BRITISH EMPIRE FORESTRY CONFERENCE

SOUTH AFRICA, 1935

SOIL EROSION IN NIGERIA

J. R. AINSLIE, Dip. For. (Oxon.), B.Sc. (Oxon.)

Conservator of Forests, Nigeria

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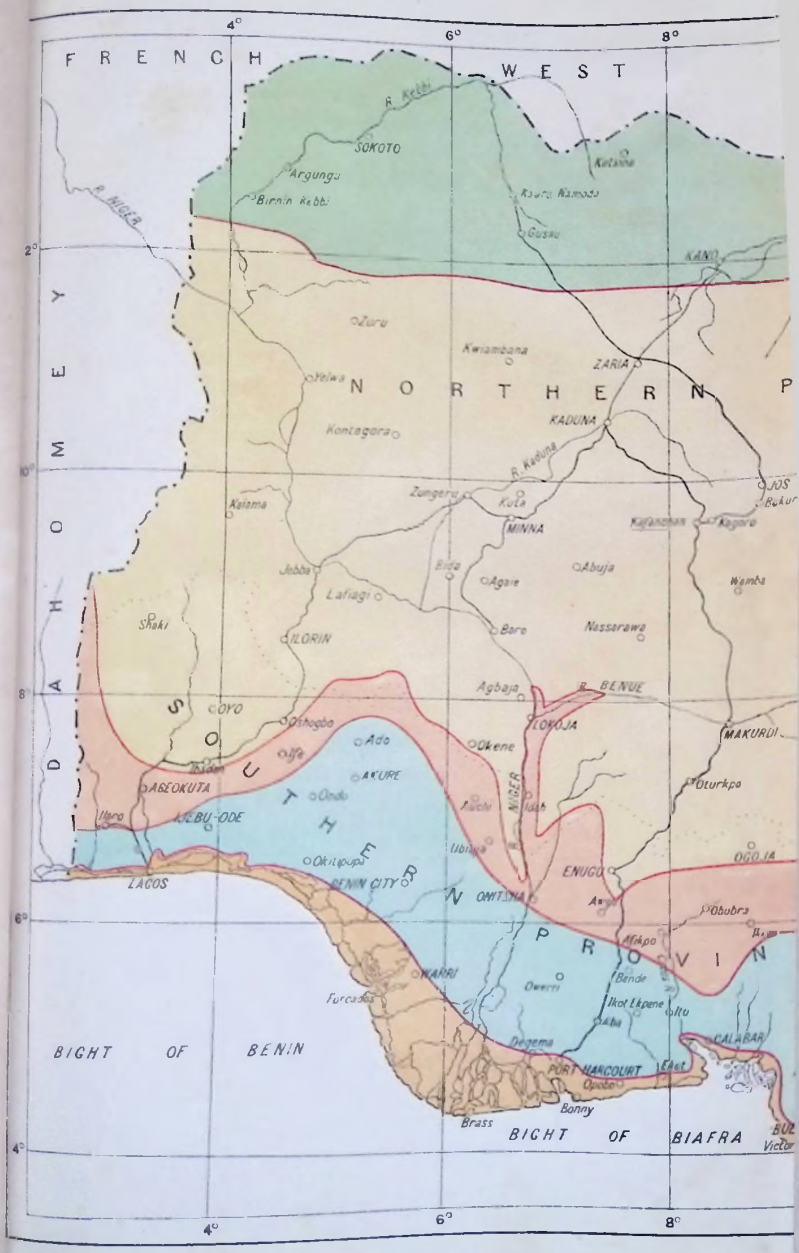
LIST OF PLATES

Acknowledgment.

Figures 1, 3, 4, 5, 6, and 7: Photographs by A. H. W. Weir.

Figure 8: Photograph by W. D. MacGregor.

Figure 9: Photograph by D. F. Chesters.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OYO
Shagbo
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LOKOJA
MAKURDI
Ife
Ede
AKURE
ABEOKUTA
Ondo
Oturkpo
Ilaro
AIEBU-ODE
Ikeja
NIGER
Ubiaja
Okitipupa
ENUGU
OGOJA
LAGOS
BENIN CITY
OMUTSHA
Aba
Obubra
Afikpo
PROVIN
WARRI
Owerri
Bende
Forcados
Ikot Ekpene
Uyo
Degema
CALABAR
BIGHT OF BENIN
PORT HARCOURT
Opobo
Bonny
Brass
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BUE
Victor
2°
4°
6°
8°
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Drawn & Reproduced by Nigeria Surveys. Lagos. Aug. 1932

SOIL EROSION IN NIGERIA

General.

Erosion in a country is the product of its geology, soils, relief, climate and vegetation but especially of the mutual interaction of these agencies. A map showing erosion therefore will not as a rule correspond with a map representing any one of the above features. Of these features, probably that which affects erosion more than any other is the vegetation, its types and its presence or absence; a vegetation map of Nigeria is attached to this report.

Physical Features.

In Nigeria the physical features are small and certainly not outstanding compared with the vast extent of the country. Viewed as a whole the country may be described as a vast undulating plain rising northwards from the seaboard to a plateau with an average height of 2,000 feet. The rise on leaving the coast is generally very gradual; at certain points, however, occur isolated rocky and precipitous hills (*inselbergs*), crystalline ridges of hills, and occasional sharp escarpments. The last named are most developed along the southern edge of the Bauchi Plateau, a tableland of 4,000 feet elevation in the north-centre of the country, and bordering the Udi Plateau in the south-east; the inselberg type of landscape is best developed in the North and centre of the country. North of the Bauchi Plateau, lie the Hausaland Plains, a tableland of 1,000 to 2,000 feet elevation in which is included the vast alluvial plain surrounding Lake Chad.

Excepting the Lake Chad Plain in the North and the Benue Valley, the eastern frontier is mountainous; the hills increase in elevation from North to South and culminate in the Cameroons Peak, a volcano of 13,500 feet on the coast. A marked feature of the country is the Niger-Benue depression, which running north from the coast forks at the Niger-Benue confluence; one branch forms the Upper Niger valley and extends north-west into Dahomey and the French Niger Colony; the other branch, the Benue valley, enters the French Cameroons to the north-east.

Climate.

The seasons are well defined. The dry season, October-November to March-April, is characterised by the Harmattan a north-easterly wind conveying a haze of fine sand and desert dust. During the wet season, April to October, the wind blows from the south-west and carries with it heavy rain clouds from the Gulf of Guinea; these

striking the undulating wooded coast produce heavy rains in the littoral region: the maximum rainfall occurs on the southern slopes of the Cameroons mountain. The general low relief of the country and the very inappreciable increase in elevation towards the North causes a rapidly diminishing rainfall inland, and although at Lagos, Brass and Debunscha, on the coast, the average annual precipitation is 60, 140 and 356 inches respectively, at Sokoto, Hadeija and Maiduguri in the North it is 27, 20 and 25 inches. Generally towards the East owing to the more mountainous country the rainfall is greater than in the West, but it is also more seasonal: thus Olokemeji and Ibadan, western stations, have an annual fall of 49 and 50 inches while Enugu and Ogoja, eastern stations, have 69 inches and 73 inches respectively.

Erosion Factors, Etc.

Rain and wind are the most active erosion factors in Nigeria; river waters assist however, and solar heat plays its contributory part. The small amount of volcanic activity confined to the extreme south-east of the country (the last eruption of the Cameroons Peak was in 1922) may be neglected as a factor.

Soil erosion exists throughout Nigeria. It is present to some extent in the forest-clad South, a region of high rainfall; it exists in the centre of the country, an undulating region of semi-open forests with 50 inches of rain annually, but it is probably in its aggregate results most effective in the North where the conditions are the antithesis of the South, *viz.* a flat, sandy country of little forest, situated near the edge of the greatest desert in the world.

There must be few people living in hilly regions who have not observed that erosion and denudation go on without intermission. The erosion in such regions is easily visible, it is usually somewhat local, and its effects are, only too often, fully appreciated; to a less extent, however, is it appreciated that erosion goes on over large, more or less flat areas of land, and accordingly, although the latter type of erosion achieves results over immense areas compared with those of the former, it is the latter that is most frequently ignored until some approaching climatic crisis or physiographic danger renders immediate attention to the problem imperative.

Erosion Regions.

For the purpose of considering erosion in Nigeria, I have divided the country into the following *Erosion Regions*; the reasons for this apparently arbitrary division are shown later:—

(*a*) *The Southern Region.*
(*b*) *The Central Region.*
(*c*) *The Northern Region.*

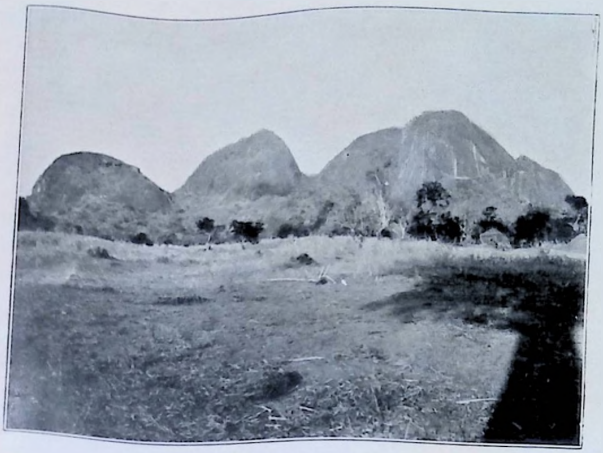

FIGURE 1—An Inselberg.
[Photo by *A. H. W. Weir.*

(*a*) The *Southern Region* is made up of the *Littoral* and *Rain Forest* vegetation zones: these form a gently undulating plain, largely forest clad, the Littoral zone with Mangrove Forest and the remainder with Tropical Rain Forest or other dense tropical growth associated with a high equatorial rainfall. The soil is deltaic or tropical redearths generally overlying soft Tertiary formations.

Erosion is not as a rule obviously present in this region; though its effects, mostly as an "invasion" from elsewhere, are to be seen in the silting of stream beds and the extensive alluvial or deltaic formations round the coast of Nigeria. Where the soil has been cleared of vegetation erosion can be remarkably active; fortunately however this has occurred only on a very small scale.

(*b*) The *Central Region* is a much dissected, formerly elevated plain: in the West, sub-aerial erosion has been going on for countless geological ages and the inselberg landscape type is frequent; in the East the Cretaceous and Tertiary sedimentary rocks give a different appearance, and the hills to some extent take the form of small flat topped table-lands instead of inselbergs. The largest of these, the *Udi Plateau*, forms a distinct erosion sub-region. Generally the ground is undulating or hilly; and the soil is the result of the weathering of the underlying rocks mixed with drift and forming almost throughout tropical red-and-yellow-earths: there is occasional lateritisation. This region was at one time completely clothed with evergreen and mixed deciduous forest: but over very large areas this has been repeatedly cleared and burnt off, and, although small patches of the original forest still remain, these are separated by wide expanses of land invaded by a depraved forest type similar to the Northern Savannahs. As is usual in this type of country in the tropics, annual fires expose the soil for the rains and wind to erode; the general surface erosion keeps pace more or less with the river cutting so that its effects are seen mainly in silting in river beds and in the lagoons of the *Southern Region*. The silt is largely the result of surface wash to which is added a small amount of wind-blown sand and the products of the friction of this on the inselbergs, many of which show the characteristic rounded shape associated with aeolian erosion and solar exfoliation. (Figure 1.)

Reference has already been made to the *Udi Plateau;* this table-land of 1,000 to 1,500 feet in height forms the main water-shed between the lower Niger and the Cross River; it is composed of soft Eocene and Cretaceous sedimentaries overlaid with a soft fine sandy drift. One to two hundred years ago this plateau was covered with dense evergreen forests; these forests were cleared by Ibo tribes, active farming peoples. Owing to this and to the locality conditions, prolonged annual droughts

and fierce bush fires followed by heavy seasonal rains, the natural vegetation has largely become replaced by grass; the old humus soil has disappeared, and has left exposed the soft surface drift which overlies an almost equally friable rock (Benin sands). Occasional lateritisation has taken place and this offers resistance to erosion, but the major portion of the plateau is being eroded not only superficially by the heavy seasonal rains but also in gullies by the deep-cutting torrential streams. So rapidly are the latter cutting back that one can almost imagine the very ground to be soluble. Canyons have been cut into the surface of the earth; large deposits of sand and silt appear at the chasm-like stream-exits from the escarpment; much of the silt is being spread over what was formerly agricultural land; the remainder, the finer material, is deposited further down the streams, causing them to become shallow, increasing flood damage and generally aggravating the physical conditions of the locality. It is only a matter of time when the softer portions of this plateau will be eroded away, and one of the tributaries of the Cross River will join up with one of those of the Niger. The *bad lands* resulting from this erosion, although small in actual area compared with those in other parts of the world America, India, etc. are almost certainly unsurpassed in ugliness and uselessness. (Figure 2.)

Such *gully erosion* is to be expected in those parts of the country where the natural vegetation has been removed and where the other contributory factors exist. Fortunately the combination of these, a soft friable soil, hilly and steep country, torrential and seasonal rains and annual fires, occurs in but few other areas in the country; and in the Udi Plateau *gully erosion* reaches its greatest extent; although it is to be seen occasionally elsewhere on a much smaller scale.

Proceeding northwards in this Central Region the vegetation becomes more open and xerophytic in type, and a more prolonged annual drought and exposure of the soil takes place; the erosion effects therefore become very gradually more severe. This increasing severity first becomes apparent in the neighbourhood of the 11th degree of latitude North, a line which very roughly corresponds with the *height of land* between the ocean drainage region of the Niger and the inland drainage system of Lake Chad. On account of the above I have, perhaps somewhat arbitrarily, fixed the boundary between the *Central* and *Northern Erosion Regions* as coinciding approximately with the line of eleven degrees North.

(c) The *Northern Region*, like the Central Region, was at one time clothed, to a considerable extent with a good deciduous forest type, a few scanty remnants of this still exist; the original forest area extended certainly as far north as Zaria and probably Kano. To-day the south of this region supports only *Savannah Forest*, this gives way

FIGURE 2—Erosion on the Udi Plateau.

to *Thorn Savannah* towards the north and finally to thorn scrub, grassland and occasionally sand; a large area of the Bauchi Plateau is treeless grassland.

This region consists of a central hilly zone of crystalline rocks surrounded almost wholly with undulating sedimentary formations; to the north-east lies the vast alluvial Lake Chad basin. In the South centre of the region the Bauchi Plateau rises to 4,000 feet, with granitic ridges up to 6,000 feet. In the crystalline areas the inselberg type of landscape predominates, but in the sedimentary areas the hills often take the form of flat topped ridges generally with ironstone caps; the latter are the result of severe lateritisation of the former land surface during a comparatively recent period; in the east basalt and phonolite stumps (Tertiary) occasionally outcrop through the sedimentaries.

Overlying the whole is a drift soil composed mostly of the weathered results of the underlying rocks, seldom however *in situ*, and partly of drift and wind-blown sand.

The difference in the extent and the appearance of the erosion in this region compared with the foregoing is due to the following causes:—

The denser vegetation in the South protects the soil.

The longer rainy season of the South does not permit the very fierce bush fires of the North; the latter expose the soil to the elements to a greater extent and for a longer period annually than is the case in the South.

The Harmattan is much stronger in the North than in the South, and in the former acts very definitely as an erosion factor as well as causing drift of the finer soils.

The rains though lasting a shorter period in the North are generally more violent than in the South. At the same time the Northern soils appear to be of a lighter texture.

Throughout this region during the winter months the Harmattan blows; this dry, dust-laden desert wind, itself bringing vast quantities of sand from the Sahara, picks up the fine dusty soil and whirls it away to be deposited elsewhere or carried by wind and water to the sea. The wind is sometimes so dust-laden that drifts of fine powdery sand resembling miniature snow-drifts in shape, etc. occur behind almost every little projection, and occasionally round such larger obstacles as houses in so short a time as one season a wreath of one to two feet may be formed. Owing to this and to the even greater erosive effect of the fierce summer rains the unconsolidated drift soils of this region are kept in a state of almost continual motion, undergoing erosion, re-arrangement and removal. (Figure 3.)

The accumulations of drift soil appears almost entirely to have taken place during comparatively recent periods of depression which alternated with intervening periods of elevation and erosion. The present period is a period of elevation and erosion with a minimum of accumulation; the previous period was one of depression and accumulation accompanied by a minimum of erosion, during the latter the drift was widely spread over very large areas and to a considerable depth. The depth is so great in some places that the rivers have not yet cut through on the underlying rock; at other points, however, the drift has practically all gone. At present it is true there is a certain small amount of annual deposit of sand from the Sahara, but annually much more than this is swept away in *sheet erosion* by rain-wash and wind, while the rivers continue their cutting and carrying work.

Sand dunes occur; these in many places have become fixed, but here and there are active, and, although this movement is not widespread in Nigeria itself, it is common in the adjoining French territory and must be looked upon as an ever-threatening and potentially increasing menace from over the Northern frontier.

While it is true that in this Northern region instances of *gully erosion* on such a large and picturesque scale as those to be seen on the Udi Plateau are generally absent, *sheet erosion* is going on with extreme rapidity. Reference has already been made to the Harmattan in this respect as a factor, and it increases in effect towards the North: rain-wash is, however, the chief active agent in producing *sheet erosion*. This can be seen almost anywhere during the wet months when volumes of shallow, muddy, surface water, often covering considerable stretches of land, flow, swirling hither and thither and bearing off loads of soil, which, naturally soft and friable and already bare of woodland vegetation, has been initially broken up and exposed by fires and grazing and finally completely loosened by farming operations. In order to appreciate the almost incredible extent to which this form of erosion is going on one must examine the rivers themselves into which these muddy rain water floods pour their loads of soil for several months in the year. A striking example of this, and one that has been referred to by other writers, is that of the Hadeija River; the head-waters of this stream rise among the farms on the highlands near Kano; they unite to flow into the Yobe River which forms the northern boundary of the country and thence reach Lake Chad.

During parts of the wet season this river flows, not one might say with water but with liquid mud; the viscosity and consistency of this liquid has been likened to "thin porridge" and the river has been described as having a "ropey texture"; these characteristics can be observed in most of the northern streams.

FIGURE 3—Thorn Savannah Forest—*Acacia verek*—gum arabic.

(*Note the open type of forest and the exposed soil.*)

[Photo by *A. H. W. Weir.*

FIGURE 4—The Gongola River in the Dry Season.

(*Note the small shallow stream and the vast extent of the silted flood plain. A typical sedimentary hill with flat iro. stone cap is seen in the background. The causeway is open only in the dry season, it is washed away in the rains.*)

[Photo by *A. H. W. Weir.*

So long as the gradient is steep this mud flows on, but with a decrease of the grade much of this load of suspended soil is deposited in the stream bed. This goes on annually, the bed of the river rises, floods increase, the river becomes more shallow and widens out, spreading over the land and exposing a large surface of water to evaporation and so more deposition of silt takes place and so on. (Figure 4.)

River capture in Nigeria has been a somewhat frequent occurrence in the past, and at the present period two great movements appear to be in progress; in the North, the gradual capturing of the streams flowing into Lake Chad by the Benue and its tributaries, a typical case of an increasingly arid inland drainage system being captured by the streams of an ocean drainage system, and in the South, the cutting back of the headwaters of some of the Cross River tributaries through the Udi Plateau towards tributaries of the Niger. The Rima River in the North in Sokoto Province has in the past captured a number of smaller north-flowing streams which formerly emptied themselves into the desert, another instance of a rapidly ageing inland flowing system being captured by the more active ocean drainage; there are many other instances of river capture in Nigeria.

Reverting, however, to the question of sheet erosion so universal throughout this Northern portion of Nigeria: Stockdale in a series of experiments carried out in Ceylon a few years ago showed that the amount of soil lost by sheet erosion resulting from rain-wash alone was as much as eleven to twenty-two tons per acre *per annum*; *i.e.*, 0.08 to 0.16 acre-inches of soil yearly; it is noteworthy that a loss of over forty tons per acre annually has been recorded from Nebraska. These experiments were carried out on undulating and even hilly land, but on a stiffer form of soil than we have in Northern Nigeria, and the ground was protected by plantation growth. Such a series of experiments has not so far been carried out in this country but with the lighter, more friable and more exposed soil and with the additional erosive effects of the Harmattan there is little doubt that equally high figures would be obtained for sheet erosion in the North.

Erosion, Desiccation and Vegetation Destruction.

The questions now arise: What is the root cause of this erosion? How does it affect desiccation? What steps are being or can be taken to remedy it?

There is little doubt that the destruction of the natural vegetation of the country is the fundamental cause of ninety-five *per cent.* of the erosion now going on. Where high forest exists erosion is negligible; where partial forest destruction has taken place and a depraved mixed deciduous woodland exists there is appreciable erosion; and where the

destruction has proceeded a stage further and the vegetational type is savannah or grassland the erosion is excessive. As the high forests are in the South, *i.e.* the zone of highest rainfall, and the Savannahs are in the North, one gets occurring in Nigeria what at first sight may appear paradoxical, viz. that the region of highest rainfall is on the whole the region of least erosion and *vice versa*. This is further increased by the facts that although the annual rainfall is less in the North the rain storms are more violent and seasonal and that there are more grazing animals in the North.

Wind is almost negligible in the South although quite a definite factor in the North, and here again the effect is magnified by soil exposure.

Desiccation.

Regarding the question of desiccation, this may be due to an actual decrease of rainfall or of other types of atmospheric precipitation, or it may be due to the actual water after precipitation becoming less available to the flora and fauna of the country, or it may be due to both.

Forests affect both rainfall and the subsequent availability of the water, so that it is natural to assume that if forests have been destroyed on a large scale, undoubtedly desiccation of some sort has taken place; thus, forests in addition to being a major controlling factor in the case of erosion are definitely a contributory controlling factor in the case of desiccation resulting from rainfall diminution. There is no doubt that the forests in the North have been destroyed in the past, but whether this destruction has taken place on a scale sufficiently extensive to cause an appreciable diminution of rainfall or not is a matter difficult to prove. It is, however, equally difficult to believe that the destruction of some 100,000 square miles of forest, which must have been at least the area of the original Nigerian Forest belt, leaving only a comparatively narrow coastal strip has had no effect on the rains. The situation requires a careful and fair review of all the available evidence.

The rainfall records of Nigeria do not go far enough back to prove any fact for or against rainfall diminution. They do seem, however, to give the impression that rainfall irregularities are increasing; this fact is held by some authorities as a proof of desiccation, and it is an admitted fact that this part of Africa, *i.e.* the Nigerian Sudan, has undergone a process of desiccation in the past; in addition, however, there appears to be certain proof that desiccation is still going on, and, whatever its original causes may have been, there is no doubt that it is aggravated by erosion and transportation of soil. Reference has already been made to this in connection with the Hadeija River, and

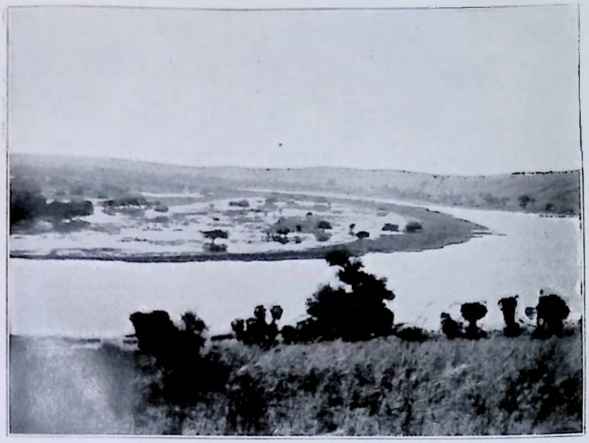

FIGURE 5—The Yobe River in Flood.

(*Taken from a ridge of partially fixed sand dunes forming the right bank of the river.*)

[Photo by *A. H. W. Weir.*

the process is easy to understand: The rivers yearly dumping their loads of silt, raise their beds, and the river becoming wider and shallower presents a greater surface to evaporation; dumping increases and the river becomes lost in a maze of winding shallow channels, which during floods overwhelm the adjacent farmlands and during the annual droughts dries up increasingly early in the season. This process may occur in any locality where stream gradients decrease and where erosion is going on; it is particularly liable to happen in inland drainage systems, the streams of which usually have rapidly decreasing gradients and particularly in dry areas soon become unable to keep their courses clear. (Figure 5.)

In this way rivers once perennial become seasonal: seasonal rivers dry up for increasingly prolonged annual periods, and districts through which streams at one time flowed freely may become completely arid as they are never reached at all by the water.

To this form of desiccation is added in places the effect of river capture, already referred to, and by which considerable areas of country may be deprived of water. Drifting sand too in the extreme North in some regions appears to have buried agricultural soil and to have enveloped or dammed small waterways and stream beds.

The writer had the opportunity of re-visiting this part of the country in January of this year (1935) and noticeable everywhere was the surface drift-sand always on the move from North to South, helping to fill up the already (in January) dry stream beds, aggravating the tendency of the waterways towards the formation of chains of *tapkis* along the course of former free-flowing streams, filling up wells and, becoming partially anchored by patches of scrub, forming wreaths that half bury the growth which allows them to exist; generally this sand is encroaching everywhere. (Figures 6 and 7.)

Noticeable also, however, in this region is an even more significant feature in regard to the vegetation: the natural forest in this region *at the present time* is a non-climax Acacia thorn type, containing several varieties of *Acacia*, *Balanites*, *Zizyphus* etc, with an admixture of larger trees of *Diospyros*, *Mimusops*, *Khaya* and accompanied by a low storey of xerophytic shrubs and grass: near stream beds a greater proportion of mesophytic species are represented, *e.g. Pseudocedrela*, *Khaya*, *Anogeissus*, *Mimusops* and *Diospyros*, but whereas throughout the forest the xerophytic species are represented in all the younger and to some extent too in the older age classes, the mesophytes are represented only in mature and over mature age classes; there is little or no natural regeneration of the latter.

Under natural conditions, forests arise from seed: on germination, seedlings depend on the surface soil, but once fully established with their deep seated root systems they become to a certain extent independent of the surface soil. On account of this it is possible to find a forest type growing on a soil the conditions of which are quite different from those upon which the forest originated or can regenerate itself. Here we have a forest composed of mesophytic species in the older age classes mixed with a younger growth of xerophytes. Knowing the conditions which are required for the successful germination of the former and seeing the vast amount of soil transportation and sheet erosion that is now going on one can only conclude that the original slightly less arid soil which could support seedlings of such species as *Anogeissus*, *Mimusops*, etc. has been removed leaving a more arid type in its place. There is no other explanation for this, and it is to a large extent confirmed by the soil movement now going on. Unfortunately it is not known and it is not possible to tell whether, during the period this soil movement has been going on, there has been a decrease in the annual rain. But there is no doubt whatever as regards the fact of desiccation and the consequent ecological progression, and there can be little doubt that the main contributory factor in producing this is sheet erosion and soil movement.

It is noteworthy that the natives themselves of this Northern portion of Nigeria recognise the evil of this soil movement and in recent years they have adopted various simple methods to mitigate it. The making of simple fascines as a form of direct action is to be seen occasionally, but the most striking is the leaving of crops in the soil as long as possible: thus corn is cropped just below the ear, instead of at the base, leaving the stalk standing upright: successive fields of this do undoubtedly have a slight ameliorating effect locally: I am informed on very good authority that this custom was not always practiced here, and that the local inhabitants have copied it in recent years from their French neighbours over the boundary: the latter suffer from drift even more than the Nigerians do: the custom is said to be spreading southwards. The general movement of the population of a country may also be a significant feature in regard to desiccation, and in this region there is a constant southward movement of people from the French Niger Colony: there is little doubt that most of these are driven by the increasing desiccation in the Saharan Zone to seek the less arid conditions in Nigeria.

There is one curious and fortunate feature about this ecological desiccation that is taking place in Northern Nigeria, *viz*: there are no definite records of a decrease in elevation of the *water-table*. This of course does occur where gully erosion is taking place, but elsewhere

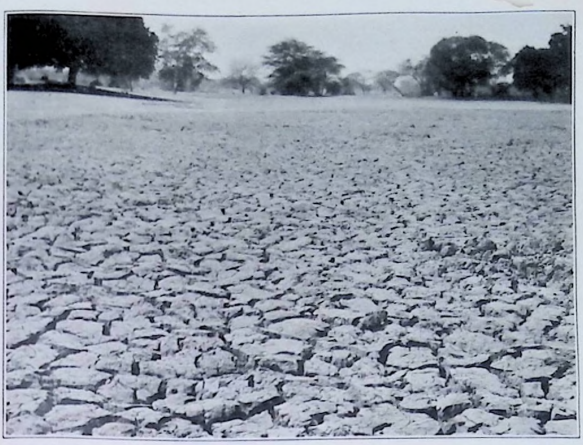

FIGURE 6—A Tapki in the Dry Season.

[Photo by *A. H. W. Weir.*

FIGURE 7—A "Wet" Tapki—Part of the bed of a former free flowing river; this dries up in the dry season.

[Photo by *A. H. W. Weir.*

when wells etc. have dried up there is strong reason to believe that this has been mainly due to filling or falling in rather than lowering of the water. Well-boring operations are now going on in Northern Nigeria on a very large scale under the direction of the Geological Survey Department of Nigeria, and the future may produce some such records; though this is less likely than formerly; as such a reduction in the water-table would be most marked during a period of rapid forest destruction.

It is generally admitted that North Central Africa was at some time in the comparatively recent past much better watered than it is now, and it is just possible that this progressive Nigerian desiccation is part of a climatic retrogression on a continental scale, and not a purely local affair. I am aware that a number of authorities support the former view, and the problem known as the "Desiccation of Africa" has been in the past a subject of considerable discussion. The authorities of the adjoining countries report desiccation similar to that occurring in Northern Nigeria so that it appears to be progressing on a more than purely local scale. Doubtless, however, the discussion and correlating of views and the facts brought to light from North, South, East and West Africa at this conference will help to throw fresh light on this question which is of vital importance to the future of the continent, and they may at the same time be the means of adducing some steps by which this progressive desiccation may if not brought to a standstill be at any rate materially retarded.

Anti-Erosion Measures.

Dealing now with the steps that can be taken to delay this process of erosion, and consequent desiccation, the most natural means, and that likely to be most effective in the long run, is forest protection; for this reason large forest reserves have been created as *protection forests* not only near the northern boundary of the country, but also as far as possible on watersheds and on hills forming important catchment areas. The total area of such protection forests in the North is some 7,000 square miles. To get the full benefit of these absolute fire protection is necessary and the results of this whenever it has been possible to put into effect are remarkably good; in five or six years much improved growth appears; the locality becomes more genial and an increasing number of mesophytic species establish themselves. Moreover the soil becomes more and more fixed and less erosion takes place in consequence. It is obvious, however, in a country where bush fires are a regular seasonal occurrence that absolute protection of such large areas from fire is not merely difficult but well nigh impossible without a huge staff and vast expenditure. On account of this in Nigeria there has developed a special technique, called the *early firing* system which

originally introduced as a "second best thing" in the matter of fire protection has nevertheless achieved remarkable results. Early firing in Nigeria is done at the earliest moment of the dry season when the grass is sufficiently dry to burn: a late fire results in a huge conflagration destroying everything but the oldest and most coriaceous fire-resisters and leaving the soil utterly exposed to the elements; the effect of early firing, however, is that the grass, twigs and small brushwood are burnt, while the soil itself is merely scorched: the fire is insufficient to kill tree growth and usually results in stimulating seeds lying dormant in the ground to germinate and in exciting the production of root suckers from the trees: having been already burnt the whole area is much less liable to fire throughout the dry season: and as green herbage appears shortly after the fire the soil has a covering during its most vulnerable period when the first rains appear. Moreover in a few years time a marked improvement in the quality and density of the forest growth is apparent: records taken in several reserves where early firing has been practised for some years have shown an improvement of the growing stock from approximately fifty to sixty stunted over-mature standards per acre to as many as two or three hundred young trees per acre: this improvement in growing stock further helps to protect the soil and so the ameliorating process increasingly goes on. It is believed in some quarters also that early firing has had a definite effect in ridding certain areas of *Glossina morsitans*, possibly partly due to the fire itself and partly possibly due to the fact that by preventing the usual late season fierce fires, added protection is given to many of the smaller insectivorous birds.

On the Udi Plateau where *gully erosion* is taking place definite anti-erosion operations have been initiated: here the methods employed are similar to those in practice in other countries. An area is marked off for absolute fire protection: a series of contour ridges and trenches are laid out working downwards from the top of the local *height of land*: the trenches are one foot wide, one foot deep and ten feet long and are arranged in echelon so that the longest clear run is not more than twelve feet.

The whole area is treated as above and subsequently planted up generally with stump plants of suitable species, but in some cases direct sowings have been resorted to. The above effectively stops most of the surface erosion, and thus prevents large volumes of silt being washed into the gullies and ravines.

"Mild" ravines are also similarly treated: where, however, the banks are too steep and "raw" edges are actively undergoing erosion, the sides are broken down to a comparatively flat angle and smoothed off; ridges and ditches are then constructed and planted up. In some

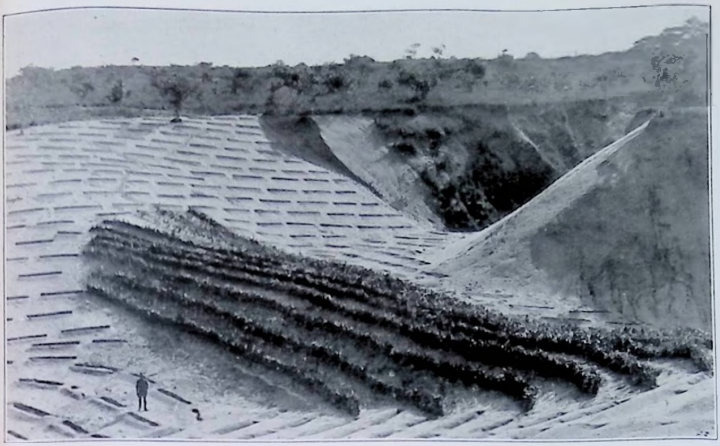

FIGURE 8—Anti-erosion Operations on Udi Plateau.

(*Prior to the introduction of the young trees, a knife-edged ridge has been broken down; the sides of the ravines sloped off and the ditches shown in echelon; the fascines are live cuttings of* Mæsopsis, Acioa, *etc.*)

[Photo by *W. D. MacGregor.*

FIGURE 9—The same ridge taken four years afterwards; the young trees are now eight to fifteen feet high. The trees seen are mostly *Acioa barteri.*

[Photo by *D. F. Chesters.*

cases the introduction of grass as a soil fixing agent preceeds the ordinary stump-planting of trees. At certain strategic points in the ravine dams are constructed with water escapes arranged to prevent overflow.

The results of the above have been remarkable as the two appended photographs show; the first, Figure 8, shows the end of a knife-edged ridge the sides of which have been broken down, rounded off and already planted with surface binding grasses, but before the introduction of young stump plants; the second, Figure 9, shows the slope of the same ridge four years later with woody growth fully established and eight to fifteen feet high. (Figures 8 and 9.)

The chief source of danger to such operations is of course fire, and if this can be prevented their success is assured. The cost of establishing these areas is between two and three pounds per acre for the first three years; thereafter they require only fire protection and prevention from grazing. It is regrettable that owing to financial stringency during the last few years much of this work has had to be curtailed, but it is not improbable that it will be recommenced in the course of the next few years.

Finally in the extreme north of the country, on the international boundary, a planting scheme which it is believed will have very far reaching consequences has been embarked upon by the Katsina Administration under the advice and supervision of the Forestry Department. Summarised the scheme involves the establishment of a series of plantation belts, linking up and utilising as far as possible any existing forest areas, these belts are distributed at right angles to the north-east wind, *i.e.* the wind causing most sand drift. A single belt 1,500 feet wide has already been partially established along the Katsina section of the International boundary and this will be supported behind by the series of belts already referred to. These belts are to be established where possible by direct sowings but supplemented by *Chena* plantations; in this connection the cultivation of cotton as the agricultural crop with gum arabic as the forest crop appears to be a very suitable combination and is being extended. As stated above these operations are mostly being carried out by the Native Government of the Emirate of Katsina. Ordinary agricultural pursuits are of course permitted except on actual planting areas. It is hoped, if after a year or two these plantations prove successful, and they certainly have the appearance of success now, to extend these operations all along the Northern frontier, wherever necessary, as well as in certain areas further south where such steps are likely to prove beneficial.

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