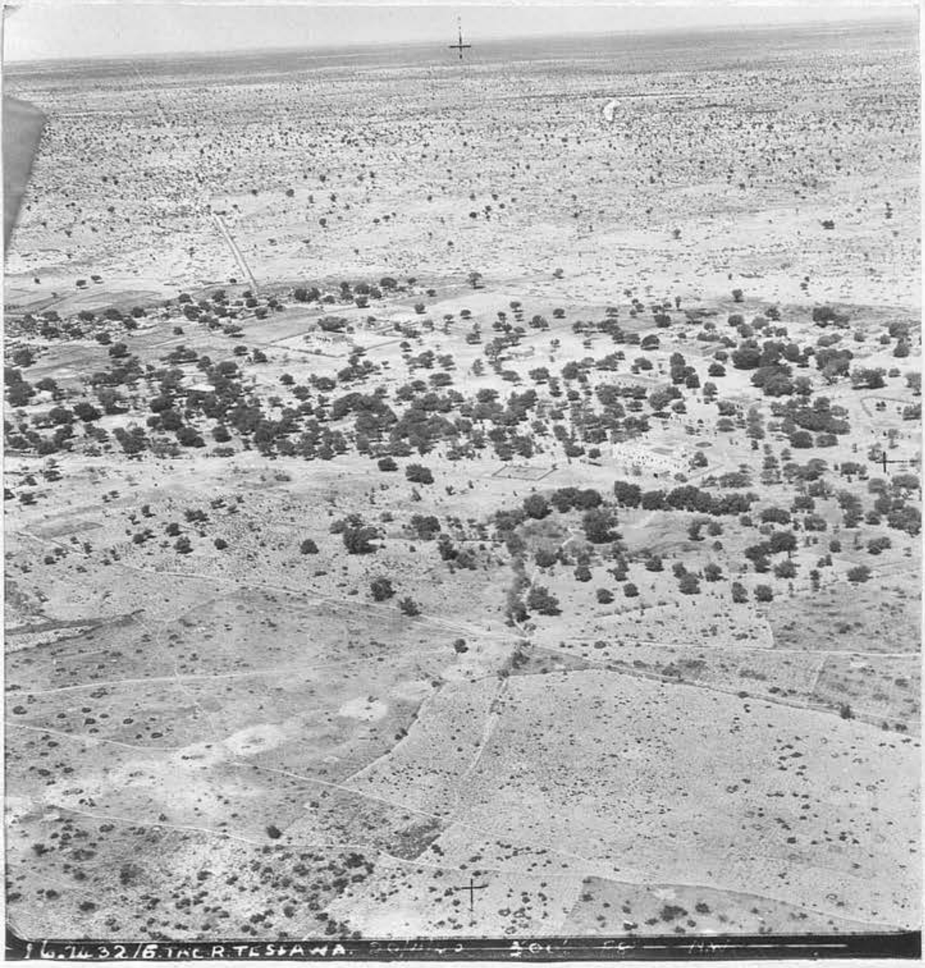
The village of Gazawa with an example of swamp-woodland in the depression above the village. Hyphaene can be observed in the swamp-woodland. The vegetation on the top left hand corner of the photograph consists of a consociation of Acacia seyal.

The identification of forest types and of types of land is not difficult in the area under review, largely because of the well defined forest types and because of the relative scarcity of the vegetation in the climatic dry woodland as opposed to the equatorial forest types of the edaphic moist woodland. In the case of some low vertical and some low-oblique aerial photographs the identification and even the distribution of individual species presents little difficulty. The aerial photographs taken from 4,000 to 12,000 feet indicate only the vegetation-:al types and the types of land. One important point is that the aerial photographs clearly indicate the true espacement of trees on any area as compared with ground photographs in which the tree canopies are seen to overlap and the vegetation appears to be much denser than it really is. This is well demonstrated by the aerial and ground photographs at Takieta.

Anyone who knows the area and the vegetation under examination can identify it from the air and can interpret the photographs. It is true however, that it will frequently be necessary for the photographs to be studied by someone who knows the region and the vegetation on the ground but who may not have seen it from the air. It then becomes necessary for the interpreter who has studied this region from the air to record his observations for the benefit of others; otherwise serious mistakes can, at times, be made.

Two types of aerial photographs are included in this paper, the low oblique, normally taken at a height from /

An example of a mosaic built up from a series of vertical photographs.
The river Maradi and the road from Maradi to Jibiya in Nigeria. The vegetation consists of riparian and savanna woodland.



Intensive farmland to the east of Tessawa. This should be compared with the vertical photograph from 12,000 feet. In the foreground the farm ridges of the previous season's crops can be seen with coppice of Guiera and Bauhinia already some size.

These photographs constitute a good stereoscopic pair of aerial photographs of the thorn-woodland at Maradi. Farmland can be seen in the vicinity of the river bend, beside the native town and to the right. The gully erosion on the escarpment is readily seen.

from near ground level to 600 feet, and the vertical photograph, taken from a few hundred feet to 14,000 feet, though in certain conditions they can be taken at an even greater height.

The low oblique photographs in this series were taken at about 400 feet. A camera is mounted in the side of the aeroplane and is operated by the pilot or observer as the machine flies at right angles to the subject to be photographed, if necessary, banking over the object.

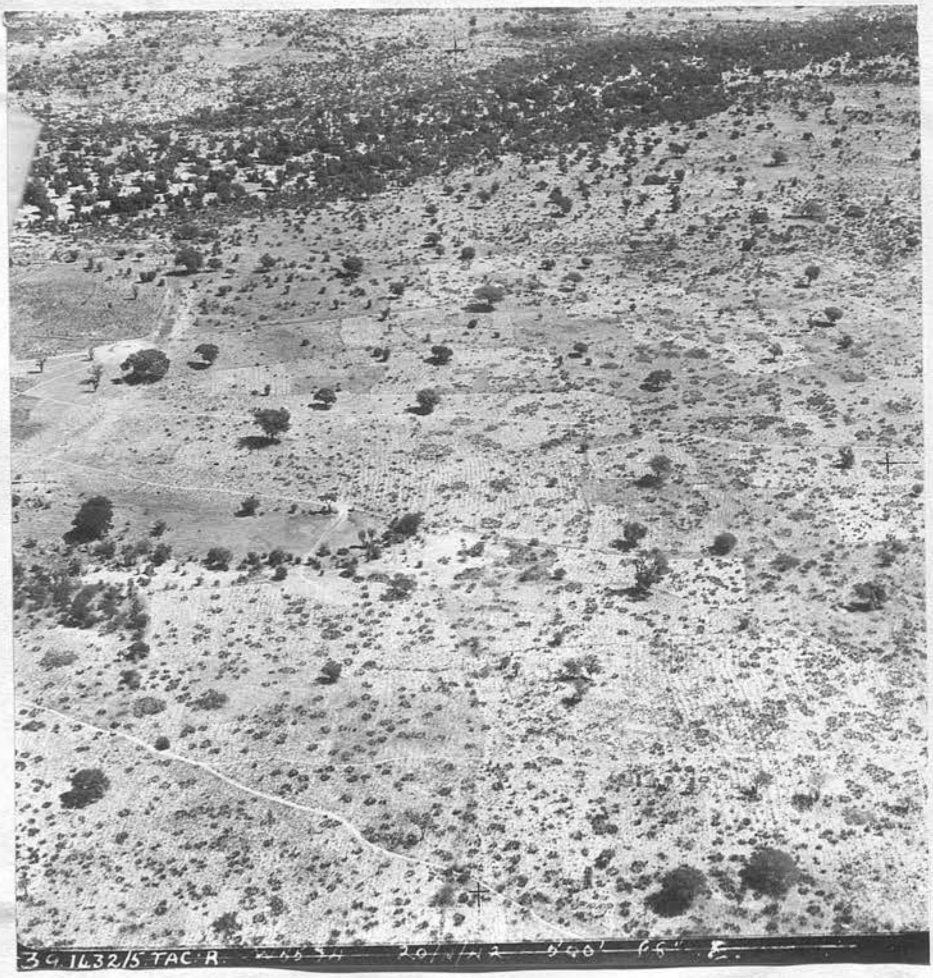
The vertical photographs are taken with a camera set in the floor of the aeroplane, and operated by the pilot or observer when he chooses or at regular time intervals when traversing a certain objective, such as a river or road.

The conditions for aerial photography in West Africa can be perfect at certain times of the year and good photographic weather can be guaranteed for long periods on end.

It will be noticed that a large number of the photographs have been taken in the early morning and in the evening and the long shadows assist in showing the ground relief in the resulting photographs.

A number of the photographs included in this paper can be used as stereoscopic pairs, but this is merely accidental, as they were taken sufficiently closely to form overlaps of parts of the pictures.

The best results in vertical aerial photographs are obtained from stereoscopic pairs taken with a special camera operated either by the pilot or observer or at regulated time intervals. Good shadows and perfect weather conditions are again essential to show the detail and relief on the ground. /



A belt of swamp-woodland at Gazawa. A mixture of Acacia savanna and Acacia scrub is seen in the distance.

The road from near Gangara to Tessawa showing farm and fallow-land. Areas of orchard-woodland-savanna can be seen in the distance.

Agades from approximately 12,000 feet, showing thorn-scrub consisting mostly of Acacia raddiana along the stream beds and smaller natural drainage channels. Thorn-savanna consisting of Acacia seyal and Acacia raddiana seen at the top of the photograph.

Gao and the River Niger from approximately 15,000 feet, showing the extreme aridity of the semi-desert area away from the river. Scattered thorn-scrub and grass is represented by the darker toned, irregular patches. Acacia scrub is seen in the top left hand corner of the photograph.

ground. The art of stereoscopic photographs has now reached a high standard and it has become possible even to estimate the heights of trees from good stereoscopic pairs.

Some of the pairs included in this paper very strikingly demonstrate river beds, sand banks, roads, tracks, ditches and the gully and accelerated soil erosion, as for instance, at Maradi.

It should be noted that the different surfaces on the ground are represented by differences of tone in the photographs. It will be seen also that water-logged areas, moist soil, moist sand, or green grass is shown as almost black in the photographs, and whilst the actual colour of the desert sand from the air is red-brown it appears in the photographs as light grey or nearly white.

It will be remembered that when examining aerial photographs they should be turned so that the shadows fall opposite to the direction of the source of light - this gives a better indication of the relief on the ground. The aerial photographs have been mounted throughout the thesis as if the source of light were from the top of each page. A magnifying glass is of great assistance in the examination of the photographs.

INTERPRETATION OF VEGETATIONAL TYPES.

There is no difficulty in recognising the three climatic divisions of edaphic moist woodland, climatic dry woodland and desert from the aerial photographs, all are distinctive in the area under review.

The vegetational classification is included at the beginning of this paper for easy reference.

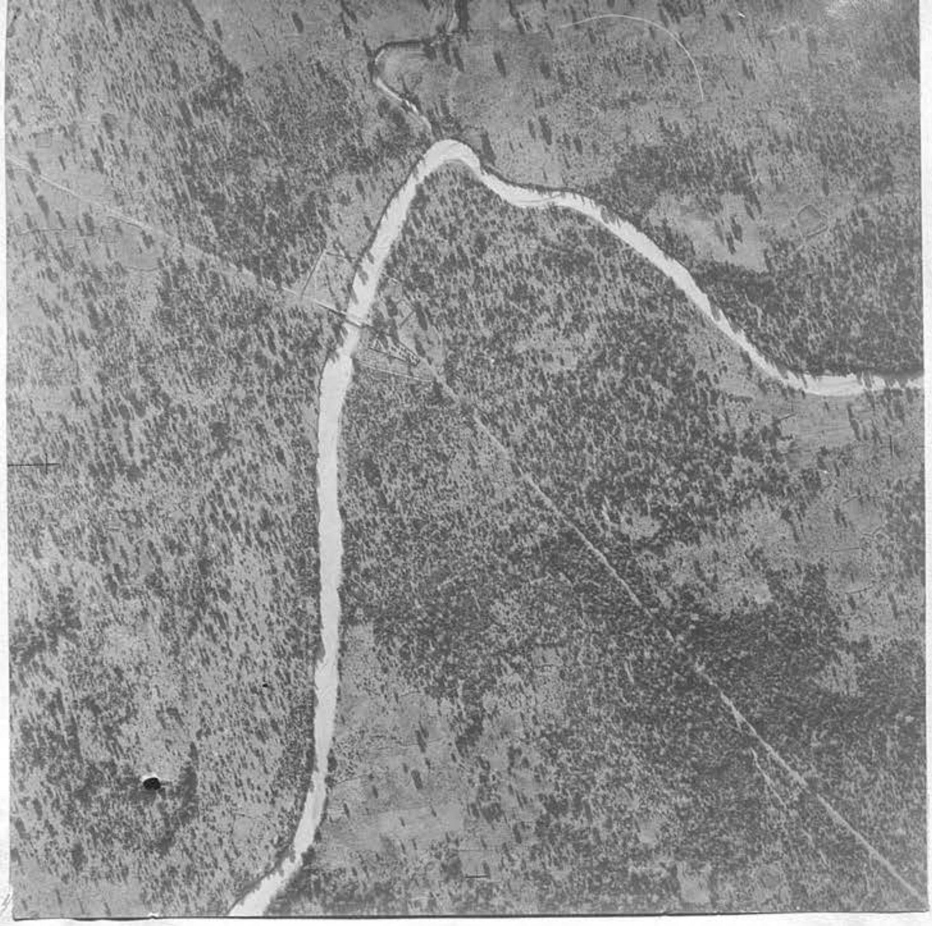
TROPICAL /

Farm and fallow-land at Gazawa, showing an excellent example of riparian woodland in the valley of the River Dankama which is seasonal. Individual Adansonia, Hyphaene and Tamarindu can be seen. The farm scrub consists of Bauhinia, Guiera and Ziziphus mauritiana.

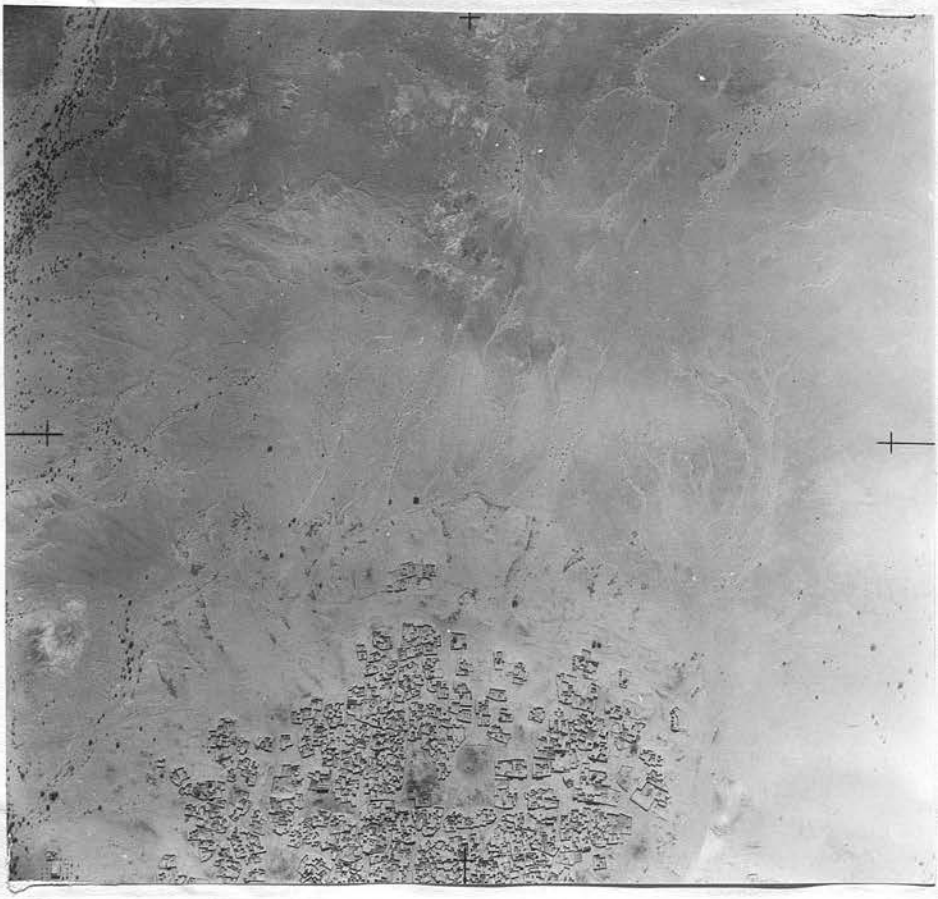
TROPICAL RIPARIAN AND TROPICAL SWAMP WOODLAND.

The formations under the formation-types Tropical Riparian Woodland and Tropical Swamp Woodland are readily distinguished since they occur on river banks and swamp areas in the climatic dry woodland. The riparian woodland is ribbon-like while the swamp woodland usually occurs in clumps and patches. A photograph of riparian woodland is included. It is less easy to distinguish between the formations riparian woodland and riparian thornland, for even in the latter the species do not consist entirely of thorn species; they can, however, usually be differentiated by their position in the zonal vegetation belts. The sub-formation of bamboo brakes can be distinguished by the lighter green foliage of the bamboo leaves in riparian woodland. The dallol vegetation sub-formation is recognised by the denser vegetation occurring in ribbon-like bands or, on occasion, in belts in wide valleys running through dry woodland.

Similarly under the formation-type tropical swamp-woodland, the formations Swamp Woodland and Swamp Thornland can best be distinguished by their position in the vegetation zones, except in the case of swamp thornland, (occurring beside perennial or nearly-perennial ponds or lakes), in the desert or semi-desert areas- where the dark tone of the damp soil and its swamp vegetation show in most striking fashion against the light colour of the sand.



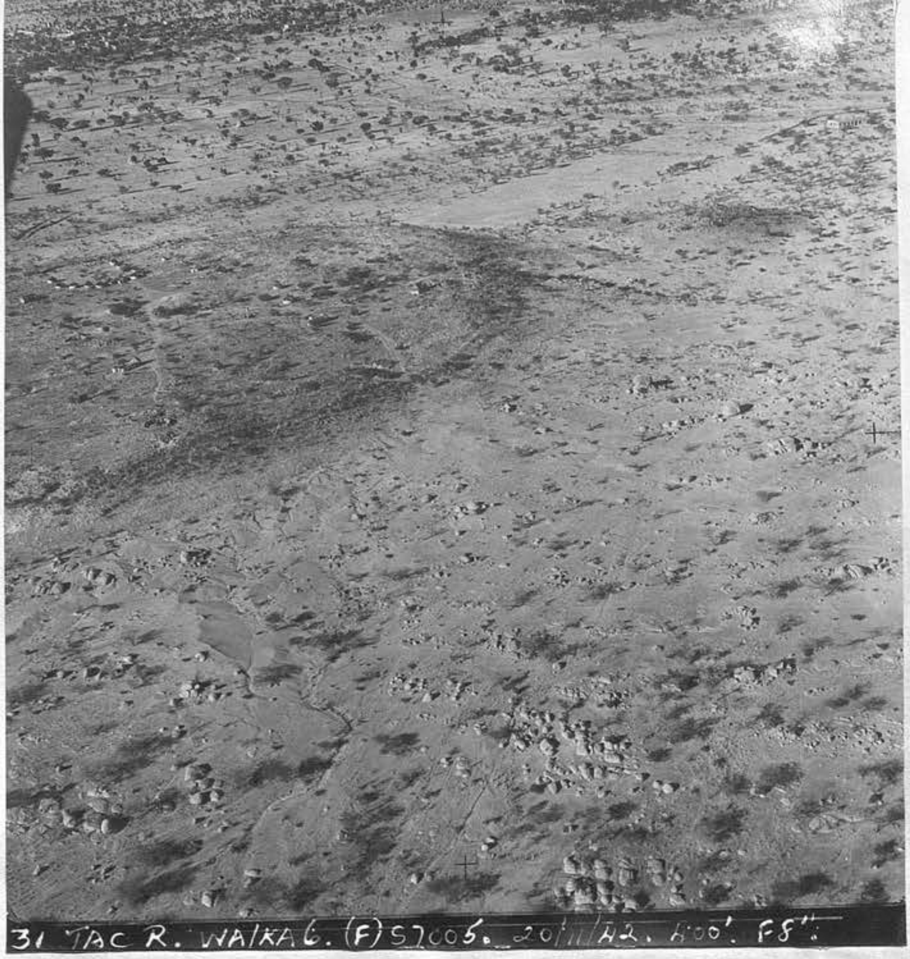
The Madarunfa Bridge. An area of savanna woodland with an almost closed canopy in places.



Agades from about 11,000 feet. The natural drainage channels can be seen above the town; riparian thornland consisting mostly of Acacia raddiana on the left.

Thornland-woodland in the vicinity of the River Maradi. Riparian woodland on tributary in centre of the photograph. Farm clearings are easily seen. The vegetation on the lower right hand corner consists of thorn-woodland consisting of Acacias, Balanites, Ziziphus and other non-thorny species. This should be compared with the ground photograph.

Combretaceous scrub at Daura, showing an unusual area of farmland in this type of scrub.



The hill Dutsin Bidawa and Zinder. Hill scrub remanants on the hill and scattered Acacia seyal can be seen in the foreground.

Zinder showing the protected Acacia albida on the farmland beyond the town. The fort can be seen on the inselberg in the centre of the photograph.

TROPICAL SAVANNA WOODLAND.

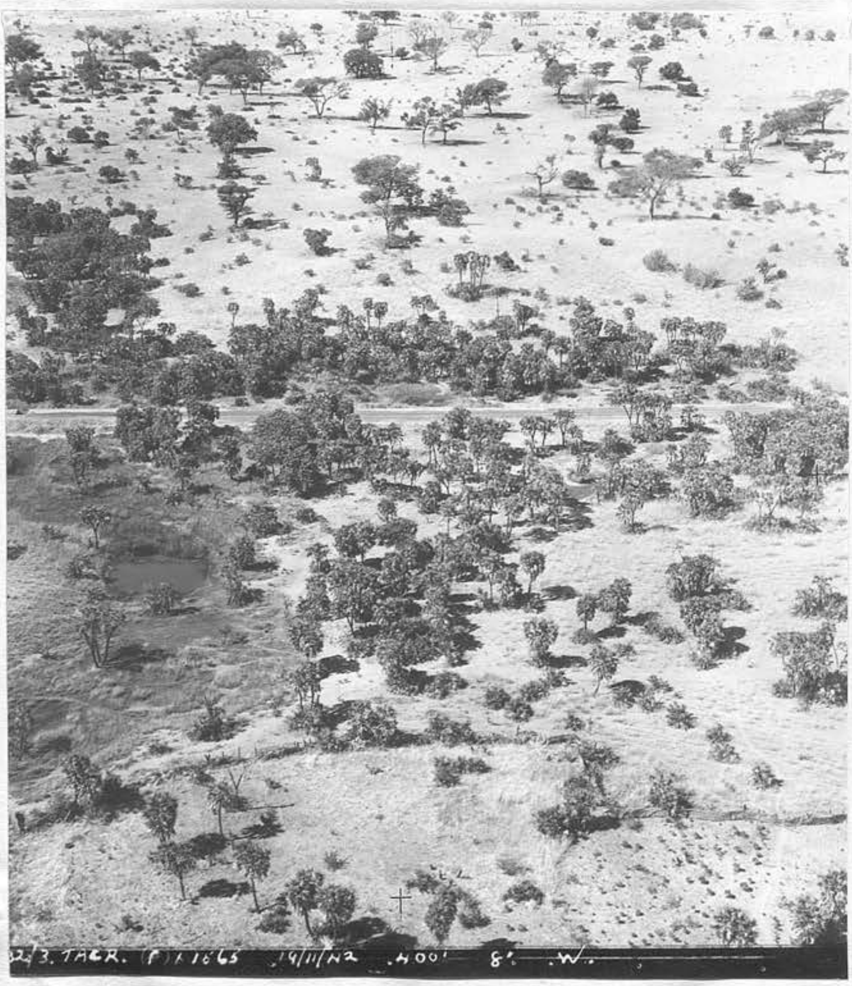
The formations under the formation-type Tropical Savanna Woodland are very readily distinguished from the air and from aerial photographs. The formation woodland savanna can be recognised by the scattered espacement of the trees and the intervening lighter tones of the grass and still lighter tones of exposed or semi-exposed soil. The crowns of the larger trees show up plainly especially if the photographs have been taken, (as they should be), in the early morning or late evening when the shadows are long and the relief is accentuated.

The formation orchard woodland savanna can be recognised by the wide espacement and the more scattered nature of the trees; it is difficult to distinguish the difference in tree height of this and the previous formation of woodland savanna except with perfect conditions of shadow by early morning or late evening photography and the use of stereoscopic pairs of photographs. They can, however, be distinguished rather from the tree espacement and the posi-:tion in the vegetational zones.

The sub-formations in the Woodland Savanna forma-:tion are, on the whole, very readily distinguished in low-oblique photographs and in vertical photographs up to two thousand feet; thereafter unless the stereoscope is used it is difficult to distinguish them especially with the unaided eye on photographs taken at over 10,000 feet - they can, however, be distinguished by a person who knows the vegetation and the area.

In the low-obliques inselberg, hill-scrub and combretaceous scrub are very obvious. In vertical photographs the inselbergs show up as rough, though restricted excrescences and /

Daura native town showing the landing ground, farm and fallow-land and the extensive areas of scrub consisting of a consociation of Combretum micranthum.



Palm stand of Hyphaene thebaica in an area with a high water table on the road from Daura to Zinder.

and they can be picked out with practise. The hill-scrub can be distinguished from the fact that it is on an eminence unlike that of the plain and that the tree and shrub vegetation appears to be more dense on the ground - this is due to the fact that the surrounding vegetation of the plain is largely cut and destroyed to obtain farming land.

Combretaceous scrub is recognised by its very dark tone and its continuity, its close espacement and the lack of clearings in it for farming. In low-oblique photographs it is very striking and in the verticals it can be readily recognised up to 10,000 feet, especially if the area is known.

The formation of dry palm stands is quite striking in aerial photographs. In low-oblique photographs the crowns of the palms are very easily recognised, in low verticals they are recognised by the dark patches, sometimes indicating even the double branch of the Dum palm, (Hyphaene thebaica) and their fairly close espacement. The Fan palm, (Borassus aethiopum) stands can be differentiated from the Dum palms by their much denser crowns and in a good palm-stand the crowns appear from the air to form a continuous plane of green -in aerial photographs they appear in a grey tone, lighter than that of the Dum palm, whose leaves are recorded in a very dark tone.

TROPICAL THORNLAND.

The formations in the formation-type Tropical Thornland can be distinguished readily from each other from the air.

The formation thorn-woodland is not easy, however, to identify as such unless the vegetation is known on the ground, as it might well be ordinary savanna-woodland without thorn species. Pure thorn-woodland is more easily recognised at lower altitudes as the tone of the tree crowns is somewhat lighter /

Part of a consociation of Acacia seyal south of Takieta. An area of seasonal flooding. This should be compared with the photograph showing the whole consociation.

lighter due to the sparser crowns and the less dense leaves. In mixed savanna woodland the thorn species can be distinguish-:ed from low altitudes, by their smaller and lighter-toned crowns. This is seen in the aerial and ground photographs of vegetation on the road from Jibiya to Maradi.

The formation thorn-savanna is more readily distinguished by the wider espacement of the thorn species. The crowns are small and feathery and their tone is fairly light. This can be seen from photographs taken at below 4,000 feet, but not from those at 10,000 to 14,000 feet. Thorn-savanna is recognised by its scattered appearance, the small size of the individual trees and the light toned, feathery, or even fluffy appearance of the individual crowns. This can still be seen at altitudes of about 4,000 feet, but is not discernible at over 10,000 feet, where the species appear as black specks.

Thorn scrub is the most easily recognised in the tropical thornland formation-type. It can be distinguished by the scattered nature of the vegetation and by the apparent lack of height in the individuals when viewed from less than 4,000 feet.

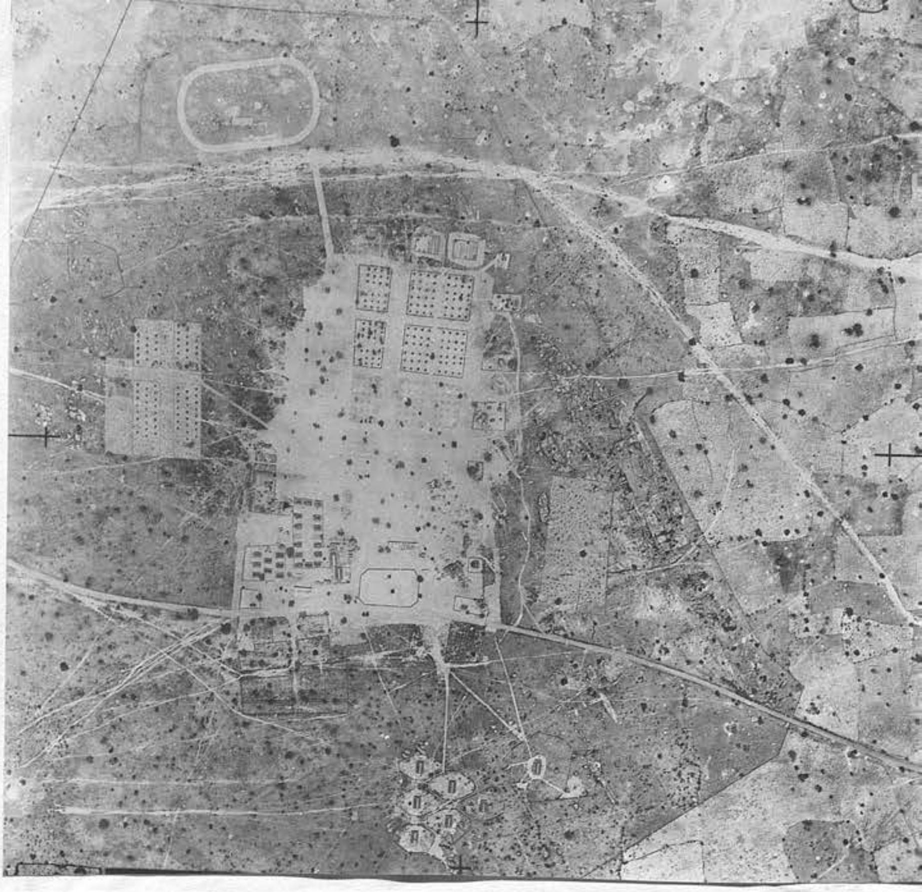
At 10,000 feet to 14,000 feet (as in the photograph of the area round Gao), the scrub is merely seen as a series of irregularly spaced dots, where it is found in depressions, on dry stream banks and in surface water channels.

TROPICAL GRASSLAND.

The formation-type Tropical Grassland is fairly readily distinguished from the air and the presence of water in the surface soil and the density of the grass are recognised by the very dark grey or almost black tones.

Savanna consisting of grassland with scattered

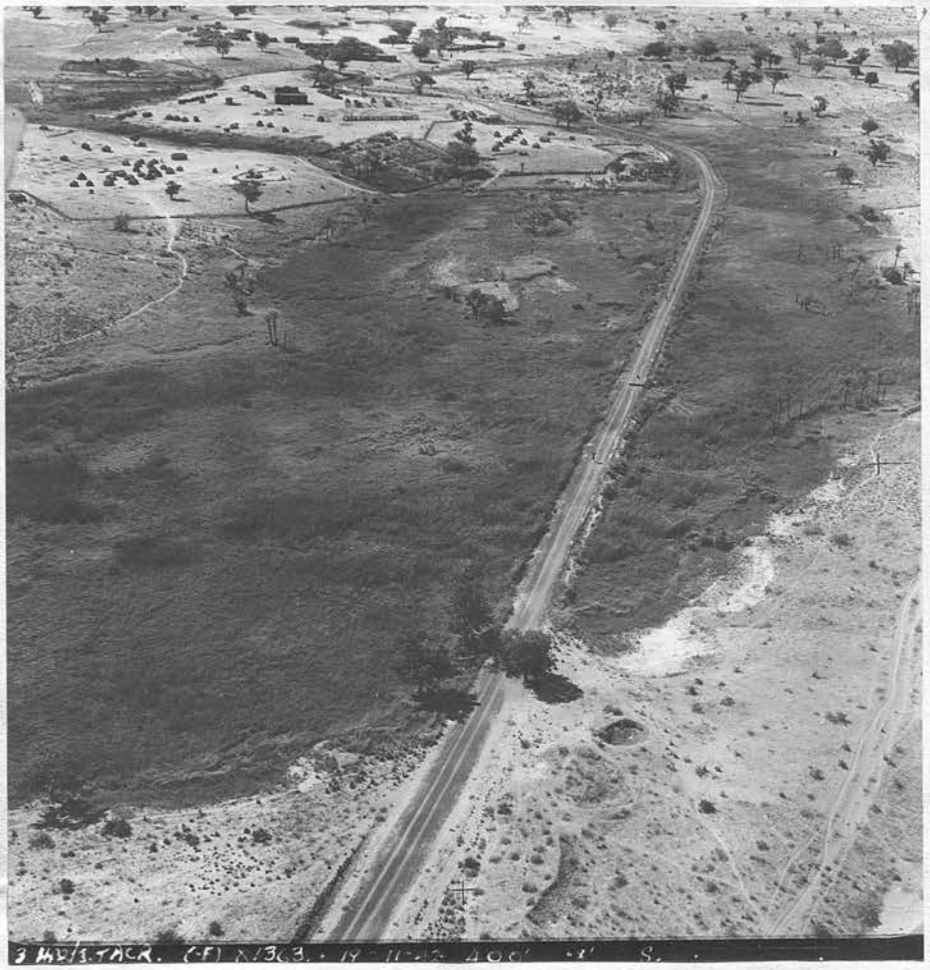
trees /



A former defensive position at Zinder showing the dark tone of the uncut grass as opposed to the light tone of the surrounding farmland.

The 'oasis' of Myrria, showing the area of swampland with a high water table and on which intensive irrigated cultivation is carried out. The area in the bottom left-hand corner consists of undulating sand dunes with only grass vegetation and very few trees. The ordinary farm and fallow-land can be seen at the top of the photograph, which should be compared with the ground photograph.

Farmland in the vicinity of Matamaye. Farm-
:land with Acacia albida in the foreground, and
Bauhinia and Guiera scrub in the foreground.



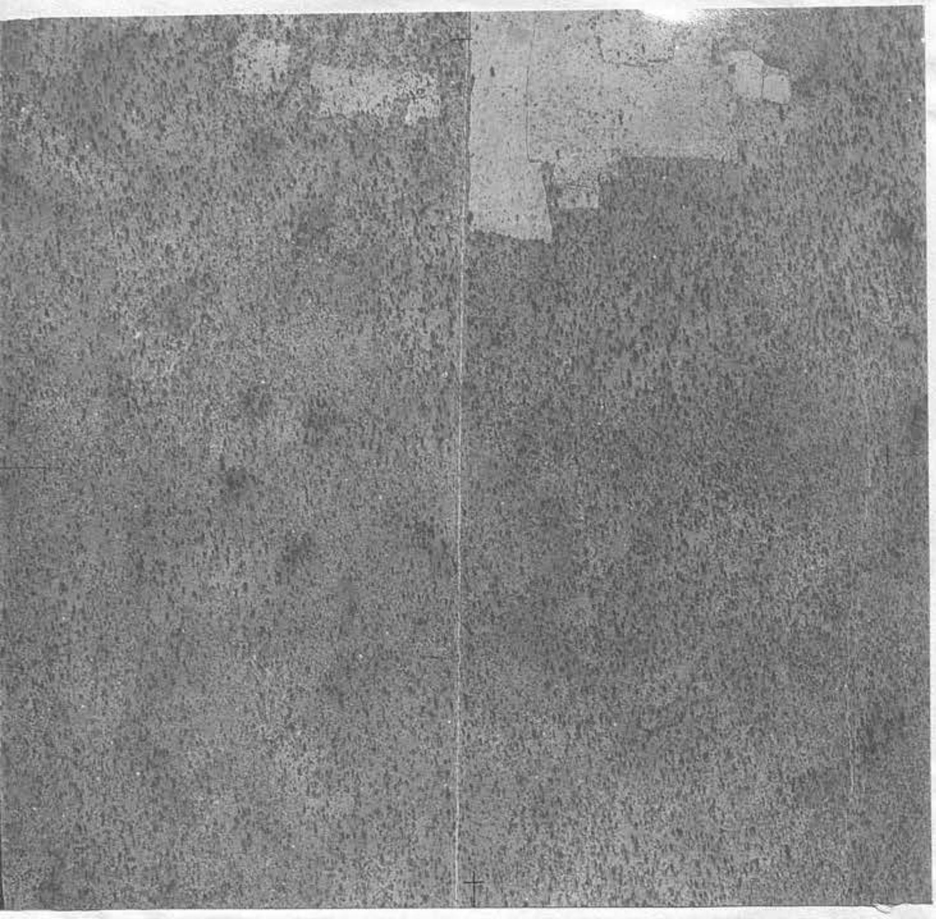
Marshland at Matamaye in the bed of a former river of Quaternary times. Farmland,(on the right) with a light sandy soil, trees is readily seen and is distinguished from bare farmland (with the scattered protective trees), by reason of the darker tone produced by the grass covering. This is perfectly demonstrated in an aerial photograph of one of the defensive positions near Zinder where the grass has been uncut and protected from grazing animals and therefore shows as a darker tone within the boundaries of the position.

The formation grass steppe is recognised by the very scattered nature of the isolated trees and the darker tone produced by the grass as described above. An excellent example of this is seen in the photograph of Myrria where in the bottom left hand corner the dark-toned grassland on the low undulating plains can be dis:tinguished from the light tone of exposed sand round the houses and barracks, especially in the top left-hand corner of the photograph.

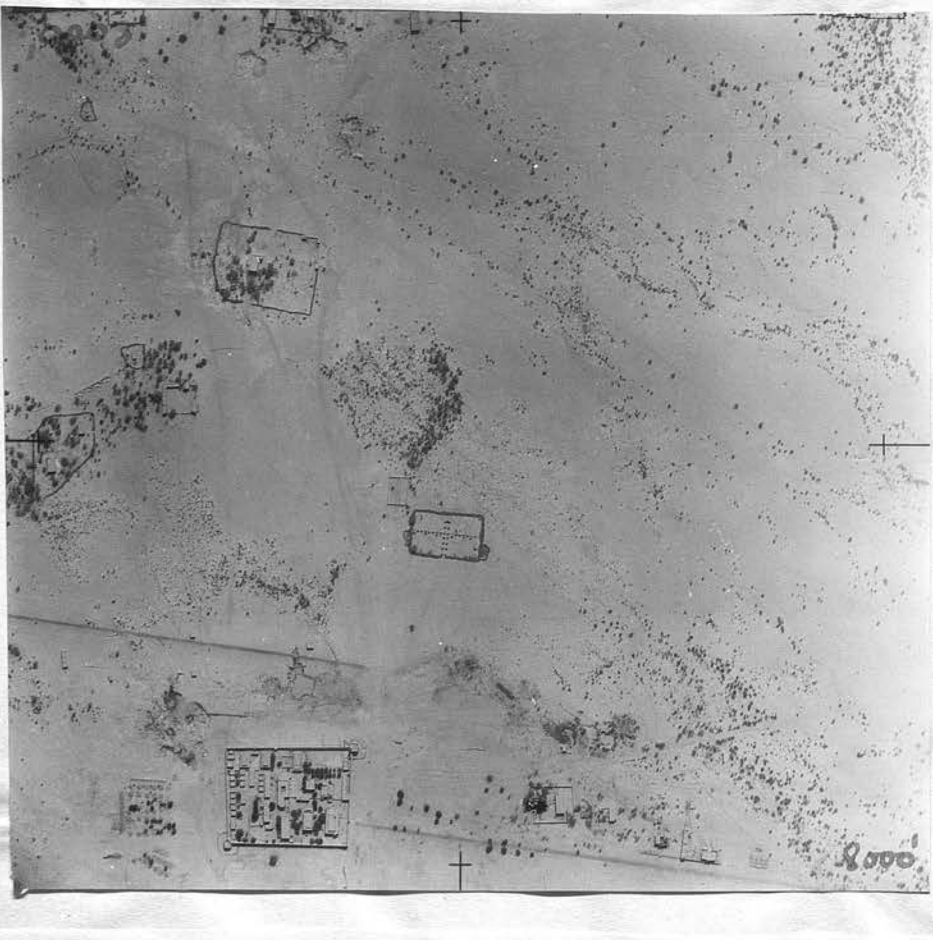
Marsh grassland can be identified immediately by the very dark even-surfaced tone, which appears almost as an artist's wash. This is well seen in the photograph of the Myrria area where in the top centre of the photograph grassland in the valley above the native town of Myrria is clearly shown. This demonstrates how essential it is for the photographs to be studied with a knowledge of the ground itself so that they can be correctly interpreted.

An example of Marsh grassland is shown in the low oblique photographs at Matamaye where the dark tone of the grass in the valley and in minor depressions, (where the soil is more moist), can easily be seen. In this photograph the individual areas of the grass Andropogon gayanus can be identified. The lighter tone of the grass on fallow-land and the white colour of the exposed soil on recent farmland is clearly demonstrated.

TROPICAL /



Thorn-woodland and occasional farmland on the road from Madarunfa to Maradi.



Agades fort from 8,000 feet. Semi-desert with patches of Acacia raddiana scrub.

TROPICAL DESERT.

Desert with its scattered vegetation or entire absence of vegetation is readily recognised from the air or from aerial photographs.

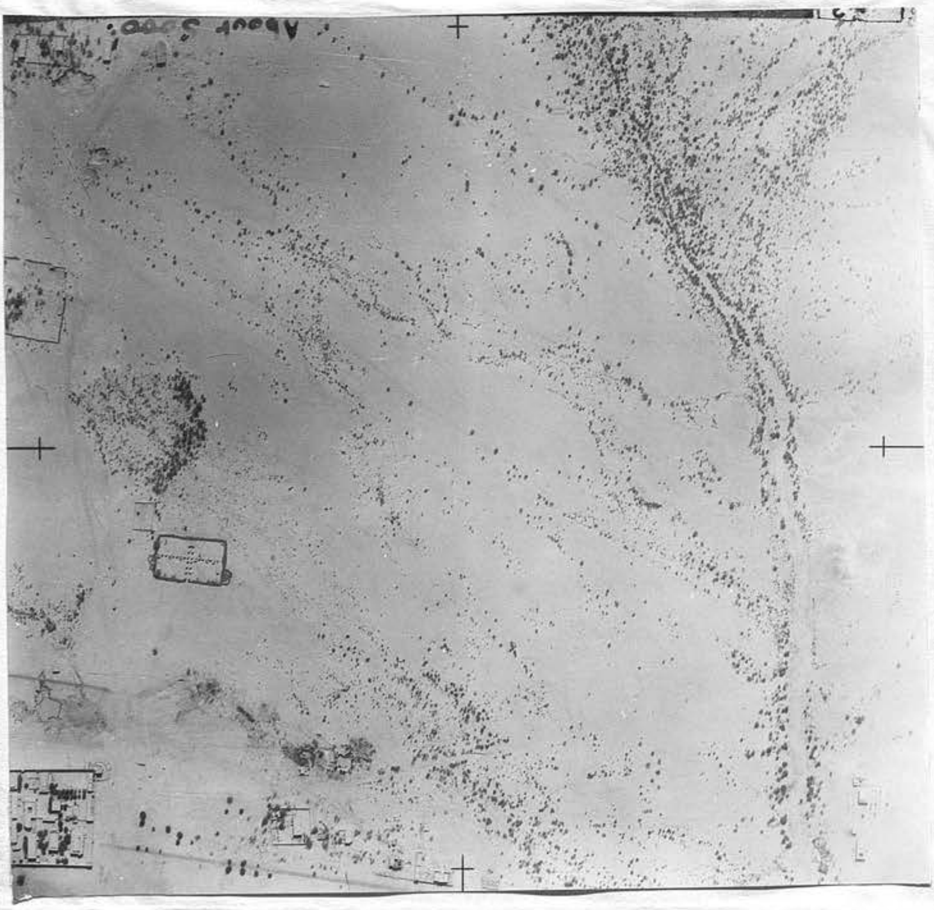
In the semi-desert the vegetation is seen as an agregation of dots when viewed from a high altitude. At 5,000 feet the individual trees can be seen and clumps of thorn-scrub can be easily identified. This is best illustrated in the photograph, taken at approximately 6,000 feet, of the Agades fort area. It is interesting in that it shows the grey tone of the landing ground which has been cleared of vegetation, although the lines of former low, irregular sand-dunes can be observed. Individual shade trees planted within the fort give a useful comparison in size. The larger trees are not Acacias, which are seen as smaller dots.

The photograph taken at 12,000 feet of the area round Agades fort shows in most interesting fashion, the occurrence of thorn species in the water courses and drainage channels. From about 10,000 feet to 14,000 feet, the scrub is seen as a series of irregularly spaced dots (with a similar appearance to iron filings in a magnetic field), where it is found in depressions, on dry stream banks and in the surface water channels. The dry stream beds from the slightly more elevated ground in the top right-hand corner of the photograph can be easily distinguished.

The sub-formation of desert palm stands stand out very strikingly as dark patches and clumps of vegetation either in the immediate vicinity of an oasis in the desert or along the banks of a river. It is regretted there is no aerial photograph in this series to show their appearance

from /

An example of an oasis with a high water table in an area of true-desert. The dark tone of the moist soil in the depression is striking.



The area of the fort at Agades showing thorn-scrub and along the dry river banks riparian thornland. Lines of Acacia raddiana can be seen along the drainage channels.

A date-palm stand at the oasis of Reggan in the northern Sahara. The water is led from foothills of the Hoggar Mountains some fifty miles away.

from the air, but a ground photograph of a date-palm stand is included to show their close espacement; this photograph was taken near Sidi-Bel-Abbès to the south of Colomb-Béchar in North Africa.

True desert is striking in its monotonous appearance from the air, for, to the untrained eye it appears to be unvariable. The photograph of true desert to the east of Gao shows its appearance from 15,000 feet. The light tones of the sand will be noted, although it is a shade darker than the constantly disturbed white glaring sand of the main road through the native town.

Some irregular sand-dune formations can be observed and there are some patches of thorn scrub in the top middle portion of the photograph.

CONCLUSION.

From these notes it will be appreciated that most valuable work in connexion with land planning can be carried out by aerial surveys. These surveys can now be made at a relatively cheap cost and the information which can be obtained is of value to the scientific, technical and administrative departments of any colony.

Aerial surveys are perhaps of greatest importance to the land planning departments, although they are useful to the colonial surveys in that large areas can be covered and checked in a short space of time. It has been recorded that at the present rate of progress in the survey of Nigeria some decades will be necessary before it can be completed; the aerial survey would take a matter of months although the computing would probably take several years to complete.

The /

The post-war planning in regard to economic welfare and social development will require quick and accurate surveys of the land and there is little doubt that aerial reconnaissance will be used in conjunction with teams of scientists carrying out ecological surveys on the ground. This is just as important in the French Niger Colony (and throughout French West Africa), as it is in the British West African Colonies and it is hoped that there will be co-operation and collaboration.

From the point of view of land planning it has now become essential to classify the land into agricultural and forest land. There is considerable land hunger in the Western Sudan and with a rapidly increasing population the question is about to become more acute. It is now necessary quickly to obtain the required area of forest reserves throughout each political division (the percentage varies in each), yet to have sufficient farmland available for the agriculturists.

In order to obtain this end quick and accurate surveys of the remaining vegetation, the present farmland and the land which is valueless for farming, is necessary, and this can best be carried out by aerial reconnaissance. The aerial survey can provide the data for intelligent and progressive administration as no other method of survey can, except over long decades.

In forestry the aerial surveys will enable the existing woodland, the general vegetation, and the true forest land (as opposed to agricultural land), quickly to be assessed. Then can forest reservation be completed so that a wise policy of land utilization can be effected.

It is hoped that international co-operation between the British and French West African Governments will be effected, for the problem is not a parochial one but international.

LIST of SPECIES.

Acacia albida Del.
" arabica Willd.
" ataxacantha DC.
" campylacantha Hochst.
" laeta R.Br.
" macrostachya Reichb. ex Benth.
" nilotica Del.
" raddiana Savi
" senegal Willd.
" seyal Del.
" sieberiana DC.
" stenocarpa Hochst. ex A. Rich.
" tortilis (Forsk) Hayne
Acanthospermum hispidum DC.
Acroceras amplectens Stapf
Adansonia digitata L.
Adina microcephala Hiern
Afromosia laxiflora Harms
Afzelia africana Smith
Albizzia zygia Macbride (Albizzia brownei)
Albizzia chevalieri Harms
Alchornea cordifolia Meull. Arg.
Amaranthus viridis Linn.
Amorphophallus dracontioides N.E.Br.
Andropogon gayanus Kunth
" pseudapricus Stapf
Annona senegalensis Pers.
Anogeissus leiocarpus Guill. & Perr.
Anogeissus schimperi Hochst. ex Hutch. & Dalz.
Anthocleista vogelii Planch.
Antiaris africana Engl.
Aristida adscensionis L.
" mutabilis Trin. & Rupr.
" pallida Steud.
" pungens Desf.
" stipoides Lam.
Balanites aegyptiaca Del.
Bambusa vulgaris Schrad
Bauhinia rufescens Lam.
" thonningii Schum.
Berlinia auriculata Benth.
Bombax buonopozense Beauv.
Borassus aethiopum Mart.
Borreria stachydea Hutch. & J.M. Dalz.
Boscia angustifolia A. Rich.
" salicifolia Oliv.
" senegalensis Lam.
Boswellia dalzielii Hutch.
Bridelia ferruginea Benth.
Butyrospermum parkii Kotschy
Cadaba farinosa Forsk.
Calonyction muricatum G. Don
Calotropis procera (Willd.) Ait.
Capparis tomentosa Lam.

Cassia absus Linn.
" arereh Del.
" aschrek Forsk.
" mimosoides Linn.
" obovata Collad.
" sieberiana DC.
" singueana Del.
" tora L.
Celtis integrifolia Lam.
Cenchrus biflorus Roxb.
" ciliaris L.
" prieurii (Kunth) Maire
" setigerus Vahl
Centaurea alexandrina Del.
Ceratotheca sesamoides Endl.
Chlorophora excelsa Benth. & Hook.
Chrozophora senegalensis A. Juss.
Cleome monophylla Linn.
Combretum aculeatum Vent.
" elliotii Engl. & Diels
" hypopilinum Diels
" lecananthum Engl. & Diels
" leonense Engl. & Diels
" micranthum G. Don
" passargei Engl. & Diels
" verticillatum Engl. ex Engl. & Diels
Commelina nudiflora Linn.
Commiphora africana (A. Rich.) Engl.
Corchorus olitorius Linn.
Cordia gharaf Ehrenb. ex Aschers.
Crateva adansonii DC.
Crossopteryx febrifuga (Afz. ex G. Don) Benth.
Crotolaria aschrek Forsk.
Ctenium elegans Kunth
Cucumis melo Linn. var. agrestis Naud.
Cussonia nigerica Hutch.
Cymbopogon proximus (Hochst. ex A. Rich.) Stapf
Dactyloctenium aegpytium Beauv.
Daniellia oliveri Hutch. & J.M. Dalz.
Desmodium lasiocarpum DC.
Detarium senegalense Gmelin
Dichrostachys glomerata (Forsk.) Chiov.
Digitaria debilis Willd.
Digitaria gayana Stapf
Diospyros mespiliformis Hochst. ex A.DC.
Echinochloa colona (L.) Link.
" stagnina (Retz.) Beauv.
Ekebergia senegalensis A. Juss.
Elaeis guineensis Jacq.
Entada sudanica Schweinf.
Eragrostis ciliaris (L.) R. Br.
" gangetica (Roxb.) Steud.
" pilosa (L.) Beauv.
" tremula (Lam.) Hochst. ex Steud.
Eremopogon foveolatus (Del.) Stapf
Erythrina senegalensis DC.
Erythrophløeum guineense G. Don
Evolvulus alsinoides Linn.

Feretia canthioides Hiern
Ficus capensis Thunb.
Ficus gnaphalocarpa A. Rich.
" iteophylla Miq.
" platyphylla Del.
" kawuri Hutch.
" teloukat
" vallis-choudae Del.
Flueggea virosa (Roxb. ex Willd.) Baill.
Gardenia erubescens Stapf & Hutch.
" sokotensis Hutch.
Grewia betulifolia Juss.
Grewia flavescens Juss.
Grewia mollis Juss.
Guiera senegalensis Lam.
Gymnosporia senegalensis Loes.
Heeria insignis O. Ktze.
Hibiscus asper Hook. f.
Hibiscus cannabinus Linn.
Hibiscus sabdariffa Linn.
Hippocratea richardiana Cambess.
Hymenocardia acida Tul.
Hyparrhenia dissoluta C.E.Hubbard
Hyphaene thebaica (Del.) Mart.
Indigofera arrecta Hochst.
Indigofera astragalina DC.
Indigofera prieuriana Guill. & Perr.
Ipomoea repens Lam.
Isoberlinia doka Craib & Stapf
Khaya grandifoliola DC.
Khaya senegalensis A. Juss.
Kigelia aethiopica var. Bornuensis Sprague
Lannea acida A. Rich.
" barteri (Oliv.) Engl.
Lasiurus hirsutus (Forsk.) Boiss.
Latipes senegalensis Kunth.
Leptadenia lancifolia Decne.
" spartium Wight
Lonchocarpus griffonianus Dunn
Lophira alata Banks
Maerua angolensis DC.
" crassifolia Forsk.
" rigida R.Br.
Mimosa asperata L.
" pigra Mill.
Mitracarpum verticillatum Vatke
Mitragyna inermis O. Kuntze
Oldenlandia senegalensis Hiern
Oxytenanthera abyssinica Munro
Panicum laetum Kunth
Panicum turgidum Forsk.
Parinari curatellaefolia Planch.
" macrophylla Sab.
Parkia oliveri Macbr.
Paspalidium geminatum (Forsk.)Stapf
Pennisetum hordoides Steud.
" mollissimum Hochst.
" pedicellatum Trin.
" polystachyon Schult.
Peristrophe bicalyculata Nees

Phoenix dactylifera L.
Piptadenia kerstingii Harms
Polycarpaea linearifolia DC.
Prosopis africana (G. & P.) Taub.
Psorospermum guineense Hochr.
Pterocarpus erinaceus Poir.
Raphia venifera
Raphia sudanica A. Chev. ~~Flora~~
Ricinus communis Linn.
Rogeria adenophylla J. Gay
Salvadora persica L.
Sarcocephalus esculentus Afzelius
Schizachrium exile Stapf
Sclerocarya birrea Hochst.
Securidaca longipedunculata Fres.
Sehima ischaemoides Forsk.
Sesbania aegyptiaca Poir.
Setaria sphacelata Stapf & Hubbard
Smilax kraussiana Meisn.
Solanum incanum Linn.
Sterculia setigera Del.
Stereospermum kunthianum Cham.
Syzygium guineense DC.
Tamarindus indica L.
Tephrosia bracteolata Guill. & Perr.
Terminalia avicennioides G. & P.
Terminalia glaucescens Planch.
Thelepogon elegans Roth.
Tribulus terrestris Linn. TYPHA AUSTRALIS SCHUM. & THONN.
Uapaca guineensis Muell. Arg.
Urochloa lata (Schum.) C.E. Hubbard ex Hutch. & Dalz.
" trichopus (Hochst.) Stapf
Vitex cuneata Thonn.
Waltheria americana Linn.
Ximenia americana L.
Ziziphus mauritiana Lam.
" mucronata Willd.
" spina-christi Willd.

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